

# **The Future of Aircraft Maintenance in Australia:**

**Workforce Capability, Aviation Safety and  
Industry Development**

**Final Report of Findings from  
Australian Research Council  
Linkage Project 110100335**

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**THE FUTURE OF AIRCRAFT MAINTENANCE IN AUSTRALIA:  
WORKFORCE CAPABILITY, AVIATION SAFETY AND INDUSTRY DEVELOPMENT**

**REPORT OF FINDINGS OF ARC LINKAGE PROJECT 110100335**

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# Executive Summary

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## In a nutshell

1. By 2025, there will be an estimated 30% global workforce shortfall in aircraft maintenance capacity, with Australia and the Asia Pacific region particularly hard hit: Australia has both a strong need and excellent opportunity to help meet this shortfall in the region.
2. This means moving quickly to rebuild both our aircraft maintenance and maintenance training industries by 2020, to permit Australia to handle a high proportion of its own needs across the civilian airline, general aviation and Defence sectors.
3. This is also a great opportunity to capitalise on our strong safety standards and high-end maintenance capability by building a maintenance and training capacity, capable of competing aggressively in the highest-value niches of the global market.
4. We must move to establishing a system of quality control safeguards, adequate to guarantee that maintenance on Australian aircraft, whether done in Australia or elsewhere, is carried out to best international safety standards.
5. Australian maintenance qualifications must be globally integrated through complete alignment with International Civil Aviation Organisation (ICAO) and European Aviation Safety Agency (EASA) training and licence standards; teething problems in the introduction of the new licensing and training system must be quickly addressed.
6. Regional and General Aviation are essential national services and so the new small aircraft maintenance licensing system must be quickly finalised, to ensure a nation-wide supply of qualified staff to perform and sign off on repairs and overhaul.
7. Developing workforce capability and career paths to meet the impending maintenance skills shortfall and develop a maintenance training export industry will require:
  - The expansion of training both in the skills required to work on existing aircraft and in innovative techniques for work on next generation aircraft
  - Keeping as many as possible of the present generation of aircraft maintenance engineers productively employed, and their skills and knowledge current, until local market demand revives
  - Reforming and rebuilding MRO training to ensure that a new generation of properly qualified engineers will be available to replace the current one as it retires
  - Harmonising training and career paths across sectors (Civilian and Defence; airline and General Aviation) and between aerospace manufacturing and aviation.
8. To help develop the training capacity required to build an innovation-oriented aircraft maintenance workforce, and to ensure that maintenance training makes a significant contribution to Australia's education exports, a National Aerospace/Aviation College (NAAC) should be established, with nationally-networked branches in each state and territory. It would draw on the combined resources of the university and TAFE sectors, gain recognition as Part 147 category Maintenance Training Organisation, a Registered Training Organisation and a nationally registered higher education provider, and have support from aerospace and aviation industry employers for the in-depth provision of practical skills training and experience.
9. A national Aircraft Manufacturing/ Maintenance Industry Forum or Working Group needs to be established to advise on planning towards achieving these goals.

For recommendations, see pages xv to xviii.



## Executive Summary – more detail

### The Australian aircraft maintenance industry: Structure and trends

1. The aircraft maintenance industry as a whole has been subject to significant restructuring, the most important aspects of which have been an increase in outsourcing and offshoring – particularly of labour-intensive heavy maintenance of wide-bodied aircraft.
2. Global third party maintenance, repair and overhaul (MRO) has grown into a AUD 84.4 billion industry. Its cumulative annual growth rate (CAGR) is expected to be 4.1% over next 10 years, taking it past \$AU 100 billion around 2024.
3. Aircraft maintenance is classified into line, heavy, engine and components. While on average labour accounts for 70% of the cost of maintenance, the labour component of line maintenance is 75%; heavy is 55%, engine is 9%.
4. The aircraft maintenance industry is embedded in both the airline industry and the aerospace industry. Line maintenance is dominated by airlines. Half of heavy maintenance is still performed in-house by airlines, while original equipment manufacturers (OEMs) are already dominant in engines and increasingly offering “whole of life” maintenance plans for their products – including whole planes.
5. In addition, there are approximately 350 independent MROs in the domestic and general aviation (GA) sectors and a significant range of civilian Defence contractors, specialised aerospace manufacturing suppliers and firms providing professional services such as modification design, testing and maintenance auditing services.
6. Most of the international fleet is not old, and although the majority is maintained overseas, a significant portion of it is still maintained domestically.
  - There remains capacity for heavy maintenance of large aircraft that could be reactivated, for example hangar space in Melbourne
  - Most of the small plane fleet is very old (67% older than 21 years), and not technically complex. However, a significant portion of small aircraft is less than 10 years old, and some small planes are retrofitted with advanced systems
  - Thus, size is not an infallible proxy for technical complexity, and this poses challenges for licensing and training alike, demanding maximum flexibility in qualifications, skill sets, and group and type ratings.
7. About half of single aisle domestic commuting aircraft are currently maintained domestically, while heavy maintenance of the rest is offshored but could be repatriated.
8. Aircraft used for regional Regular Public Transport (RPT) are maintained domestically, and this maintenance sector is ripe for expansion.
9. The large GA sector is critical to work across primary industry, tourism, scientific work, surveillance, freight and essential services, requiring geographically dispersed maintenance and maintenance approval services.
10. The aircraft maintenance workforce is difficult to measure, with the last reliable estimate (2011 Census) being 14,489 aircraft maintenance engineers (AMEs), spread across the defence and civilian sector.
11. A number of factors make the further development of an onshore maintenance industry achievable:

- Onshoring will be facilitated technically by the changing nature of both line and heavy maintenance requirements for next-generation wide-bodied aircraft
  - Major OEM subsidiaries have a significant footprint in Australia, and there is significant number of innovative Australian aerospace manufacturing suppliers
  - A330 maintenance capacity has been kept onshore and provides a useful platform for maintaining the A380 subsequently, as global maintenance skill shortages emerge
  - Australia could capitalise on the convergence between Defence and civilian aviation in usage of aircraft types.
12. Airports, with government support, have an excellent opportunity to take the initiative in making Australia a regional service training hub for heavy maintenance and aircraft on the ground (AOG) work in the emerging and maturing helicopter, regional jet and business jet markets.

### **Safety oversight and offshoring**

13. Risk is a combination of the likelihood that something will go wrong and the consequences if it does. Statistically, main-route passenger aviation today is by far the safest of all modes of travel, but the low probability of having an accident is balanced by the high impact of those accidents which still occur
- In the post-war period, the numbers of fatalities rose till 1980, then began a slow decline to the present low incidence – despite the very large increase in the volume of air travel
  - However, substantial risk still does exist. The Australian Transport Safety Bureau (ATSB) reports a 90% rise in “incidents” in commercial aviation, and a 135% rise over the decade for high capacity RPT
  - In RPT accidents, 70% of passengers die.
14. The accident rate for GA and charter has risen to three times that of RPT in 2011. Rotary wing aircraft in turn have a higher rate than fixed
- The rate of “serious incidents” (i.e. near misses) in GA is increasing
  - This increase could reflect factors specific to Australia, given that the corresponding rates in the US are decreasing.
15. Between 8–10% of accidents and incidents are related to maintenance, and its contribution to accidents involving particular systems is higher – for example, maintenance is a direct contributory factor in 30%, and a latent factor in 23%, of accidents involving landing gear failure.
- Accidents usually have multiple causes, including “latent” factors such as poor training, procedures and supervision
  - There is evidence of an increase in maintenance related accidents
  - Because of the relatively low rates of accidents, one of the greatest risks is complacency, and the tendency to emphasise commercial over safety considerations
  - The example of an aircraft breaking up 20 years after a poorly repaired tailstrike illustrates that to prevent accident preconditions “lining up”, no legally required safety check can be dismissed as “redundant” or “gold-plating”.

16. Outsourcing increases risk, which derives from the need to coordinate across multiple organisations in a supply chain. Known risk factors – are
  - Organisational and cultural dysfunction (the “Pressure, Disorganisation, Regulatory Failure” thesis)
  - Work intensification and long working hours; use of unqualified and inadequately trained workers; use of unauthorised or “rogue” parts which have not been properly checked; longer intervals between checks
  - “Overreaching” – growth of demand for air travel, and production of aircraft, raises demand for maintenance, which depends on a supply of trained and licensed engineers and this may not always be met.
17. Evidence is provided in Chapters 6 and 7 that we cannot be confident in the safety oversight and hence in the work quality of all offshored maintenance:
  - The air operator gives up much of the control over the maintenance of its planes
  - Outsourcing creates a number of “agency” problems, endemic to contractual and time-bound and time-pressured arrangements. These can cause under- or over-servicing
  - Much of our evidence of quality problems in some offshore maintenance facilities used by some Australian airlines came from teams of inspectors who were sent over with the “first wave” of offshoring (2006–09) — eg “scribe lines” (small scratches that can become cracks) — but no longer carry out that function
  - There appears to have been a declining presence over time of CASA (Civil Aviation Safety Authority) inspectors on the shopfloor of overseas MROs.
18. The 2014 Aviation Safety Regulation Review (ASRR) expressed concern about CASA’s domestic safety oversight, but omitted to investigate the regulation of offshore maintenance:
  - ASRR noted a worldwide shift in the nature of safety oversight and inspection from direct inspection of workplace processes and systems, to the documentation of process and auditing of workplaces’ safety management systems
  - The International Air Transport Association (IATA) also noted this trend with concern in its 2013 Safety Report, which insists that *MRO certification is not a guarantee of work quality*
  - ASRR advocated a “trust but verify” approach — but CASA may be trusting too much and verifying too little
  - It is now difficult to have confidence in the international system of safety oversight based on the 1944 Chicago Convention.
19. The various arms of International Civil Aviation Organisation (ICAO) regulation are somewhat at cross-purposes, producing a “regulatory tangle” with some lack of clarity as to who bears the responsibility for regulatory oversight of offshored maintenance:
  - Article 31 and Annex 8 affirm that the safety oversight of offshored maintenance is the responsibility of the state of registry, yet Article 33 of the Convention allows, or arguably even requires, each country to accept the regulatory arrangements of another country – provided they meet or exceed ICAO minimum standards
  - Article 33 and Article 31 rely on the Universal Safety Oversight Audit Program (USOAP), based on ICAO inspection and rating of member countries’ compliance with ICAO standards, and their ability to ensure safety oversight, but since 2009, the

USOAP has been replaced by a “continuous monitoring approach”. (Australia was last audited in 2008.)

20. There are thus issues requiring resolution in the current trend to cede the safety oversight of Australian registered planes to the national aviation authorities of another country, including through Bilateral Aviation Safety Agreements (BASAs):
- According to ICAO, CASA is responsible for the safety oversight of offshored maintenance. Yet CASA also effectively devolves “offshore” its responsibility for oversight and Parts 42 and 145 of the new Civil Aviation Safety Regulations (CASR) assume that the offshore approval process is identical with the onshore one
  - In response to concerns about the safety of offshored maintenance, the US Federal Aviation Administration (FAA) has intensified safety oversight of offshored facilities. Australia does not appear to be following suit
  - If CASA is going to approve overseas facilities, it needs to rely on its own inspectors. There is a need to intensify the inspections of offshore maintenance facilities. Yet, as the recent Aviation Safety Regulation Review found, the training of CASA’s inspectors in latest safety management systems (SMS) auditing techniques is lacking.

### **The Civil Aviation Safety Regulations (CASR) suite of maintenance regulations**

21. The new “suite of maintenance regulations” – the CASRs 42, 66, 145 and 147 – have introduced potential safety risks that need to be addressed. In particular it will be important to:
- Ensure clarity around the certifying role of the LAME, by removing use of ambiguous terms like “certifying employee”
  - Prevent shifting risk from CASA to other actors in the aviation system – notably training providers and employers.
22. There is a need to safeguard the status of licensed aircraft maintenance engineers (LAMEs) under ICAO Annex One, as agents of the state, fulfilling a socially protective role, where this comes into tension with their obligations to their employer. This tension may involve disagreement over when an aircraft is “safe to depart”, or when an imperfection becomes a defect:
- The new CASRs seek to implement a version of the EASA system. But the EASA system is designed to “paper over” tensions between conflicting approaches to “sign off”. Some constituent countries prefer a company-approval system, rather than a state-based licensing system. Ambiguities allowing for both remain in the regulations, and some of these have been reproduced in the CASRs
  - ICAO Annex One makes it clear, however, that the role of the licence holder is to certify for the safety of stages of maintenance, as well as to release the plane to service following maintenance
  - To the extent that Annex One allows for an alternative “company approval” system (with no license) this is permissible only where “certifying employees” hold qualifications and experience equivalent (to the Annex One licence holder)
23. The new part 66 licensing structure replaces a system that suited Australia’s circumstances (especially the way in which it provided for career mobility across the GA and RPT sectors) with one based on the system developed by the European Aviation



Safety Agency (EASA), but which also departs from it in significant respects. The following discrepancies need to be resolved:

- EASA B licenses require Diploma level qualifications – Australia’s former CAR31 regulations set AME qualifications at Certificate IV level, supplemented by targeted category knowledge and type training
  - Controversially, a new category “A” licence holder qualified at Certificate II level, can perform limited tasks in line maintenance, and release a plane to service. In Australia, the Category A licence is attainable at a far lower level of training and experience than in other “best practice” countries, notably the UK. It may not be ICAO compliant
  - Part 42 requires a new organisational form, the Continuing Airworthiness Management Organisation (CAMO), to plan maintenance work for the part 145 organisations which perform it. While it is designed to ensure clear lines of safety accountability in which responsibility cannot be delegated, some concern has been expressed that in practice there may be increased risk of miscommunication across organisational silos.
24. CASR Part 145 requires organisations to assume greater responsibility than before for the competence of their AMEs, potentially sharing liability for licenses and qualifications. Company approvals are not transferable:
- Clarification is required to ensure that these requirements do not undermine the responsibilities of LAMEs in a way that may compromise safety.
25. The new system gave rise to many transitional problems, including lack of clarity around licence privileges: resolution of remaining issues must be a priority:
- Many holders of the new licences have faced “exclusions” – their licences were deemed “partial”
  - Initially, licences were not recognised overseas, even in Europe. To gain full B level licences, licence holders have had to undergo further training and/or assessment, often very costly and involving travel
  - One consequence has been difficulty, during the transition period in securing overseas recognition for Australian qualifications and licenses.
26. EASA B licences apply to the large planes in the RPT sector. A separate licence was thought to be needed for the small plane GA sector. Defining the structure of this licence has been a perennial problem, including for EASA itself, which has not resolved the issue:
- The present proposal for a Small Airplane Licence (SAL), underpinned by a Certificate IV qualification, would divide the occupation into two sectors and impede mobility. It is based on a presumed equivalence between size and complexity that does not hold, in that some small planes are, or have, technically complex systems suitable for type ratings.
27. Qualifications underpinning the career path should provide flexibility to
- Enable work and sign off on small, non-complex aircraft (suited to the group system) but also small aircraft with technically complex systems more suited to type ratings
  - Enable smooth progression from Certificate IV to Diploma, with appropriate prior standing

- Allow the addition of SAL as a category rating to a B licence, in a way similar to the former CAR30 Group system.
28. The ASRR recommends that the CASR 1998 regulations be re-written in a plain language “third tier”. The very act of doing so would force to the surface the lack of clarity in the regulation.

## Training

29. An emerging global shortfall of appropriately trained and licensed engineers means that Australia will have to rely on its own capacity to meet this need.
30. In Australia, training capacity has declined below its replacement level:
- The numbers in training in 2013–14 were the lowest since statistics have been available
31. The introduction of the new licensing system has imposed a load on the training system:
- The qualification required for a B licence is now a Diploma (formerly it was a Certificate IV). But state governments almost uniformly have refused to fund the 1000 hours difference between the Certificate IV and the Diploma, or even to fund the cost of exclusion removal training and assessment
  - Only 176 commenced a Diploma in 2012–14, and only 39 had completed, with 37 still in training. 97.6% of apprentices are studying for Certificate IV.
32. Aircraft maintenance licensing training is regulated by CASA (under CASR part 147) as well as by ASQA (the Australian Skills Quality Authority). It is subject to regulations that sometimes conflict. Type training is performed in part 147 organisations, and is not regulated by ASQA.
- ASQA, requires “mutual recognition” – a RTO must recognise qualifications issued by another RTO. This cuts across CASA’s requirement that only part 147 organisations deliver competencies for licensing purposes
  - According to the CASR Part 66 Manual of Standards (MOS), the pass mark for category modules must be 75%, yet “mutual recognition” requires that RTOs/MTOs grant prior standing to certificates of attainment from non Part 147 organisations (which can have a pass mark of 50%).
  - Competency based training (CBT) as the central “language of capability” in the Australian Training System has been variously interpreted. The issue has been particularly acute in developing and assessing paraprofessional and technician level skills, such as those required for the B licence
  - For units of competence requiring knowledge and diagnostic skills beyond trade level, such as those covering advanced troubleshooting, there is a need to specify the high-level theory required, and to ensure adequate training in and assessment of diagnostic skills
  - Because CBT specifies performance standards and assessment criteria, its role is not to mandate training curriculum. The relevant Industry Skills Council has provided guidance material on curriculum content and advisory material on how to set up assessments, for example of the performance of diagnostic tasks that require the application of advanced theoretical understanding. But the use of such material is not mandatory.

- It has been difficult to date to ensure compatibility across RTOs/MTOs in achieving the common standard of theoretical knowledge specified in the CASA syllabus (Part 66 MOS) as overlaying each unit of competency.
- 33. The training and licensing system should accommodate Defence as well as Civilian personnel – Defence personnel usually work on different aircraft, and have different sign off procedures which do not involve licensing or require a Diploma:
  - Before the 1990s, there were five aircraft maintenance trades. After a “reform” process, there were three, and a common non-competency-based curriculum (NAC95) across Defence and Civilian training.
- 34. The ICAO Training Manual has been the basis for international standards around training, and it contains – specified in detail – knowledge, skill and experience requirements, complete with levels of proficiency and numbers of training hours deemed necessary to attain them. Australian training appears to be falling short of the requirements specified in the ICAO training manual as well as in EASA regulation.
  - Funded hours sometimes fall short of ICAO as well as EASA requirements
  - Some training providers question the effectiveness of the encoding of theoretical material in competency standards, and efforts to do require the support of guaranteed hours and curriculum and assessment resource materials, aligned to European approaches to competence
  - There appears to be a trend to neglecting experience for licensing purposes – with experience rolled into the overall assessment of “competence”.
- 35. International aviation training, including maintenance, appears to be in the midst of considerable reform – ICAO’s “Next Generation of Aviation Professionals” (NGAP) program is an example. Although this program uses the terminology of CBT, it means something different by the term – notably, a complete “training process” as specified by Instructional Systems Design (ISD) methodology.
- 36. Currently there is a process of reform in the Australian training system. The possibilities this raises for progressive reform should be seized.

### **Australia and the emerging MRO skills shortage**

- 37. Authoritative international sources – IATA, ICAO, Boeing, CAVOK – make clear that the aviation world is heading into a global crisis in the supply of skilled and licensed personnel. This will make it difficult if not impossible to keep up current standards of maintenance on its fleet.
- 38. Calculations of shortfall have been made for this study, based on the following assumptions:
  - Each region roughly maintains its own fleet
  - A 1:3 ratio of “certificated” (i.e. licensed) AMEs to non-certificated ones
  - 12–14 AMEs per plane across most regions
  - Any significant reduction in total maintenance demand from addition of more technically advanced planes is a decade off.
- 39. The world maintenance workforce in twenty years’ time will need to be around twice the number employed in the base year for each set of forecasts.

40. Virtually all of this workforce – not just the net increase – will need to be recruited and trained from scratch over this period. There is therefore a need for regions to upgrade their training systems to increase output.
41. The biggest shortfalls are expected to arise in precisely those parts of the world (Southeast Asia) to which Australian carriers are increasingly turning to meet their maintenance requirements. This is already happening.
42. Shortages of skilled labour in these regions will necessarily affect both their capacity to take in work from countries like Australia, and the prices they will be able to charge in what will progressively become a seller's market – as well as potentially the quality of that work.
  - In the medium term, this is bound to mean a compression of the cost differential between performing maintenance in Australia and outsourcing it; eventually it could undermine much of the economic case for offshoring Australian work
  - It could also force Australian airlines to offshore work to “second tier” MRO suppliers of dubious quality, if Australia lacked its own capacity.
43. Australia will face a genuine threat to the safety of its domestic aviation unless it is able to rebuild sufficient capacity to handle at least a reasonable proportion of the work which has been lost overseas.
44. Can Australia make up the gap? There are no official forecasts. Nevertheless:
  - An examination of the training sector's performance in the last 5 years indicates that swift turn-around action is required
  - There has been a recent severe decline in training activity and output relative to historical levels: for the March quarter the number of commencements in 2014 was the lowest this century and the third-lowest in the 20 years for which statistics are available
  - Yet it seems inevitable that Australia will eventually have to take back a significant part of the maintenance load which is currently either already offshore, or in the process of being moved offshore.
45. Australia still could regain a substantial slice of work currently done overseas. However, doing so would require a coordinated strategy that included:
  - Combining the capabilities of civilian and defence training facilities
  - Managing the level of wastage within the civilian training system
  - Serious investment in new training and retraining.
46. If Australia is to be in a position to seize the opportunities offered by the skills crisis, a major effort will need to be made now.

### **Aircraft maintenance — Future role in regional development, trade, security and innovation**

47. Overseas studies of the economic impact of the aviation industry, based variously on the impact of airports, of new manufacturing and maintenance facilities, and of the General Aviation sector, typically indicate that:

- Each new job creates up to three other jobs, and each dollar of output creates two more dollars' worth of output elsewhere in the economy. Conversely, the scaling back of operations has a commensurate negative ripple effect
  - Government subsidisation of new airports or manufacturing/maintenance facilities, through infrastructure and incentives, is more than returned in tax revenue.
48. Investment in new aircraft maintenance capacity, as an integral part of investment in the development of the aviation and aerospace industries, will yield four sets of benefits:
- *Regional development:* regional economies will be stimulated, the viability of smaller regional centres will be restored, and essential services and supply lines to remote communities will be kept intact
  - *Economic development and trade:* Australia's national income can gain greatly through maintenance self-sufficiency and through export of MRO training and services. A range of OEMs are using Australia as the lynchpin of their operations in the world's fastest-growing aviation sector. There are significant new niches into which Australian maintenance can move, including technology diagnostics and aircraft on ground services; advanced manufacturing and precision engineering supply chains; maintenance and upgrades of fleets including helicopters, business jets and very fast turboprops for the emerging Asia-Pacific market
  - *National security:* Civilian contractors to the Australian Defence Forces play a key role at the developmental and non-routine end of MRO work, in the continuum between MRO, OEM and Tier 1/Nadcap accredited supply chain work. Defence project work fosters the development of specialist and innovative techniques, enhancing national technological self-sufficiency
  - *Innovation:* In the new relationship among air operators, OEMs and MROs, Australia can capitalise on the nimbleness offered by integrating R&D, manufacturing, and afterservice maintenance in a design/make/deliver/ maintain/repair/recycle model. In fields such as automation/robotics, "big data" management, biomaterials, nanotechnology, molecular precision, flexible fabrics, and the creation of light cheap high quality parts, Australia potentially has a strong role in the Asian century.
49. The interconnections between aviation and aerospace tend to be based on the role of airports as hubs of maintenance activity, linked to clusters of surrounding manufacturing activity, which in turn are integrated into national, Asia-Pacific and in some cases global aviation/aerospace supply chain networks:
- The relationship between Williamstown and Hurnetnet is an example of a collaboration between state and local government, airlines and the RAAF. Significant regional multiplier effects have been traced to the network of small and medium engineering and technology firms supplying MRO operations. Innovation stimulus includes a program to promote STEM study in local schools
  - The Queensland government has actively promoted that state as an aviation hub. The Brisbane Airport Master Plan provides for expanded maintenance facilities and maintenance training, with State government funding support. As well, the Queensland Government has promoted regional aviation/MRO clusters, for example the joint Defence/civil facility at Townsville, and the Asia-Pacific market oriented Australasian Aviation Group – Cairns (AAG-C)
  - Both Victoria and South Australia have specialised civilian/Defence supply networks based on advanced manufacturing, while Melbourne houses the large OEM-linked Boeing Aerospace Component Repairs facility

- Badgerys Creek offers the opportunity for developing state-of-the-art MRO capacity, linked to nearly civilian and Defence facilities and based on a Western and Southwestern Sydney network of over 100 aviation and aerospace-linked firms and OEM branch offices. These include Airbus Defence/civilian maintenance activity
- A more sustained national approach however is required, to meet emerging opportunities in the Asia-Pacific region. It will be necessary to build on emerging hubs, clusters and supply chain networks, draw in under-utilised infrastructure and workforce capability, and create new capacity.

## **A way forward**

50. In order to turn the impending shortfall of skilled aircraft maintenance engineers into an industry development and export opportunity, all sectors of the aviation and aerospace industry need to be engaged in a conversation to develop a Strategic Aircraft Manufacturing/Maintenance Industry and Workforce Development Plan, covering all civilian and Defence aviation sectors, and innovative manufacturers. Most immediately, strategies are required for:
- Rebuilding sufficient domestic MRO capacity by 2020 to permit Australia to handle a high proportion of its own requirements
  - Establishing a system of quality control safeguards adequate to guarantee that maintenance on Australian aircraft, whether done in Australia or elsewhere, is carried out to best international safety standards
  - Ensuring that as many as possible of the present generation of L/AMEs remain productively employed, and their skills and knowledge are kept current, until such time as market demand revives in Australia.
- More generally and in the longer term, planning needs to address approaches to:
- Building a new domestic MRO industry capable of competing aggressively in the highest-value niches of the global market
  - Reforming and rebuilding MRO training to ensure that a new generation of properly qualified L/AMEs will be available to replace the current one as it retires
  - Developing the interface between the aviation, aerospace and MRO industries , and between civil and Defence aviation maintenance, in order to facilitate the transfer of technical innovation
  - Building a leading role for the Australian maintenance industry in aviation and aerospace innovation, globally and in the Asia-Pacific region.
51. To develop a strategy for the future of the industry an **Aircraft Manufacturing/Maintenance Forum or Working Group**, should be established. It should receive seed funding from, for example, the Industry Skills Fund, and government funded secretarial support:
- The Forum should include employer and employee organisation representatives from the following sectors: air operators, independent MROs, manufacturers of aircraft systems/components, and aeroskills training providers, as well as representation from Australian Defence Force aviation. It is also important that small and medium enterprises, whether innovative manufacturers or GA MROs, be well-represented
  - Such a body should serve as a consultative planning mechanism, identifying needs and avenues for future aerospace/MRO industry. It should interface closely with the

new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established

- Its role would include the monitoring of emerging workforce development needs, and skills planning, for new intakes, for skill upgrades and skill and career transitions in aerospace-related advanced manufacturing and engineering, aircraft maintenance and maintenance management
- The Forum should provide an umbrella for strategic planning Working Groups, whose priority task would be to build a multi-faceted but integrated maintenance and maintenance training capability that is both nation-wide and export-oriented
- The Forum should also function as a clearing-house for information of strategic importance to workforce development.

52. One approach to providing the training capacity to rebuild national aeroskills and career paths, and to ensure that maintenance training makes a significant contribution to Australia's education exports, would be to establish a **National Aviation/Aerospace College (NAAC)**:

- This National College should consist of networked local branches in each state and territory and draw on the combined resources of the university and TAFE sectors, linking existing and new providers
- It should have recognition as Part 147 category Maintenance Training Organisation, a Registered Training Organisation, and a nationally registered Higher Education Provider
- It should provide quality-assured programs allowing for career pathing through qualification structures that provide for smooth progression between advanced manufacturing, aeroskills, licensed maintenance, engineering specialisations and maintenance management roles
- It should offer qualifications that are fully compatible with the international (EASA and NGAP) protocols, in order to attract international enrolments, playing a significant role in educational exports to meet the coming Asia-Pacific aeroskills shortfall
- It should bring together the capabilities of civilian and Defence training facilities, and make greater provision for group apprenticeships, to provide new trainees with the diversity of workplace experience needed to create the flexible and versatile workforce required by the coming decade of transition
- It will be necessary to ensure support from aerospace and aviation industry employers for intensive shopfloor practical skills training and experience.





## RECOMMENDATIONS

### Ways forward– Chapter 12

- **RECOMMENDATION 1:** That a new Aircraft Manufacturing/Maintenance Industry Advisory Forum be established, with Federal Government infrastructural support, to provide a clearing-house for industry information and to act as a participatory planning body to support the transformation of the MRO and MRO training industry, as part of the broader civilian and Defence aviation and aerospace industries.

*With membership to include representatives of the relevant civil and Defence industry sectors, CASA, Skills Service Organisations, training authorities and providers, and front-line employees, this forum be tasked with generating proposals for a coordinated approach to meeting national, rural and regional aircraft maintenance needs and to identifying areas of competitive advantage for establishing Australia as a significant exporter of specialist maintenance and maintenance training nationally and in the Asia-Pacific region.*

- **RECOMMENDATION 2:** That a priority task of the new Forum be to interface closely with the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established. One of its roles would be to facilitate a consultative process for the development of a workforce plan for the new expanded industry, including a review of current job classifications and training arrangements to facilitate mobility of skilled labour and portability of qualifications across the different sectors.

### Industry development initiatives – Chapter 11

- **RECOMMENDATION 3:** That Commonwealth and State governments and the industry (including Defence establishments and contractors) work towards a coordinated strategy, with attached incentives as appropriate, to repatriate as much as possible of the heavy maintenance currently being carried out offshore before the skills crisis begins to curtail the options.
- **RECOMMENDATION 4:** That Federal and State/Territory Governments adopt the recommendation of the 2014 NSW Parliament Legislative Council Inquiry into Regional Aviation Services, that regular passenger transport services in regional Australia be seen as an essential service, and that a dedicated grant/loan fund be established to assist local government authorities to support the consolidation of MRO services.
- **RECOMMENDATION 5:** That the Aircraft Manufacturing/Maintenance Industry Advisory Forum and those developing Airport Master Plans, including those working on the Badgerys Creek Second Sydney Airport, plan for precincts that will attract clusters of MROs, maintenance training providers and OEMs, networked to aerospace manufacturing and engineering providers.

*This will facilitate the role of airports as hubs linking air operators, MROs, research and development (R&D), advanced manufacturing and the export of maintenance training. Overseas evidence (Ch 11) suggests that multiplier and catalytic effects on local economies repay government developmental support several times over in revenue returns.*

## Regulation of offshore maintenance – Chapter 7

- **RECOMMENDATION 6:** That a review be undertaken of Australia’s safety oversight of offshored maintenance, having regard to the diminished effectiveness of the international regulatory system in detecting and discouraging unsatisfactory practices

*This review should examine the extent to which the current ICAO regulations provide clarity and certainty around the safety oversight of offshored maintenance, and should form the basis of recommendations for new quality assurance mechanisms that can be applied either within, or additional to, the current international scheme. The review should note the inconsistencies in ICAO regulation, the evident violations of good safety practice that have emerged in the course of this research, and the precedent set by the FAA in negotiating a “trust but verify” model of mutual recognition in its agreement with EASA.*

- **RECOMMENDATION 7:** That air operators increase their own safety oversight of offshored maintenance, with CASA playing a greater role in the inspection of offshored maintenance facilities to which it has issued Part 145 approvals. The increase in inspection frequency and intensity should be funded by the offshoring air operators, on a full cost-recovery basis.
- **RECOMMENDATION 8:** That CASA be required and funded to build its capacities for inspection, specifically in terms of the number of inspectors and their training in the latest auditing techniques.

## Licensing reform – Chapter 8

- **RECOMMENDATION 9:** That Australia reaffirm its commitment to state-based licensing as the most effective mechanism for ensuring independence and quality in aircraft maintenance certification, and remedy any loopholes in the existing regulation which permit its substitution by a company authorisation scheme.
- **RECOMMENDATION 10:** That the interactions between the *Fair Work Act* and the *Civil Aviation Act* be examined with a view to resolving the conflict revealed by the *Sunstate* decision in a way that safeguards the statutory independence of the licence holder.
- **RECOMMENDATION 11:** That the issue of international transferability and mutual recognition of qualifications and licences be explored and resolved at both the national and the intergovernmental level, including urgent action to ensure that Australian licences are genuinely equivalent in their knowledge content to those issued by EASA and other jurisdictions which have adopted the same model, and negotiation of bilateral recognition arrangements (with appropriate safeguards) where these do not currently exist.
- **RECOMMENDATION 12:** That the parts of the CASRs relevant to maintenance licensing be rewritten in plain language as recommended by the Aviation Safety Regulation Review, with a view to resolving ambiguities in key terms which are a potential source of confusion and/or conflict between interest groups.
- **RECOMMENDATION 13:** That the minimum qualification requirement for an A licence be set at the same minimum level as required by best-practice EASA members (i.e. Certificate III), and that this licence become part of an articulated progression of licence categories built around a common training framework and qualification structure.
- **RECOMMENDATION 14:** That the arrangements for a new small aircraft licence be finalised as quickly as possible in order to permit GA operators and MROs to recommence recruiting

for LAME vacancies, but in a way that allows a seamless pathway between small aircraft and RPT aircraft, while making provision for licensees to train in and be endorsed for new small aircraft technology as it comes into wider use.

*This should include provisions for smooth transition from Certificate IV to Diploma, group category endorsements which could be added either to a Diploma-based B licence or to a Certificate IV-based SAL, type ratings for selected small planes, and an exercise to rate all small planes (including retrofitted ones) for licensing purposes in terms of their technical characteristics and associated maintenance skill sets.*

## Training – Chapter 9

- **RECOMMENDATION 15:** That appropriate funding be made available to support exclusion removal for those partial B licence holders who wish to recover their former potential productivity by regaining a full B licence.
- **RECOMMENDATION 16:** That institutional and funding measures be put in place as a matter of urgency to ensure that the 98% of apprentices currently studying for a Certificate IV qualification have a readily accessible option on completion to upgrade to the Diploma required for a licence.
- **RECOMMENDATION 17:** That a National Aviation/Aerospace College (NAAC) be set up, drawing on the combined resources of the university and TAFE sectors, to take carriage of the training of Australia's aircraft maintenance engineers, to provide career paths to and from advanced aerospace manufacturing - and to provide a commercially attractive vehicle for an export industry in aircraft maintenance training and qualifications.

*That this College consist of nationally-networked local branches in each state and territory, including both civil and Defence aviation education and training providers, and gain recognition as a Part 147 category Maintenance Training Organisation, a Registered Training Organisation and a nationally registered higher education provider. It will be necessary to ensure support from aerospace and aviation industry employers for a new model of shopfloor practical skills training and experience.*

- **RECOMMENDATION 18:** That the training structure for AMEs be redesigned to provide for:
  - A curriculum-based approach which is compatible with the international (EASA and NGAP) protocols and reflects the work already done in Australia on a common civilian/defence syllabus;
  - Expert and independent oversight/moderation of the assessment process; and
  - Closing the current loophole in the VET regulations that allows non-category training to provide prior standing for category training.

*Pending the establishment of the NAAC, that the current constraints of the VET framework be relaxed for this occupation to the extent required to make these reforms possible, in recognition of the major public safety implications of having a properly qualified aircraft maintenance workforce.*

- **RECOMMENDATION 19:** That the training package be reviewed to create a broader base of capabilities (possibly based on a common first year) allowing trainees to specialise in either traditional MRO or the expanded industry, as well as providing avenues for early-career AMEs who find themselves temporarily surplus to requirements to move into related occupations (e.g. automotive mechanics or aluminium shipbuilding) with minimal retraining.

## **Addressing the coming maintenance workforce shortfall – Chapter 10**

- **RECOMMENDATION 20:** That an emergency initiative be funded to restore the number of apprentices in aircraft maintenance engineering at least up to replacement level.
- **RECOMMENDATION 21:** That in view of the near certainty that the world faces a serious shortage of qualified aircraft maintenance engineers, the occupation be restored immediately to the Skilled Occupations List.
- **RECOMMENDATION 22:** That immediate action be undertaken to identify the reasons behind the current level of wastage within the civilian training system and increase the rate of on-time completion.
- **RECOMMENDATION 23:** That incentives be provided to airlines and MRO providers to retain experienced L/AMEs in productive employment, pending a spontaneous recovery of the labour market, in order that Australia should continue to have a basis of expertise for training and mentoring the next generation of skilled workers.

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## Abbreviations

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|        |  |
|--------|--|
| AAG-C  | Australasian Aviation Group - Cairns                             |
| ABC    | Australian Broadcasting Corporation                              |
| ABS    | Australian Bureau of Statistics                                  |
| ACT    | Australian Capital Territory                                     |
| ADDIE  | Analysis, design, development, implementation and evaluation     |
| ADF    | Australian Defence Force   |
| AEI    | Air Engineers International                                      |
| AHMS   | Australian health monitoring systems                             |
| AIU    | Airline Industry Update  |
| ALAEA  | Australian Licensed Aircraft Engineers Association               |
| AMC    | Acceptable Means of Compliance                                   |
| AME    | Aircraft maintenance engineer                                    |
| AMO    | Approved maintenance organisation                                |
| AMROBA | Aviation Maintenance Repair and Overhaul Business Association    |
| ANAO   | Australian National Audit Office                                 |
| ANTA   | Australian National Training Authority                           |
| ANZSCO | Australia and New Zealand Standard Classification of Occupations |
| ANZSIC | Australia and New Zealand Standard Industry Classification       |
| AOC    | Air operator certificate   |
| AOG    | Aircraft on ground   |
| APBC   | Australia Philippines Business Council                           |
| APMA   | Australian Parts Manufacturing Approval                          |
| AQFC   | Australian Qualifications Framework Council                      |
| AQTF   | Australian Quality Training Framework                            |
| ARSA   | Aeronautical Repair Stations Association (United States)         |
| ASF    | Australian standards framework                                   |
| ASQA   | Australian Skills Quality Authority                              |
| ASRR   | Aviation Safety Regulation Review                                |
| ATC    | Air Traffic Control  |
| ATO    | Approved training organisation                                   |
| ATSB   | Australian Transport Safety Bureau                               |
| AU     | Australia  |

|          |  |
|----------|--|
| AWD      | Airworthiness Directive  |
| AWN      | Airworthiness notice   |
| AWPA     | Australian Workforce Productivity Agency                                       |
| A & P    | Airframe and powerplant  |
| BACR     | Boeing Australia Component Repairs   |
| BASA     | Bilateral aviation safety agreement  |
| BOAC     | British Overseas Airways Corporation   |
| CAA - AU | Civil Aviation Authority (Australia)   |
| CAA - UK | Civil Aviation Authority (United Kingdom)                                      |
| CAE      | Centre for adult education   |
| CAGR     | Compound annual growth rate  |
| CAMO     | Continuing airworthiness management organisation                               |
| CAR      | Civil Aviation Regulations   |
| CASA     | Civil Aviation Safety Authority (Australia)                                    |
| CASA RIS | Civil Aviation Safety Authority Regulatory Impact Statement                    |
| CASA RRP | Civil Aviation Safety Authority Regulatory Reform Program                      |
| CASR     | Civil Aviation Safety Regulations  |
| CBT      | Competency based training  |
| C-E      | Communications - Electronic Solutions  |
| CIV      | Certificate IV   |
| CLAMOR   | Coalition to Legislate Aircraft Maintenance Outsourcing Reform (United States) |
| CMA      | Continuous monitoring approach   |
| COAG     | Council of Australian Governments  |
| CRS      | Certifying for release to service  |
| DEEWR    | Department of Education, Employment and Workplace Relations                    |
| DER      | Designated Engineering Representative  |
| DIRD     | Department of Infrastructure and Regional Development                          |
| DOTARS   | Department of Transport and Regional Services                                  |
| EADS     | European Aeronautic Defence and Space Company                                  |
| EASA     | European Aviation Safety Agency  |

|       |  |
|-------|--|
| EEC   | European Economic Community                      |
| ETS   | Emissions trading scheme                         |
| EU    | European Union                                   |
| FAA   | Federal Aviation Administration (United States)  |
| FARs  | Federal Aviation Regulations (United States)     |
| FBO   | Fixed Base Operator                              |
| FIFO  | Fly in fly out                                   |
| GA    | General Aviation                                 |
| GAMA  | General Aviation Manufacturers Association       |
| GAO   | Government Accountability Office (United States) |
| GDP   | Gross domestic product                           |
| GFC   | Global Financial Crisis                          |
| HAECO | Hong Kong Aircraft Engineering Company Ltd       |
| HAESL | Hong Kong Aero Engine Services Ltd               |
| HRO   | High Reliability Organisation                    |
| IATA  | International Air Transport Association          |
| Ibid. | The same   |
| ICAO  | International Civil Aviation Organisation        |
| IFE   | In flight entertainment                          |
| IOSA  | IATA Operational Safety Audit                    |
| IR    | Industrial relations                             |
| ISC   | Industry Skills Council                          |
| ISD   | Instructional systems design                     |
| ITQI  | IATA Training and Qualification Initiative       |
| JHAS  | John Holland Aviation Services                   |
| LAME  | Licensed Aircraft Maintenance Engineer           |
| LCC   | Low cost carriers                                |
| MEA   | Manufacturing and Engineering - Aeroskills       |

|        |   |
|--------|---|
| MOS    | Manual of Standards   |
| MRO    | Maintenance Repair and/or Overhaul Organisation                                 |
| MSA    | Manufacturing Skills Australia  |
| MSD    | Multi-site fatigue damage (to an aircraft)                                      |
| MTO    | Maintenance Training Organisation   |
| MTOW   | Maximum take-off weight   |
|        |   |
| NAA    | National Aviation Authority   |
| NAC    | National Aeroskills Curriculum  |
| Nadcap | (derived from) National Aerospace and Defence Contractors Accreditation Program |
| NCO    | Non-Commissioned Officer  |
| NCVER  | National Centre for Vocational Education Research                               |
| NDI    | Non Destructive Inspection  |
| NDT    | Non Destructive Testing   |
| NGAP   | Next Generation of Aviation Professionals                                       |
| NPA    | Notice of Proposed Amendment  |
| NPRM   | Notice of Proposed Rule Making  |
| NQC    | National Qualifications Council   |
| NTB    | National Training Board   |
| NTRA   | National Training Reform Agenda   |
| NTSB   | National Transportation Safety Board (United States)                            |
| NZ     | New Zealand   |
|        |   |
| OECD   | Organisation for Economic Co-operation and Development                          |
| OEM    | Original Equipment Manufacturer   |
| OIG    | Office of the Inspector General (United States)                                 |
|        |   |
| PMA    | Parts Manufacturing Approval  |
| PNG    | Papua New Guinea  |
| PMD    | Per million departures  |
| PO     | Partner organisation  |
| PRI    | Performance Review Institute  |
| PTB    | Pacific Turbine Brisbane  |
| PwC    | PricewaterhouseCoopers  |
| R & D  | Research and Development  |

|              |  |
|--------------|--|
| RAAF         | Royal Australian Air Force   |
| RAAP         | Rural Airport Access Program   |
| RA-Aus       | Recreational Aviation Australia  |
| RIS          | Regulatory Impact Statement  |
| RO           | Research objectives  |
| RPL          | Recognition of Prior Learning  |
| RPT          | Regular Public Transport   |
| RQ           | Research question  |
| RTO          | Registered Training Organisation   |
|              |  |
| SADIG        | Sydney Aerospace and Defence Interest Group  |
| SAL          | Small aircraft licensing   |
| SAR          | Singapore Aviation Regulation  |
| SARP         | Standards and Recommended Procedures   |
| SCM          | “Swiss cheese” model   |
| SD           | Standard deviation   |
| SEWRSBERC    | Senate Employment, Workplace Relations, Small Business and Education<br>References Committee |
| SIA          | Singapore Airlines   |
| SIAEC        | SIA Engineering Company  |
| SME          | Small or medium enterprise   |
| SMS          | Safety management systems  |
| SOE          | Schedule of experience   |
| SRM          | Structural repair manual   |
| SSP          | State safety program   |
| SASCO        | ST (Singapore Technologies) Aviation Services Co.  |
| ST Aerospace | Singapore Technologies Aerospace   |
| STP          | Standardized Training Package  |
| STARCO       | Shanghai Technologies Aerospace Company Limited  |
| SWSI         | South West Sydney Institute  |
|              |  |
| TA           | Technical Agreement  |
| TAA          | Trans- Australia Airlines  |
| TAFE         | Technical and Further Education  |
| TDG          | Training development guide   |
| TSA          | Transportation Safety Administration (United States)   |

|       |  |
|-------|--|
| TWU   | Transport Workers Union of America       |
| UAV   | Unmanned aerial vehicle                  |
| US    | United States                            |
| USOAP | Universal Safety Oversight Audit Program |
| VET   | Vocational Education and Training        |
| VH-   | Australian aircraft registration prefix  |



# Chapter 1 Introduction

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## 1.1 Thematic overview

This project was conceived in 2009 to address a number of issues which had arisen as a result of recent losses of Australian aircraft maintenance jobs, particularly in the airline sector. Thus the project's first aim was:

- To estimate the short, medium and longer term supply of and demand for aircraft maintenance engineers (AMEs)<sup>1</sup> and licensed aircraft maintenance engineers (LAMEs) authorised to return planes to service after maintenance, and to identify causal factors influencing the match between requirements and supply.

The project also arose from perceived quality issues linked to maintenance carried out by offshore contractors on Australian-registered aircraft, as well as perceived weaknesses in the safety oversight system. Thus a further aim was:

- To investigate the links between offshoring and maintenance quality, including safety.
- In the years leading up to the start of the project, there had been a shortage of Australian maintenance engineers and the occupation had been a migration skill in demand. It was therefore deemed important to identify ways of guaranteeing an ongoing local supply of highly skilled AMEs and LAMEs. Retention of this workforce, once recruited, was also seen as important. The project therefore sought to explore the roles of training and licensing, workplace skill development and recognition and career-pathing in ensuring continuity of skill supply. Concurrently, the industry was experiencing a significant supply impact from a new licensing system, introduced with the stated aim of aligning Australia and European licensing standards, but accompanied by a lack of clarity in the transition. Further aims were therefore:
- To investigate AME/LAME access to skills/qualifications development and possible links to (a) safety and (b) LAME retention,
- To identify any consequences flowing out of the implementation of the new licensing scheme for aircraft maintenance engineers.

In addition, the research was intended to look ahead and identify new and as yet unexploited prospects for the growth of a viable Australian maintenance, repair and overhaul (MRO) industry. Specifically, the final objective was:

- To investigate the potential for a sustainable MRO industry and aeroskills training industry in Australia, and to estimate their benefits and the opportunity costs of not investing in them, by reference to overseas practice and taking account of Australian policy conditions.

Over the time it has taken to complete the research, the aviation industry, both in Australia and across the world, has been in a phase of particularly rapid evolution. As the research proceeded, it became obvious that the project had opened up a complex set of changes operating at the interfaces between technological advancement, regulatory reform and decay, work

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<sup>1</sup>The term "maintenance engineer" dates back to pre-war British usage, where "engineer" generally meant a trades-level worker. AMEs in Australia hold trade or more recently technician qualifications, and need to be distinguished from aeronautical and aerospace engineers, who are university-trained and play different roles in the industry.

organisation, and an unpredictably shifting political and commercial environment at both global and national levels. The technological changes alone can be expected over the next 10–15 years to produce major shifts in the structure and boundaries of the MRO industry and the nature of the work done in it, and in consequence the work of many AMEs is likely to look very different at the end of the period from the way it has up to now. We discuss this changing model of MRO in the next section.

Quite apart from the scope and diversity of the change processes involved, the pace and direction of change remained highly unpredictable through a period when the global aviation industry was subjected to major stresses, airline business models evolved rapidly, diverging and re-converging in the process, new technologies and products apparently reached the verge of commercial takeoff only to see their markets contract again in line with the unexpectedly falling price of aviation fuel, and the international regulatory model which had governed safety in commercial aviation throughout the world began to unravel. During the years in which the research was undertaken,

- Average world airline profitability fell to as low as 2.5 US cents per passenger carried and returned to 3–4 times that level;
- Australian airlines virtually abandoned the international routes to Europe which they had once pioneered, effectively outsourcing their services on these commercially important routes to much more powerful codeshare partners;
- Qantas moved within the space of little over a year from approaching the Commonwealth government for substantial financial and/or regulatory assistance to ensure its survival, through to recording a massive turnaround in profit; and
- The number of aircraft maintenance apprenticeship commencements in Australia peaked sharply in 2008 at one of its highest points ever, only to fall by 2014 to the lowest point since records have been kept.

Because of this unexpectedly complex and unpredictable environment, the main part of the report has tended to shake out into a number of more or less independent sub-reports, each likely to appeal to a different primary readership. Predictions of future developments in the industry needed to be revised several times as a result of new developments in the course of writing up the research. The report should be seen primarily as a snapshot of the industry and of its expected future development over the period when it was finalised – roughly between December 2014 and October 2015 —and as building a baseline and a justification for continuous updating through new research.

## **1.2 Towards a new MRO model**

The most visible change over the last five years is that outsourced aircraft maintenance, originally viewed within Australia purely as a cost-saving measure and a source of additional risk, now appears widespread throughout the global aviation industry. Growth in the contract MRO industry has spread across many parts of the world. It has been marked by increasing specialisation which increases its competitive edge over in-house maintenance. Only a handful of airlines still take direct responsibility for all their own maintenance, and one of the two conglomerates which currently dominate commercial passenger aviation in Australia has never had a significant onshore heavy maintenance capability.

Aircraft MRO has become a highly profitable global industry with strong growth prospects. From an Australian perspective, it has become increasingly important for local businesses to achieve competitiveness in this global industry and adapt Australia's valuable resource of world-class maintenance skills to the new business environment. What began as a threat has progressively metamorphosed into an opportunity, albeit one which will not fall easily into Australia's hands.

This is not to suggest that the dangers have been resolved, but over five years it has become possible to define them much more precisely, and above all to see that they are not linked purely to the single trend of offshore sourcing, particularly of wide-bodied aircraft maintenance.

There is a growing role for original equipment manufacturers (OEMs) in the performance of afterservice maintenance. This is associated with newer generation aircraft ranging from the B787 through to helicopters, increased reliance on software-actuated components, on composite airframe repairs and parts, and on “big data” monitoring. The two major aircraft manufacturers, several helicopter manufacturers and a range of component OEMs have a significant presence as MRO providers in Australia.

A third significant development is the emergence of a new sector of businesses, distinct from traditional MRO businesses but beginning to encroach in different ways on their role. In contrast to the traditional high-end MRO industry, which has been in decline over recent years, this new sector of high-end aviation technical support, built largely around the leading edge of advanced manufacturing, has been on a gradual if seldom-remarked growth trend. Building initially on defence contracting, it has gone on to form lasting partnerships with airframe and component OEMs, mainly through the supply of components and large component assemblies, but increasingly handling specialist types of work on aircraft in service. This new sector is described in greater detail in Chapter 3.

Taken together, these developments point to a significant shift in the way MRO is being done, and in the structure and boundaries of the industry. The shift from established practice is big enough to count as a new model of MRO. Besides being marked by greater outsourcing of maintenance work and greater specialisation, it involves a growing tendency to handle component wear and faults by replacement and off-site remanufacturing rather than by on-frame or on-wing repair. It also signals a change in the pattern of MRO work resulting from technological advances in the generation of aircraft (including light as well as large passenger aircraft) which is just beginning to come into service. These newer designs incorporate advanced self-diagnosis and self-rectification capabilities, meaning that human intervention is more likely to be needed when unanticipated faults arise in highly defended systems, as opposed to the established pattern of periodic checks at specified intervals. Simultaneously with these technological developments, a gradual shift is occurring towards all-composite airframes lacking the panel and frame joints which have been a very important source of problems and risks in heavy maintenance.<sup>2</sup>

Together, these coinciding developments mean that aircraft maintenance in future is likely to depend increasingly on high-level diagnostic skills, implying a continuation of the evolution from trades to paraprofessional status which has been in progress since the turn of the century and is reflected in the most recent reforms to maintenance licensing regulation. At the same time, the scope of MRO will need to expand to include the areas of advanced manufacturing and component supply (including component re-manufacturing) that will increasingly not only support it but supplant many of its traditional functions. This convergence suggests that we may see at least some merging of what are currently separate labour markets, with AMEs needing a skill base and a system of qualifications which allows them to move back and forth between traditional and advanced-manufacturing subsectors as the location of work moves.

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<sup>2</sup> See for example Holland and Davies, 2013.

### **1.2.1 First signs of a transition: the current Australian MRO environment**

In the airline sector, between now and 2025, the growth in demand for MRO services is projected to be distributed fairly evenly across aircraft built between 2000 and 2010, although work on aircraft built in the 1990s will also continue to grow. The highest volume of MRO work is projected to remain with A320 and B737 aircraft. At present, about half the Australian fleet of these aircraft is maintained onshore, with scope for this proportion to increase. This work is done in-house by air operators, or through tied contractors, or particularly in the case of off-wing components, through independent MROs, including specialists. Contractual arrangements are increasingly varied. Air operators may sign maintenance contracts with independent MROs or with other air operators. Independent MROs may specialise, either in components such as engines or avionics, or in repainting or refurbishment. Alternatively, they may specialise in an aircraft type: A320 and B737 specialists are seen as having good prospects over the coming decade. Increasingly also, MROs are working across the Defence/civilian aircraft divide.

Australia, like most developed nations, is heavily dependent on air transport for a number of functions essential to life in a civilised society. Regional regular public transport (RPT) is increasingly provided by subsidiaries of the major airlines; other regional and rural operators and airports have been struggling for viability, and the peaking of the mining boom will put pressure on fly-in-fly-out (FIFO) services. The aircraft which make up the irregular public transport sector and those in Australia's large general aviation (GA) sector, are maintained in a domestic maintenance industry. This sector too has afterservice tie-ins with smaller aircraft and component OEMs, linking it into global manufacturing and distribution networks. Yet particularly for providers of MRO services to charter operators seeking to meet gaps in low-volume RPT provision, support is needed in gaining accreditation as approved maintenance organisations.

The diverse GA sector, comprising domestic low-capacity regular and irregular public transport at one end, and embracing a whole range of vital public service functions such as the Flying Doctor Service, firefighting, aerial surveillance, search and rescue, aerial work and policing at the other, makes an essential contribution to the economy. These functions could not easily be substituted by any other means, and for just that reason the industry needs to be adequately resourced and built up in pace with national economic growth. MROs servicing the sector need support, particularly in securing local LAMEs and in maintaining currency of training.

One of the key challenges coming out of this project is the need to identify innovative measures to manage the sector as a whole, to ensure its continuing growth and contribution to the Australian economy, and to expand its innovative and technological capacity.

## **1.3 Key findings**

For the purpose of introducing our findings, we summarise them below. Each of the statements made below is backed by comprehensive and detailed evidence in Chapters 2 to 11.

### **1.3.1 Is there a future for aircraft maintenance in Australia?**

A key research finding is that there can be a good future for an Australian MRO industry, provided the right settings and incentives exist. In a very competitive global market, Australia has many of the prerequisites to play a significant Asia-Pacific role, as well as to meet its own domestic needs. Its advantages start with a stock of highly skilled maintenance engineers — a major asset at a time when many nations — notably those whose domestic aviation markets are growing fastest — are struggling to find the specialised labour supply they require. This advantage is backed up by world-standard professional education in aerospace engineering, an innovative if steadily declining research capacity, a small but impressively capable set of advanced manufacturing firms and MRO businesses, and a production workforce with leading-

edge manufacturing experience, mainly in the automotive and component industries, which is or soon will be in search of new employment opportunities.

The Australian aerospace industry, though small by international standards, is already well regarded by the world's largest aircraft and component manufacturers. The experience gained through Defence contracts, and particularly through widespread participation in the supply and production chains of major aerospace companies, as well as the F-35 Joint Strike Fighter (for which Australia has been designated as the heavy maintenance hub for the South Pacific), has left Australia with a nucleus of manufacturing suppliers who are well used to meeting the demanding requirements of OEMs operating at the leading edge of aviation technology. Australia accounts for a larger proportion of Boeing's outsourced production than any other country outside the United States (US). This advantage will become increasingly important in the MRO field as OEMs become steadily more involved in maintenance, or integrated supply-maintenance arrangements.

For some time, it has been alleged that Australia has lost its competitiveness in MRO because of its relatively high labour costs. In practice, this disadvantage has often been less pronounced than it initially appeared, allowing for the trade-off between price and productivity and the impact of reworking on the total maintenance budget. But in any case, it is a disadvantage which is likely to diminish quickly over the next ten years as the world moves into a major shortage of aircraft maintenance skills. In what will increasingly become a seller's market, people with the appropriate skill sets should be able to command wage rates which move steadily closer to those in Australia, even in those countries which have previously relied on low labour costs for their competitiveness in the global MRO market. Already a number of the better-known outsourced providers in low-cost countries have needed to buy into established MROs in industrialised countries in order to get the capability they need to meet their expansion plans. As fleets grow and labour supply remains constrained, it is likely that nations in the region will start to find Australia an unexpectedly attractive option to meet at least their more technically demanding maintenance needs.

Australia, like any other nation entering a globalised market, needs to specialise in its areas of strength. It will need to find and target niche activities which require advanced skills and advanced technological solutions, and where the criticality and value of the work are such that price is a secondary consideration. As noted in the last section, the most promising of these are likely to involve a convergence between maintenance as typically understood, and the areas of advanced manufacturing which offer the combination of a product and a service. This is not to understate the ongoing importance of the everyday work of aircraft maintenance, in particular in areas of work that enjoy a measure of natural protection from overseas competition – in that their aircraft are both too small to fly overseas – and are crucial to civilised life in Australia.

But it should not be assumed that the transition to a new industry model will come about automatically. Such radical transitions seldom occur, especially in mature industries, without coordination and support from governments. The shift will require a significant restructuring of the industry and the labour market, involving the emergence of new firms and occupational groupings and the disappearance or significant resizing of others. But it is difficult for this to happen purely through the operation of markets. European governments have a stake in a number of the aerospace organisations currently establishing a regional footprint in Australia – Airbus/EADS, Safran, Thales, Finnmeccanica SpA and RUAG, to name but five. In the US, the State of Georgia's infrastructural and tax support for Gulfstream's Savannah Airport manufacturing and maintenance centre has continued to provide multiplier employment and revenue benefits.

A serious and pressing threat is that the key resource on which Australia relies for its competitiveness could easily be dissipated over the next few years. Employment in MRO, particularly at the most skilled end, has been in decline ever since the last Census, with some

annual estimates putting the rate of attrition at over 20%. Unless these retrenched employees get the opportunity to continue exercising their skills, those skills will surely decay, and just as importantly, will lose currency as new generations of aircraft come into use at the most profitable end of the market. Meanwhile training of the next generation of AMEs remains at well below replacement rate (particularly if Defence is excluded from the calculations). A number of the Technical and Further Education (TAFE) institutes which had gained international reputations for the quality of their aircraft maintenance training have either discontinued or seriously curtailed their programs. Without a major effort to upgrade training, the supply of qualified entrants to the workforce might well have dried up by the time when the world shortage is at its most acute and demand recovers spontaneously.

### **1.3.2 Do safety problems still exist for Australian aviation?**

Looking only at the accident statistics for main-route passenger fleet, it would be easy enough to conclude that flying has ceased to be dangerous. Statistically, flying is by far the safest mode of travel, and has been for a very long time. The world accident rate for this segment has fallen to somewhere between three and two accidents per million departures over the last ten years, with a slightly declining trend; in Australia, the level has been around the same, albeit with a very slight rise. Generally speaking, though, the number of accidents recorded in each year is so small that any remaining variation has to be treated as random in statistical terms, and this is even truer for fatal accidents. Moreover, the accident rate has remained relatively stable since the 1990s. A recent study by the United Kingdom (UK) Civil Aviation Authority (CAA) calculated that the average passenger in a jet aircraft in our region would have to fly over 5 million times, or once a day for almost 15,000 years, to reach statistical probability of being killed in a crash.

However, some worrying indications remain. The same study revealed that across the world, the average fatal crash cost 70% of the lives on board, and the two highly publicised disasters in 2014 (neither of which appears to have been an accident in the strict sense) demonstrated how easily hundreds of lives can be lost at a time. While it would be premature to read much into the slight rise in the trend for accidents in Australia since 2002, there is some cause for concern in the fact that reports of “incidents” to the safety authority in Australia over the last decade have risen almost twice as fast as the number of kilometres flown. And since all experts agree that new passenger planes have become significantly safer in the last two decades, it seems somewhat puzzling that the fatal accident rate has not fallen more noticeably over that period.

Other evidence suggests that the sustained low rate of fatal accidents may have led to some complacency, particularly among airline managements faced with a very difficult competitive environment where there has been increasing pressure to trade off safety margins against operating profit. Recent statements by airline representatives, following incidents that have involved obvious and severe risk to the safety of passengers, even suggest a level of denial. More generally, evidence across a range of activities (including manufacturing standards, aircrew vigilance and separation management) suggests a gradual slackening of safety cultures in aviation as a whole.

An important aspect of this declining safety culture, particularly relevant to maintenance, is a reliance on technological redundancy as a risk management strategy. Modern aircraft are very unlikely to crash, largely because in each area of risk, a number of redundant measures are in place to contain the likelihood of a mistake developing into an accident. This multiple defence against system failure does not mean that it is unimportant if an individual mistake occurs or an individual step in the process is skipped. If such assumption spreads, it can only be a matter of time before redundancy is fatally weakened in a situation where the threat of an accident is imminent.

A gradual weakening of the safety net also appears to be emerging with a shift in regulatory practices. Aviation operates internationally under a very detailed and ostensibly uniform system

of regulation coordinated by the International Civil Aviation Organisation (ICAO), drawing its basis from the Chicago Convention, a treaty which has been in place since 1944. However, the ICAO has virtually no coercive powers of its own and depends on its member nations to enforce the provisions of its code. Its standards and regulations allow significant scope for individual nations to reach their own interpretations of compliance, or even to depart from the standard provisions of the code provided they notify the ICAO. On the other hand, the Convention effectively obliges each member nation to grant licences and certificates issued by another nation equal status to its own, unless it can be demonstrated that they fall clearly below the minimum specifications. The result is that consistency may decay over time, with substandard practices emerging in individual countries and “leaking” into the global system through the channel of mutual recognition obligations.

Another aspect of the process which particularly affects regulation is a growing tendency to issue approvals by inspecting and approving the documentation rather than verifying that the processes actually applied in the cockpit or on the workshop floor meet the necessary standards. This risk appears to be becoming especially prevalent in the accreditation of the safety management systems (SMS) of individual carriers or MROs, which are rapidly becoming the primary tool of quality assurance for safety regulators, replacing traditional processes such as on-site inspections and surprise spot checks. While the system-based approach has many theoretical advantages (primarily that of being effectively self-enforcing once it is in place), there has been an apparent tendency to accredit on the basis of the system that exists on paper, rather than the system actually in operation within the enterprise. Decades of research on organisational culture have shown that the two often diverge markedly, and there is reason to suspect that this will apply just as much in aviation, particularly where the system relies on the commitment of senior managers who are under strong pressure to maintain profitability.

The above observations apply to main-route, high-capacity passenger and freight services, which together account for only a tiny proportion of the world and Australian fleets. In charter operations and other areas of GA, the accident rate is not only many times higher, but actually rising. The higher incidence of accidents in GA is largely attributable to these planes flying more often at altitudes where severe weather conditions can be expected, and operating over often difficult terrain out of small airfields and strips which lack the sophisticated air traffic control technology of larger airports. Smaller planes are generally if by no means always much older than those used in mainstream passenger work, and lack many of the safety features that are now built into passenger jets; the increasing average age of the GA fleet is one probable reason for the rising accident rate, as these smaller planes, though robustly engineered and perfectly capable of being flown safely for many decades, depend increasingly on good maintenance to keep them safe as they age.

### **1.3.3 What are the safety concerns that affect maintenance?**

Widely varying estimates exist of the contribution to accidents made by faulty or neglected maintenance. The most reliable of those currently available suggest that it is a significant factor in around 10% of accidents, though rather more important for certain categories like landing gear failure and engine failure in flight. However, it is generally estimated that around 30% of accidents involve some kind of failing in a mechanical or electronic system, which could conceivably be maintenance-related. Because some kinds of faulty maintenance have consequences which are hard to detect, it is likely that its contribution is somewhat underestimated even in professional accident reports, particularly where there is an obvious primary cause such as pilot error.

Precisely because maintenance is one of the least visible aspects of service quality to the consumer, it is especially vulnerable to cost-cutting. The earliest entrants into the offshore maintenance industry, serving the new US airlines that emerged after deregulation, competed

mainly on the basis of price, and subsequent reports found that malpractice and neglect in these workshops (including the use of unsafe spare parts) had been the primary cause of several very serious fatal accidents. While the industry has since diversified, with many of the newer firms seeking to compete through specialisation, economies of scale or service quality, the general quality of work and standard of care still appears to be highly uneven.

Since there are some potentially fatal consequences of poor maintenance which can remain latent for as long as 20 years, it is likely that other Australian planes have remained in service with such defects until they reached the end of their service life, or else were sold on to other countries or prematurely retired for fuel economy reasons.

One difficulty which emerges when maintenance is split up between several contract providers is a loss of the “whole-of-plane” approach to airworthiness. If each contractor is required to work only on a particular component or a particular set of operations on the airframe or electronics, there is a risk that the contractors will look only to the precise requirements of their respective contracts.

The last line of defence in releasing aircraft to service after maintenance is the licensed aircraft mechanical engineer (LAME), a special category of maintenance engineer requiring more post-training experience and a demanding examination on the underlying theory.

The need for a licence issued by government regulator means that the LAME, though in most respects an employee of the carrier or MRO in question, has a parallel role as a delegate of the State required to make decisions independent of the management chain and based purely on safety considerations. This means that the LAME should not be unduly deflected from this vital responsibility by the tension between profitability and safety which can complicate and compromise managerial decision-making.

There is thus a safety risk in any move towards a “company approval” model, which does not involve personnel licensing but places with the operator the responsibility to “approve” the “certifying employee”. Since such a company-based approach is entirely legitimate under the Chicago Convention, it could in principle be adopted by an individual nation, in either pure or hybrid form, without coming into conflict with international responsibilities – provided the latter are correctly understood. Much of the controversy over the new licensing scheme introduced in Australia from 2006 onwards has centred on concerns about whether the new regulatory framework may facilitate such a shift of responsibility.

The most obvious problem with offshore maintenance is that it is very difficult to maintain the level of supervision which Australia used to apply over all the available providers. This is an international problem, which in principle would be addressed most cost-effectively by multilateral action, but under its present constitution the ICAO has neither the powers nor the resources to run such a scheme. While there are options for independent non-government standards accreditation which are emerging, the only real safeguards today lie in the due diligence carried out by individual airlines before putting work out to a contractor, which in nearly all cases is treated as confidential commercial information.

However, each of these threats is overshadowed by the most important development since this program began: the strengthening evidence that the world will shortly face a serious shortage of skilled aircraft maintenance labour. This now appears to be of sufficient proportions to merit the description of a crisis, and is starting to emerge already as a practical problem for MRO providers in some parts of the world. Unless Australia takes proactive measures to build up its capacity to service its own fleet, we believe that by next decade this skills crisis will represent the largest single threat to the safety of Australian aircraft users since the jet era began.



### 1.3.4 Can Australia meet its future labour supply requirements?

Predicting future demand for skilled labour within Australia has become steadily more difficult because of the uncertainty about the future structure of the Australian airline industry. Questions remain as to whether any Australian airline will still be operating significant international services in ten years' time, how long the low-cost carrier (LCC) model represented by Jetstar and TigerAir will remain viable within a horizontally integrated duopoly, and whether increasing levels and/or different mixtures of foreign ownership will influence decisions on the sourcing of maintenance. Of even greater impact will be the recent wide and unpredictable fluctuations in the price of jet fuel. The spectacular price fall over the last year, unforeseen only two years ago, is bound to have lasting but currently unpredictable consequences for decisions on whether or when to introduce new-generation aircraft, and the timing of the introduction of these low-maintenance models is likely to become an important determinant of how much maintenance is needed across the world at any point in the future.

The same uncertainties are faced, in one form or another, by most other nations, but planning for future training and labour supply requirements still needs to proceed on some kind of defensible basis. International bodies like ICAO and the International Air Transport Association (IATA) have tried to meet this need by developing indicative projections of demand over a 20-year period which are acknowledged to be imprecise, but which are considered sufficiently consensual to function as a scaffold for planning. Boeing has also produced its own projections, updated every year, which can be assumed to incorporate a lot of corporate knowledge unavailable to the broad policy and research community. According to these projections, the world aviation industry will need somewhere around a million new qualified aircraft maintenance technicians by the early 2030s (the Boeing figure is substantially lower, but applies to a smaller segment of the world fleet). Based on 2010 figures, the capacity of the world training system in each of the twenty out years was expected to fall at least 25% below the annual growth in labour requirements, while in the Asia-Pacific region, achievable output was running at only a third of that level. This implies an annual shortfall of over 18,000, 80% of it concentrated in the Asia-Pacific region. According to estimates produced independently by IATA, demand growth was most likely to peak somewhere towards the end of this decade and start levelling off only in the mid-2020s.

The clear implication is that in the near future at least, there will be a very high world demand for training capacity, especially from other countries in Australia's region. This could well represent a highly profitable business opportunity. Australia, with its excellent international reputation as a provider of tertiary education and training to world markets, would appear in principle to be very well placed to capture this new demand, except that the institutions which might have supplied it have been run down in recent years and need swift action to assist a recovery sufficient to meet even the likely Australian demand for skilled labour within the period when the demand is most likely to peak.

Our own calculations, set out in more detail in Chapter 10, suggest that even with heroic measures to restart training effort, there would be no realistic possibility of Australia increasing its output sufficiently to meet the ICAO formula for the numbers required to handle all the maintenance on its own fleet within the next twenty years. Taking a somewhat lower demand estimate calculated from Boeing's forecasts, we calculate that it would just be possible in favourable circumstances to raise output sufficiently to meet the requirements by the early 2030s. This would mean starting with an intake equivalent to the largest number of annual commencements recorded in the last decade (including defence establishments), increasing that intake by an additional 5% in each year up to 2020, and taking a number of other measures to increase retention in training and reduce attrition in the employed workforce. While definitely challenging, such a strategy appears to us feasible in principle and within the current potential capacity of the training system, assuming the will and resources were there to support it.

The present situation bears little resemblance to this vision. Training output is falling below replacement level for the existing workforce and likely to fall further behind by around 17% over the next decade. Unless the situation is remedied quickly, it seems inevitable that Australia must become a net importer of either MRO services or MRO labour just at the time when the world supply will be at its tightest.

The necessary adjustment will need to take account of the interaction between the new licence system and training arrangements. Training under the now predominantly privatised system has become expensive and increasingly hard to access as more of the established providers withdraw their courses in the face of declining demand. While the newly introduced licensing scheme requires a base qualification at the diploma level, very few States in Australia have adjusted their student support policies to accommodate the additional training time this implies. This means that experienced workers wishing to upgrade or update their qualifications, to progress from a basic AME qualification to the licensing stage, or in some cases to restore privileges which they lost in the transition to the new licensing system, increasingly find themselves having to bear the full cost of the training and/or assessment since few employers are willing to provide the necessary support.

There is a need to ensure that the new Australian qualifications are genuinely comparable with those required by the European Aviation Safety Agency (EASA) scheme on which the new Australian licence structure is based. It is important to ensure that training hours measure up to those prescribed by EASA or the ICAO. This issue requires resolution as it will potentially place further obstacles in the way of either new or experienced Australian LAMEs seeking employment in Europe or in other countries whose licensing system follows the EASA model. Problems in the quality and adaptability of graduates are also emerging, at one end of the scale because of a declining investment in theoretical background training, at the other because there are inadequate opportunities to develop manual skills.

Smaller planes make up well over 90% of the Australian fleet. Controversy continues over the design of a small plane license which can articulate with the new licenses and qualifications built around the EASA system. The separation between small and large planes, along with the assumption that size equates with technical complexity (the basis of the licensing system), is increasingly challenged by the increasing technical complexity of some small planes. Developing a sophisticated license structure that can prevent the two (GA and RPT) developing into separate labour markets remains a challenge.

The problems with skill development and retention stem from institutional arrangements which are inappropriate to the challenges currently facing the industry. The highly reactive, market-lagging and individualised model which has shaped training arrangements in Australia over the last two decades has proved inadequate to meet the needs of radical industry transformation, because it has sacrificed forward planning, anticipatory adjustment, resilience and continuity to an overwhelming imperative of short-term responsiveness to the immediate requirements of existing employers. As a direct consequence, the decline in demand from the existing employers threatens to result in a break in the continuity of skills supply from which it may prove very difficult to recover.

## **1.4 Limitations of this study**

So far as we are aware, this is the first detailed academic study on this broad topic to have been carried out in Australia. Its methodological limitations are discussed in detail in Appendix 1. In terms of content, we have said very little about helicopters, despite the fact that they face a risk four or five times greater than fixed-wing aircraft, have specialised and in many respects technically advanced requirements for maintenance skill, handle a high proportion of the public service work, and are making up a growing proportion of the fleet, particularly at the smaller

end. We see the maintenance needs of rotorcraft as an important focus for future research in its own right, and one that may offer better prospects of getting support and involvement from the major employers and their customers. In the closing chapters, we in fact identify helicopter MRP as a potential niche for Australia in the Pacific region.

A second content limitation is that we did not investigate in any depth the organisation of maintenance and maintenance training within Defence. At most we looked at some civilian MROs doing maintenance and training work for the Australian Defence Forces under contract, and made some reference to the role of Defence as a client of OEMs. Our survey data provided tangential evidence on career mobility between the sectors. A follow-up project would examine these issues thoroughly as significant ones for national aviation and aerospace industry self-sufficiency and sovereignty. We believe an important issue for consideration is a closer alignment between civilian and Defence maintenance training and qualifications.

Wherever possible we have provided quantitative analysis drawing on reputable resources. Unfortunately this kind of information proved much less available than expected, partly because the occupation is spread across two small industries (4-digit in the Australian and New Zealand Standard Classification of Occupations (ANZSCO) classification), Aircraft Maintenance and Repair and Air and Space Transport, and many of the important official sources like the National Accounts and some of the major series on vocational training are not disaggregated sufficiently to separate it out. Other information is simply not available in the public domain – notably statistics on the amount of work outsourced and where it goes. This kind of information does not need to be disclosed to either the regulatory authority or government research organisations in Australia, though in the US reporting of these matters is now mandatory.

## 1.5 Structure of the report

**Chapter 2** begins by providing an overview of the world MRO industry and goes on to outline the historical background to the current state of play with civilian aircraft in Australia, focused primarily on the airline sector.

**Chapter 3** provides a detailed profile of the Australian civil MRO industry, and its relationship to domestic aerospace manufacturing. It begins with a breakdown of the CASA-registered fleet by aircraft age, category and application, followed by a summary of where these aircraft are maintained and the volumes of maintenance work generated. It then provides a mapping of Australian MROs, a summary of their civilian and Defence activities, and a mapping of training providers, OEMs and manufacturing suppliers, and aviation and business services. It also summarises key survey-based findings about the MRO workforce and their career trajectories, and about the business strategies and outlook of small, mainly GA-sector MROs.

**Chapter 4** examines the statistical evidence on aviation safety and the role of aircraft maintenance in guaranteeing it, identifying some trends which suggest that the long-running decline in accident rates could be less permanent than it appears.

**Chapter 5** examines qualitative aspects of safety, looking at the factors behind the excellent safety record of high-capacity RPT and identifying threats which are emerging to the multiple systems that protect aircrew and passenger safety.

**Chapter 6** examines the evidence on the safety of offshored maintenance arrangements and concludes that the emerging shortage of qualified engineers is likely to put growing pressure on safety management systems.

**Chapter 7** provides a detailed analysis of the regulatory mechanisms governing offshore maintenance safety, identifying tensions in ICAO regulation which can obscure key responsibilities. In the light of the US experience of offshore safety regulation, it concludes that

returning maintenance onshore is the only really satisfactory means by which Australia can enforce adequate quality assurance.

**Chapter 8** focuses on the role of licensing in aircraft safety oversight in Australia. Whilst endorsing the case for EASA alignment, it argues that the processes of transition from the old civil aviation regulation (CAR) 31 licence categories to the different structure of the EASA B licence could have been handled with greater clarity. It examines the obstacles which remain to the transferability of Australian licenses and qualifications to other jurisdictions, and the still unresolved problem of small aircraft maintenance licensing.

**Chapter 9** documents a sharp recent decline in AME apprenticeship training. It goes on to discuss the problems created for aircraft maintenance skill training by inappropriate requirements in the current legislative framework governing Vocational Education and Training (VET) in Australia, notably how the law bans training packages from covering curriculum, and how training not accredited by the Civil Aviation Safety Authority (CASA) can count towards a CASA-approved qualification for licensing purposes. It raises questions over whether Australian qualifications meet EASA and ICAO standards, and sets out reform proposals.

**Chapter 10** provides detailed scenario-based projections of Australian and global maintenance workforce supply and demand. It concludes that Australia is plunging unprepared into a global crisis of undersupply in MRO skills. It will be increasingly difficult to rely on offshoring, but the national training capacity has been run down to the point where urgent steps need to be taken to restore capability to perform our own maintenance, let alone become an Asia-Pacific maintenance training exporter. The first step must be an immediate moratorium on further headcount reductions, backed up by incentives to retain existing workers in the industry. To rebuild, it will be necessary to combine the capabilities of civilian and defence training facilities and invest seriously in new training and retraining. However, if the rebuilding starts now, Australia could by the early 2020s be a net exporter, of MRO services and MRO training.

**Chapter 11** contains an overview of the benefits which Australia could derive from a rebuilt national MRO industry and the factors which make it possible. It summarises evidence of the flow-on effects of aviation/aerospace business activity, identifies the nuclei of future aerospace/aviation clusters and networks, and argues their potential benefits to regional development, trade balances, national security and innovation. It concludes that Australia has the potential capacity to bring most if not all of its currently offshored maintenance back on to home soil, and that the emerging high-end aviation technology support sector provides the basis for an industry capable of targeting high-value niches in regional and global MRO markets, provided it can satisfactorily combine forces with the existing traditional MRO sector, including the large number of firms servicing regional and GA operators. Some government support may be required to bring about the necessary degree of coordination, though this depends equally on the industry developing its own co-operative institutions. It suggests the establishment of a national aviation/aerospace industry Manufacturing/Maintenance Forum in order to develop options for the future of the industry.

**Chapter 12** draws together the different threads in the report within a common strategic framework, reiterates the key findings and recommendations, and reinforces the recommendation for a National Manufacturing/Maintenance Forum, as an ongoing source of advice on industry development, and related skills development needs, to a newly formed aviation Industry Reference Committee.

# Chapter 2 Background and Historical Survey

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## 2.1 Introduction

This chapter provides definitions classifying maintenance activities, and reviews broad trends in the global maintenance industry, including future growth predictions. The next chapter provides an overview and detailed breakdown of way the Australian aircraft maintenance industry is structured, its changing place within aviation and its links to the wider aerospace industry. This chapter focuses on the global picture and the role of the major airlines, the following one presents a more nuanced view of the Australian aircraft maintenance industry.

## 2.2 Definitions

Aircraft maintenance falls into four broad categories:<sup>1</sup>

*Line maintenance* – checks, fault diagnoses, adjustments and running repairs which are carried out without taking the aircraft out of service. These include scheduled checks carried out between legs or flights, or at regular (weekly, monthly, etc.) intervals as required by the manufacturer's specifications, the latter elements being generally classified as A or B checks ;

*Heavy airframe (base) maintenance* – involves more extensive work carried out on the fabric and primary mechanical components of the aircraft, culminating in the very extensive D checks which involve removing the interior fitout and external paint to examine the fuselage and wing structures, leaving the plane out of service for a month or two, and which generally fall due every 5–7 years depending on the types currently in passenger service (for newer aircraft the time could expand out to 12 or even 15 years);

*Engine overhaul* – major checks, maintenance and replacement which require the engine to be taken off the wing and disassembled;

*Component maintenance* – including work on wheels and tyres (the largest segment, at 25% of global value added), followed by flight deck avionics (14%), fuel systems, various hydraulic systems, interiors and electrical systems.

Worldwide, it has been estimated that labour makes up an average 70% of the costs of maintenance.<sup>2</sup> Its contribution is highest in line maintenance, where it represents just over 75% of the cost, followed by heavy maintenance at 55%, and lowest in engine overhaul at only 9%.<sup>3</sup> Viewed in terms of total world labour costs, heavy and line maintenance account for around 30% each, and each of the other two categories for 20%.<sup>4</sup> This breakdown explains why heavy maintenance is the most attractive component for operators seeking to cut costs by offshoring

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<sup>1</sup> This classification is the one used by in the United States, which provides the most detailed global figures on the world aircraft maintenance market. Terminology may vary from country to country.

<sup>2</sup> Aeronautical Repair Stations Association (ARSA), 2013.

<sup>3</sup> CAVOK, 2015. Note that these estimates are considerably lower than those given by ARSA two years earlier. In particular, labour as an element of engine overhaul costs has fallen from 22%. This may be partly to do with different methods of estimation, but does suggest that strenuous efforts have been made across the entire global industry to curtail labour costs over this period.

<sup>4</sup> Aeronautical Repair Stations Association (ARSA), 2013).

work, especially as the labour required for some parts of the work (e.g. stripping out seats and cabin fittings) does not need to be especially skilled provided it is adequately supervised.

## **2.3 Background**

### **2.3.1 The global MRO industry**

Publicly available estimates prepared jointly by the CAVOK consultancy (formerly Oliver Wyman) and the US Aeronautical Repair Stations Association (ARSA) <sup>5</sup> indicate that the world civil non-general aviation (GA) maintenance repair and overhaul (MRO) industry at the beginning of 2015 consisted of some 4,743 businesses, almost 80% of them SMEs. It employs a total of 378,762 persons, 73% of them classified as “technicians”, presumably meaning highly skilled workers with similar qualifications to an Australian aircraft maintenance engineer (AME). In turn, roughly one in five of the technicians is “certificated”, i.e. licensed in Australian terminology.

The global value of the industry was estimated in early 2015 at \$US 67.1 billion (AUD 84.4 billion),<sup>6</sup> of which the largest contribution came from engine maintenance, representing 41.6%. This was followed by heavy maintenance at 21.6%, with component and line maintenance at 18.5% and 18.3% respectively. In terms of employment, component maintenance accounted for 325,408 workers across the supply chain, of whom 238,760 were technicians. Heavy maintenance employed 300,489 (220,282 technicians), engine maintenance 282,648 (206,901) and line maintenance 94,690 on-site and 10,415 in the supply chain. From these disaggregated figures (which add up to just over a million, around two thirds of them technicians) it is clear that most workers in the industry worked either across two or more specialisations, especially in the case of the technicians, or else in parts of the supply chain rather than in an actual maintenance facility.

Three International Civil Aviation Organisation (ICAO) regions, North America, Western Europe and Asia-Pacific, dominated the world market in 2015 with just over 70% of the demand. On the supply side, the United States (US) alone accounted for an estimated 85% of the world’s MRO businesses, 57.6% of direct employment in MRO, and 51% of the world’s technicians, though North America as a whole represented only 25% of world demand. However, while MRO services accounted for 75% of domestic employment in the sector, they contributed only 43% of the total value added (estimated at \$AU 54.3 billion), the balance being made up by parts manufacturing and distribution with only a third the number of employees.<sup>7</sup>

Despite the apparent domination of world supply by the US, North America as a whole remains a net importer of MRO services, probably a reflection of its enthusiastic adoption of offshoring since the 1990s, as described later in this chapter. In fact, if we exclude line maintenance which is mostly non-tradeable (at least where domestic routes are concerned), all the ICAO regions are net importers except Western Europe, which earns almost \$10 from exports for every dollar it

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<sup>5</sup> CAVOK, 2015. These estimates, along with others from the same publication which are quoted throughout this report, refer only to the maintenance of commercial jet and turboprop aircraft. GA aircraft up to 5,700 kg maximum take-off weight (MTOW) (which include what would be classified in Australia as low-capacity regular public transport (RPT)) are explicitly excluded. The consultants draw their estimates of aggregate value and employment on figures from a number of sources of which the most important are the Federal Aviation Administration (FAA, 2015a), and Oliver Wyman’s PlaneStats, while their market share estimates are based on “known MRO contracts” and hence may be less reliable.

<sup>6</sup> Based on the exchange rate as at 30 April 2015. Note that from this point on, all estimates are quoted in Australian dollar values.

<sup>7</sup> CAVOK, 2015, p.78, Exhibit 64.

spends on imported services or products.<sup>8</sup> However, the situation is more complex when disaggregated by maintenance segment, with both China and Asia-Pacific as a whole being net exporters of heavy maintenance, as is Latin America, while North America is a net exporter of component maintenance. Western Europe's positive trade balance applies across all three segments.<sup>9</sup>

This breakdown explains why specialisation has become characteristic of world trade in MRO ever since such services have become easily tradeable. Heavy maintenance is the most attractive component for operators seeking to cut costs by offshoring work, especially as the labour required for some parts of the work (e.g. stripping out seats and cabin fittings) does not need to be especially skilled – although it does need to be adequately supervised. Conversely, the most advanced industrialised nations continue to control the most profitable and least labour-intensive parts of the business.

Perhaps the single most significant change to the structure of world MRO this century has been the growing diversity of providers. In the 1980s, the vast majority of maintenance was done by airlines on their own fleets. Since the 1990s there has been a major rise in the number of businesses, independent of the operators, which exist solely to provide contract MRO.<sup>10</sup> Several airlines, notably the Lufthansa Group, have also found it profitable to develop large third-party MRO divisions, providing services to other operators, including major airlines.<sup>11</sup> In addition, the manufacturers of airframes, engines and components (original equipment manufacturers - OEMs) are rapidly increasing their direct involvement in maintaining their products, especially as new generations of aircraft with more sophisticated technology come into service.

Today the only category which is still dominated by the airlines is line maintenance, where the more regular checks do not lend themselves to systematic offshoring (as opposed to on-the-spot work at some stopping point along an international route). Consequently some 80% still takes place on the airline's own premises, but even there, the great majority of the work is now done under contract, either by subcontractors working directly to the airline, or by independent MRO businesses.

Despite the well-publicised outsourcing of heavy maintenance over several decades, on average around half of this category is still carried out in house, though airlines working solely on their own fleet account for only 28% of all work. Those airlines which have broadened their capability sufficiently to offer their services to other carriers are generally better placed to handle their own in-house maintenance because of the economies of scale they can achieve, and have managed to hold or capture another 22% of the market. Independent MROs and third-party services provided by other airlines or their specialised maintenance subsidiaries together account for just over 40%.

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<sup>8</sup> CAVOK, 2015, p.63, Exhibit 51.

<sup>9</sup> Ibid., pp. 68-69.

<sup>10</sup> The trend to using third party MROs is stronger in low cost carriers than in legacy airlines. Mulcair, 2012; BoeingEdge Flight Services, 2014. Outsourcing is more common in the case of large wide-bodied aircraft, where labour intensity is an issue, and in the GA sector, where operational scale may preclude the ongoing employment of qualified maintenance staff, unless the operator also offers third-party maintenance services to other operators.

<sup>11</sup> Lufthansa Group have found that the rate (though not the volume) of return on their third party MRO services to 800 other airlines and aircraft leasing companies has outstripped the rate (but not the volume) of return on carrying passengers. Lufthansa Group, 2014a, 2014b.

By contrast, OEMs dominate the world market for engine maintenance, holding almost 65% of the market if their partner businesses are included, and expect to increase their involvement as new generations of engine come into service.<sup>12</sup> They and their joint-venture partners together control around a quarter of the world market for component maintenance, with airlines now reduced to only 8%, and the remaining 60% shared mainly between Independent MROs and maintenance offshoots of other airlines. However, the consultants report that OEMs take most of the more complex component work, and hold a 78% share of the supply chain. At the moment their presence in heavy maintenance is negligible, but they are making strenuous efforts to take on a greater share of the work as more operators introduce aircraft with composite airframes, on which there appears to be very little expertise in the contract MRO industry so far, especially in the low-wage countries which have benefited most from the outsourcing trend.

Line maintenance may well become more complex. As aircraft and components become more reliable, airlines are thought to be finding the intervals between base maintenance airframe checks and component overhaul are lengthening, making it less economic to retain in-house base maintenance facilities and staff for newer aircraft. The development of in-flight diagnostic technologies (AHMS or aircraft health monitoring systems) may be coupled with the despatch of specialist technicians from airline or independent MRO centres, or, increasingly, by aircraft and component manufacturers as part of afterservice contracts.

The greater reliability of new aircraft is reportedly pushing OEMs to greater reliance on afterservice contracts, whether for routine maintenance or ongoing small modifications. Several OEMs offer, as part of their sales package, just-in-time maintenance, delivered through a global MRO network, based on diagnosis of individual aircraft defects and maintenance requirements, fed back to the OEM through a continuous flow of big data collection and analysis.<sup>13</sup> The use of “big data”, continually fed back from flight systems, is potentially allowing collaboration between OEMs and those airlines that have in-house maintenance capability, to achieve incremental improvements for example in fuel economy.<sup>14</sup>

### **2.3.2 Future growth predictions**

The CAVOK report predicts that world MRO activity will grow at an average compound annual growth rate (CAGR) of 4.1% over the next ten years, passing the \$100 billion mark in Australian dollar values in or around 2024. However, the growth pattern will be uneven across the segments, with engine maintenance leading at 5.1% CAGR and heavy maintenance growing at only 1.4% annually. By 2025 engine maintenance will make up 56% of the industry by value, with heavy maintenance losing around 1.5 percentage points of share.

Among the major regions, Asia-Pacific is predicted to show the highest growth rate at 5.6% annually. By 2025 it will have just passed Western Europe, where annual growth is expected to be around 3%. However, the highest growth rates are likely to be found in individual countries – within the broader Asia-Pacific region, India should grow at over 12% a year, and China at 8.6%,

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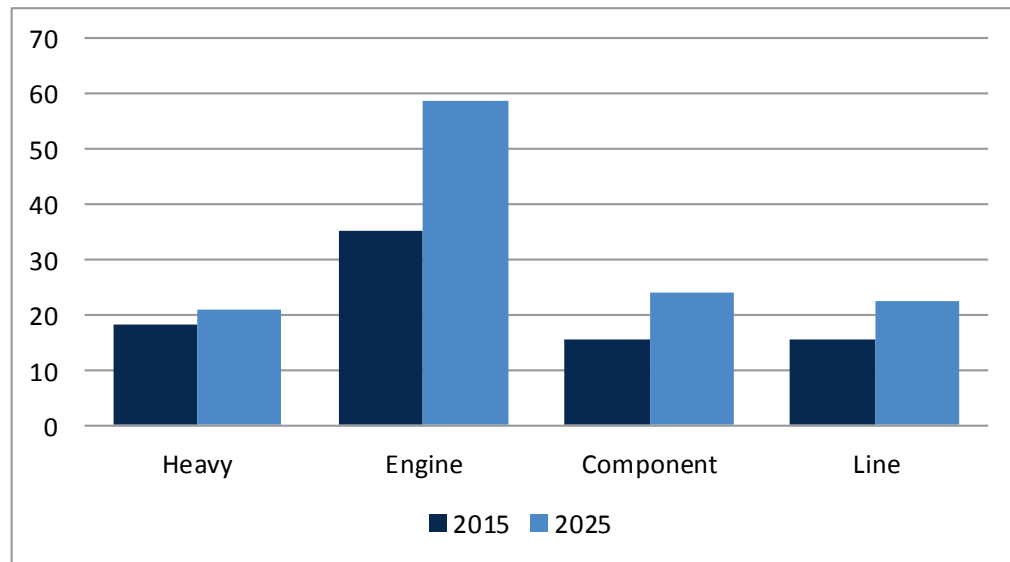
<sup>12</sup> The trend started in the 1980s based on power-by-the-hour afterservice contracts offered by the major engine manufacturers. Knowledge@Wharton, 2007.

<sup>13</sup> An example is Boeing’s B787 “Goldcare contract”. Maloney, 2011; Mulcair, 2012. In the regional jet and business jet space, Gulfstream offer similar through-life service. In the first six months of 2015, while Bombardier’s pre-tax earnings from aircraft sales increased, relative to the same period in 2014, from \$212m to \$215m, their earnings from design, manufacturing and afterservice component and repair increased from \$38m to \$84m. Stockwatch, 2015.

<sup>14</sup> Cox, 2015; Siedenman and Spanovich, 2015.



doubling its market size over the ten years, as will Latin America and the Middle East. The CAVOK consultants do not provide forward projections for shares of the supply side, but it seems reasonable to expect that the balance will shift gradually in favour of the regions and countries showing strongest growth in demand, as the OEMs establish offshoots and partnerships to give themselves an on-ground presence in the most important markets. However, the US is likely to take back a higher proportion of its own heavy maintenance (possibly as much as 30% of the work currently done offshore)<sup>15</sup> as a continuing compression of wage rates between the US and traditionally low-wage countries reduces or even eliminates the savings which American carriers currently achieve by offshoring their maintenance.



Source: CAVOK (2015)

**Figure 2.1 Total world value of MRO by segment, 2015–2025 (Billions of Australian dollars, constant 2015 values)**

Hence, while the big story of the last decade has been the growth of a global third-party maintenance sector made up of independent businesses which concentrate on heavy maintenance, the signs now are that the expansion of this sector may have hit a limit.<sup>16</sup> Airlines in the US today, and potentially in other countries that have actively sent their maintenance offshore, seem bent on taking a share of it back, while it now looks increasingly probable that some of their present business may be taken over by OEMs. This can be expected to happen particularly in engine and component maintenance, but will probably also extend into heavy maintenance as more of the new-generation planes come into service with composite hulls and other advanced technology requiring new kinds of expertise which the manufacturers may not trust the third-party industry to develop adequately. Certainly in the case of engine maintenance, the role for independents is rapidly shrinking unless they can enter into some kind of partnership arrangement to handle OEM maintenance.

This is probably a trend which lies some way in the future, because the introduction of newer types like the 787 and A350 has been slower than anticipated, owing in the first case largely to unexpected design bugs, but also because the falling fuel price over the last two years has removed some of the urgency for their introduction. The incentive is likely to return, partly with

<sup>15</sup> Spafford and Rose, 2014.

<sup>16</sup> Spafford and Rose, 2013, pp. 1, 6.

an expected resurgence in fuel prices towards the end of this decade,<sup>17</sup> but also because of the planned introduction of an emissions trading scheme (ETS) in Europe next year.<sup>18</sup> Consequently CAVOK expect it to start influencing the size and shape of the demand from maintenance from about 2020 onwards. Once this point has been passed, it seems likely that the heavy maintenance market in particular will bifurcate, one sub-segment dealing with the new airframe technologies and entailing relatively low volume but high value-added, while the other concentrates on end-of-life maintenance for the generation which is currently in service, and which will have passed out of its low-maintenance “honeymoon period” by early next decade.<sup>19</sup>

## **2.4 Retrospect and prospects**

### **2.4.1 Three decades of change in the global industry**

Up to the 1990s, fleet maintenance was seen in most countries as part of the service package that made up a “full-service” airline. Operators ran their own in-house facilities to do most or all of the routine maintenance on the aircraft they flew. In fact, in the early postwar years there was little alternative but to treat it as such, since there were few or no dependable outside sources for most types of MRO. In a time when passenger planes still crashed frequently, it was an obvious source of competitive advantage for an airline to have reliable aircraft and a competent workforce to keep them so. Developing this workforce was recognised as the responsibility of the airline, which invested heavily in developing a specialised workforce for the purpose, while engineers generally remained for much or all of their working life with the airline that had initially trained them.

The first major disruption to that pattern occurred in the US with the deregulation of passenger air services under the Carter administration. These changes saw an immediate injection of new players into the industry, many of them poorly capitalised, which were able to offer fares well below those of the established airlines. The domestic industry became price-driven, with flow-on effects that accelerated as competitive pressures intensified. Cost cutting led to the emergence of a new segment of independent MROs, many of them located in Central America, which took advantage of low wages to undercut US providers.

In one sense the crisis self-corrected, since a steep rise in fuel costs, which began in the 1990s and continued up to 2013, largely destroyed the savings that airlines once garnered from continuing to fly older, less fuel-efficient designs. Between 2007 and 2011, the proportion of the global fleet which was retired at the age of 25 or less grew from 21% to 43%.<sup>20</sup> This wave of new aircraft entering the US fleet has provided some relief, at any rate in the short term, from the lethal combination of shoddy maintenance with ageing airframes and engines. But at the same time there appears to have been a cleanout of some of the least satisfactory MRO providers, with more reputable businesses coming into the industry and a growing willingness on the part of the Federal Aviation Administration (FAA) to impose more demanding regulation on the offshore industry. This reaction is discussed in Chapter 6.

Despite the public unease, the US industry continued to rely heavily on outsourcing its maintenance to foreign countries; by 2008 some 70% of heavy maintenance was outsourced, and 35% of D checks were offshored.<sup>21</sup> In more recent years, however, there appears to have

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<sup>17</sup> World Bank forecast, cited in CAVOK, (2015).

<sup>18</sup> CAVOK, p.46.

<sup>19</sup> *ibid*, p.35.

<sup>20</sup> Spafford and Rose, 2013, p. 6.

<sup>21</sup> Office of the Inspector General - United States (OIG), 2008; Tang, R. and B. Elias, (2012), ch 2.

been a shift of opinion among airline operators towards bringing more of the maintenance back on shore. A report published at the beginning of 2013 by the US consultancy Oliver Wyman estimated that US had the capacity to repatriate 30% of base maintenance currently done offshore more or less immediately, with a potential gain of some 5000 jobs.<sup>22</sup> Since then, falling wages in the US have worked in concert with a growing inadequacy in worldwide maintenance capacity to increase the competitiveness of American-based MROs.

Meanwhile, outside the US and building on its example, a new sector of budget airlines or low-cost carriers (LCCs) emerged from the 90s onwards, initially differentiated from traditional (legacy) airlines by targeting a market segment which was much more price-driven than the traditional consumer of air travel. Like the new competitors in the US market, most of the original LCCs in other markets were set up on a very limited capital base. For most of them, however, the option of husbanding their capital by using obsolescent aircraft had ceased to be viable by the time they came into existence. Their available resources were stretched to the limit buying or leasing aircraft and covering their basic operating costs. Most lacked the means to build or staff their own maintenance shops. To cater to this demand, a new international industry of independent MROs arose alongside those which had serviced the expansion of the airline industry in the US. Some of these were offshoots of established airlines which had surplus capacity in their shops or chose to expand them to cater for the new demand, while others were set up by the manufacturers of aircraft or engines who saw an advantage in retaining control over the maintenance of new generations of product which employed unfamiliar technologies.

Several of these new MROs either were based or set up as subsidiaries in developing or emerging nations where they were able to achieve operating costs – principally, of course, wages – well below what they could achieve in their home bases. As a combined result of these input cost advantages and the economies of scale they were able to achieve, the independent operators have been able gradually to pull in more and more of the business which established airlines traditionally handled in their own shops, and in the process have tended to push up the marginal cost for those airlines which still choose to keep their maintenance in house. As a result there has been a major shift in the balance of maintenance activity from carriers to independents of one kind or another, and increasingly over recent times to OEMs.

While the line of demarcation between low-cost and full-service airlines was initially clear, cost pressures on all airlines – specifically, what seemed until recently to be an the inexorable rise in the price of fuel<sup>23</sup> — have since led many of the established carriers to copy their marketing and cost-reduction tactics. Even in the face of a stronger imperative for strategic and marketing differentiation, legacy carriers have been forced into cost-cutting, if only as a holding operation.<sup>24</sup> In the process, as happened earlier in the US, aspects of the service package which

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<sup>22</sup> Spafford and Rose, 2013.

<sup>23</sup> The International Air Transport Association (IATA, 2015a) estimates, based on data from the Platts consultancy, show that the price of jet fuel peaked sharply in mid-2008, fell just as sharply in the following six months, peaked again at a lower level between 2011 and 2013, fell steadily over most of 2014 and spiked again in early 2015, to end the March quarter at around 60% of its level a year earlier. This is expected to result in a saving for the global airline industry of \$US83 billion over 2015.

<sup>24</sup> As an indication of the kind of cost squeeze the world industry faced in this period, the president of the International Air Traffic Association estimated at the start of 2013 that averaged out across all his members, airlines had made net earnings of only \$US2.50 for each passenger they carried in 2011/12, a figure which he expected to rise to a heady \$4 in 2012/13. By the end of 2014, this had risen to just over \$6, and was expected to rise by another dollar in 2015, chiefly because of further savings from lower fuel prices beginning to flow through to most airlines as their hedging contracts expire.

had once been seen as competitive strengths came to be viewed as costs to be minimised. As one of the more invisible components of service, maintenance fell under such a redefinition.

An important consequence of these changing incentives was a shift in the way airlines regarded their maintenance workforces. In the beginnings of commercial aviation, the relationship between aircraft operators and maintainers tended to be a close and trusting one. The emergence of a strongly price-driven consumer market, putting pressure on established carriers to lower their cost base and reduce headcount, coincided with the rise to popularity of an “insourcing” model derived ultimately from the one promoted by McKinsey Consultants.<sup>25</sup> This model no longer saw the different functional areas in a corporation as interdependent parts of the one system, but rather conceptualised them as “enterprises” within the firm known as profit or cost centres, which needed to prove themselves cost-competitive with external providers if they were to remain in existence. Maintenance was one such internal enterprise, and airlines increasingly saw it as someone else’s responsibility to develop the future maintenance workforce, and nobody else came forward to fill the resulting training gap.

The type training provided by OEMs can be built only on the basis of the broad conceptual understanding developed through category training, complemented by the extensive handskills and other practical experience historically developed through the apprenticeship model. It is not at this point clear how the necessary training will be organised to meet the very significant global shortfall in labour supply. Australia is strategically placed to help meet part of the Asia-Pacific MRO skills shortfall. MRO training is potentially a significant export earner for Australia. In Chapter 10 we explore this option.

#### **2.4.2 Stocktake: Offshoring, onshoring and new relationships: The Australian experience**

It is difficult to be precise about the extent of offshoring that has happened in Australia because no hard data are kept in publicly accessible form. This contrasts with the situation in other countries, notably the US, which gathers and keeps extensive detailed data. In building our knowledge, we have thus used anecdotal reports (many of them unattributable) and occasional hints dropped by management in media releases or interviews. In addition, as part of this project, a detailed industry mapping was undertaken, using a range of information sources. This is described in the next chapter.

Despite the number and diversity of businesses undertaking MRO in Australia, maintenance on larger civilian aircraft continues to be dominated by Qantas and Virgin Australia. Over the course of 2014, the industry became a horizontally integrated duopoly, with each major airline owning a full-service, a budget and a regional brand. A small competitive fringe of regional airlines remains, of which the most important, Regional Express (Rex), is wholly Singapore-owned and operates a fleet of SAAB turboprops considerably older than anything flown by the two majors. As well, the large GA sector is served by several hundreds of MROs, some networked to suppliers, who are still waiting for clarification of the application of regulatory change.

Qantas, now the world’s longest continually operating airline and one of the few still to be flying under its original brand name, is the last survivor of the three airlines which effectively monopolised Australian aviation from the immediate post-World War 2 period through to the 1990s. It started out in private ownership as a regional carrier in the 1920s, passed into government ownership in the Postwar Reconstruction period, and for some years held a monopoly of flights in and out of Australia, initially in close cooperation with Imperial Airways (later to become BOAC and subsequently British Airways). A second government airline, Trans-

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<sup>25</sup> McKinsey and Co, 2009.

Australia Airlines (TAA) was set up in the postwar period, initially with the intent that it should exercise a monopoly of domestic main-route carriage. However, the High Court ruled against this, allowing the continued operation of two and subsequently one competing private airline, eventually to become Ansett Australia. The two continued to have sole access to this market until the 1990s under a tightly regulated two-airline policy, and even after this was lifted, the market power of the duopolists made it impossible for any new competitors to survive long. In 1994, Qantas absorbed Trans Australia Airlines (TAA), and after that point both majors ran international as well as domestic services. Over this same period, Qantas was privatised in stages, becoming fully listed in 1995.

The security offered by the two-airline policy made it possible for the major airlines to build up state-of-the-art fleets and a structure of maintenance shops at or close to the best world standards. Being at the end of the line geographically, Qantas engineering often had no choice but to fix things itself, and developed a very high level of technical excellence, evident for example when industry leaders like Rolls-Royce drew on innovations generated on the engine repair line in Sydney. In the process they became major contributors to the development of apprenticeship in aircraft engineering. Increasingly as time went on, this meant that most people who worked as maintenance engineers in Australia had done their training either in the defence services or in the shops of one of the three major airlines.

This gave way from the 1990s to a period of partial deregulation and increasing competitive pressure, especially in the international segment. The first casualty was Ansett, which went out of business at the end of 2001. This development was unexpected and came at the end of a succession of unwise commercial decisions coinciding with the collapse in demand for air travel that followed the 9/11 disaster. One of the immediate casualties was its apprentice program, leaving Qantas as virtually the only large civilian training provider. The other was Ansett's maintenance workshops. Some of these facilities were taken up by Qantas, but the demand was never fully restored, since the new main-route carriers who came into the market over the next few years to fill the gap (including one created by Qantas outside its articles of association) were built on the LCC model which, as mentioned earlier, normally does not involve the carrier owning its own workshops. A local MRO, John Holland Aviation Services (JHAS), took over part of the Ansett workshops to handle business from a variety of airlines in Australia and the Pacific (including work for LCCs), but failed to survive, leaving Australian airlines with no alternative domestic independent provider on the scale they required.

The outcome was that Qantas, or at least that part of it which continued to trade under its original business identity, became for some years both the only customer and the only provider in key areas of Australian MRO. Australia is still highly dependent on Qantas both for its high-end civilian MRO infrastructure, and for its supply of AMEs with the skills required to service current-generation large passenger aircraft. This largely explains why its activities in this field are considered a matter of public concern rather than a purely internal affair of the company.

Qantas's commercial performance deteriorated over the first half of the current decade. In the space of a couple of years it went from reporting strong growth in the domestic markets, to a pre-tax loss of over \$300 million for the first half of 2013–14, accompanied by the loss of its investment-grade credit rating at the start of 2014. It responded with an immediate plan for \$2 billion worth of cost reductions, including a reduction in employment of 5000 jobs, equivalent to about 15% of its workforce. While it announced an almost equally spectacular return to

profitability in 2014–15,<sup>26</sup> it remains to be seen how the company will juggle the constraints faced by legacy airlines against the need to manage reputational issues.<sup>27</sup>

Qantas was actually a late starter in the outsourcing process, at least so far as its core brand was concerned. While it had always offshored a certain amount of overflow maintenance, which by definition could not be performed within existing production capacity, its strategy of offshoring work previously undertaken in its own workshops began in earnest in 2006/07 with the closure of the Sydney Heavy Maintenance facility. Some of its work was shifted to facilities in Melbourne and Brisbane, but an undisclosed proportion moved overseas. Before its profitability collapse, it claimed that 90% of its heavy maintenance was still being done in Australia. Although this figure cannot be confirmed, it is clear that considerable scope remains for further offshoring, especially if the viability problems recur.

The most noticeable thing about Qantas offshoring is that the transfer of work overseas has happened more or less in phase with the introduction of new-generation designs. While it initially conducted some changeover training on the A380, it has announced a ten-year contract with Lufthansa Technik Philippines for heavy maintenance of this aircraft.<sup>28</sup> Plans so far announced for a B787 maintenance and training base in Melbourne are believed to relate only to line maintenance, although, as argued earlier in this chapter, Australia is very well placed to provide a range of airframe and structural maintenance capabilities for this aircraft. The winding-down of the Avalon facility was linked in repeated media releases to the impending retirement of the last 747s in the passenger fleet, (though the closure actually occurred some years in advance of their retirement, with the remaining 747 maintenance sent to Hong Kong).<sup>29</sup>

So far Qantas has maintained a welcome public commitment to building up a world-class A330 maintenance facility in Brisbane, where its current apprentice program is concentrated. Qantas, its subsidiary Jetstar and its contractor Cobham who manages the QantasLink fleet, are carrying out line and heavy maintenance on narrow-bodied jets and turbo-props in-house and on-shore. Nevertheless, this activity is not on its own sufficient to sustain an Asia-Pacific regional maintenance and maintenance training presence, and to effectively address the forthcoming skill shortage.

In contrast to Qantas, Virgin has made a virtue of conducting its maintenance in Australia, much of it in JHAS – albeit whipsawed against competitor facilities in New Zealand (NZ). However, since the demise of JHAS, the majority of its heavy maintenance is done in NZ and Portugal, and its in-house maintenance workforce runs out to only around 350, occupied solely in line maintenance.<sup>30</sup> Virgin's announced intention to take on 32 new apprentices over four years is welcome, but is about the same as Qantas's annual intake for 2013. There seems to be little prospect of its making a significant direct contribution either to AME employment in Australia, or to the development of the workforce, especially given the growing representation on its share register of overseas companies, some of whom have an interest in extending the market share

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<sup>26</sup> According to Qantas sources, the restructuring of maintenance was “one of the main factors” in this turnaround. In the 18 months to June 2015, the Engineering Division alone accounted for \$120 million in savings, largely through the abolition of 900 full-time jobs. Schofield, 2015.

<sup>27</sup> Sarina and Wright, 2015.

<sup>28</sup> Australia Philippines Business Council (APBC), 2015.

<sup>29</sup> Creedy, 2014.

<sup>30</sup> Freed, 2013.

of their own maintenance offshoots.<sup>31</sup> A strong campaign is required to bring heavy maintenance of Virgin's 81 B737s onshore. In September 2014, Virgin Australia was reportedly evaluating the possibility of a joint purchase of the B787 or alternatively the A350 XWB, and there may be scope for negotiating the onshoring of the maintenance Virgin's subsidiary Tiger is maintaining its 14 A320s in Melbourne.

## 2.5 Conclusion

It remains an open question how the global aviation industry will respond to the escalating skill shortage, which is charted more fully in Chapter 10. Essentially, there are two possible scenarios. In the one, nations see the shortage coming and reinvest in infrastructure and human capacity to meet it. In the other, they come to view the shortage as a fact of life, or at any rate not a sufficiently serious problem to justify the cost of responding adequately, and instead learn to cope with the consequences of a steady contraction in maintenance capability while aviation activity continues to grow.

In many parts of the world the MRO industry has passed into a phase of reinvestment since the global financial crisis (GFC). As aircraft operation and MRO evolved into separate businesses, it became increasingly obvious that MRO was a major business opportunity in its own right, attracting a new wave of investment as world economic activity revived. The industry has been in a ferment of growth and diversification for the last five years, which is evident from all the main industry publications and newsletters, many of which are referenced throughout this report. New hubs of MRO activity are rising in countries as diverse as Lithuania and Turkey, while the US has recognised aviation as a key focus of economic revival, and is rapidly rebuilding its domestic MRO capability from a low point early this century – helped admittedly by a drastic fall in blue-collar wages since 2008, but equally driven by a range of Federal, State and local government incentives, with a determined and well-organised industry lobby constantly at work on Congress to keep them coming.

With the realisation that these investments are threatened by emerging global skills shortages, private providers and individual training institutions have become more active in mounting new training programs, driven primarily by the profit potential. Recent years have seen a proliferation of training initiatives, of varying quality, at levels from undergraduate degrees in legitimate universities through to unaccredited private training colleges, many of them in parts of the world which lack Australia's tradition of rigorous but work-focused technical education. Chapter 9 discusses some of these initiatives, undertaken by international organisations.

However, the alternative scenario may still occur in which individual countries (or indeed the global aviation industry) are unable or unwilling to develop a new skilled workforce of the size required to handle growing maintenance needs at the levels previously considered acceptable, and instead adjust to a situation of permanent shortfall. Over time the problem may be addressed by lowering customer expectations, reducing quality control to bureaucratic process, lowering qualification standards for the maintenance workforce, and shifting certification rights from the licensed to the unlicensed (and therefore less well paid) parts of it. In fact, some elements of this alternative scenario have already been in evidence for some time — in particular, the levels of time pressure and work intensification experienced by workers in the industry. Some rather unnerving evidence of its presence may also be found in the 2014 Oliver Wyman survey, where 9% of respondents in an international sample, asked "What strategies

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<sup>31</sup> This observation is qualified by the fact that at this stage Virgin plans for MRO development are largely unknown.

have you considered or adopted to combat rising outsourced engine or component maintenance costs?” responded “Delay or avoid maintenance”.<sup>32</sup>

In regions where this second scenario is the reality, some evidence of the consequences can be seen in the first-hand evidence of maintenance practices in certain overseas source countries which we discuss in Chapter 5.

At this stage, before the skills crisis really begins to affect the more affluent industrialised nations, it is impossible to tell which of these scenarios will ultimately prevail – or indeed, whether they will continue to coexist in different parts of the world.

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<sup>32</sup> Spafford and Rose, 2014, p.4.



## Chapter 3 The Australian MRO Industry

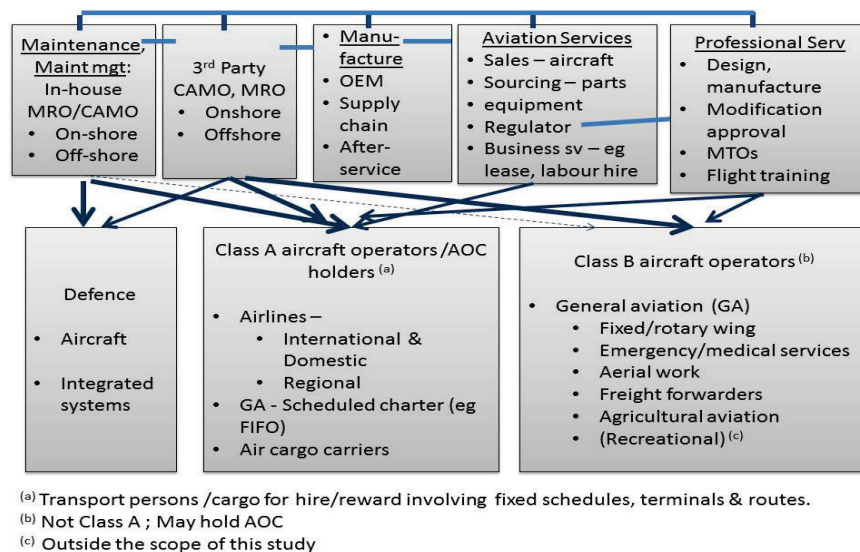
### 3.1 Introduction

To help identify options for the future development of aircraft maintenance in Australia, this chapter overviews the way the industry is structured, its changing place within aviation, and its links to the wider aerospace industry. Using new project data, it also outlines some aspects of the occupation of aircraft maintenance engineer and issues of workforce development and career planning.

### 3.2 Industry overview

Aircraft maintenance is classified in Australia and New Zealand as part of the Aircraft Manufacturing and Repair Services industry, on the basis of similarity in the production function between the original manufacture and subsequent overhaul of aircraft and components.<sup>1</sup> Aircraft maintenance work also has a strong technical and professional component, as indicated by the Australian occupational classification “(Aircraft Maintenance) Engineers”.<sup>2</sup> Overseas job titles such as Technician and Engineer signal both theoretical understanding and a professional ethic of integrity and independence in upholding safety standards.

Figure 3.1 identifies the following types of Australian organisations in which aircraft maintenance, repair and overhaul (MRO) work is carried out directly, and elements of the supply chain to which this work contributes, or on which it draws.



**Figure 3. 1 Strategic linkages – Australian aircraft maintenance industry and its relationships**

#### 3.2.1 Air operators

Air operators are held responsible by the regulator CASA (The Civil Aviation Safety Authority) for maintenance management, ensuring the continuing airworthiness of their aircraft, owned or leased. This responsibility cannot be delegated, whether the maintenance is conducted in-house or outsourced on-shore or off-shore. In the airline sector, much aircraft maintenance in Australia has

<sup>1</sup> The Australian Bureau of Statistics (ABS 2006a) singles out aircraft MRO work as an industry where the factors of production in repair work are “interchangeable” with those of original manufacture. See pp. 29, 129.

<sup>2</sup> Australian Bureau of Statistics (ABS), (2006b), p. 379.

historically been done in-house, and Qantas still employs an estimated 5,000 engineers — approximately 40% of the Australian civilian maintenance workforce. With the trend to outsourcing and off-shoring maintenance work there is a need, currently unmet, to safeguard the pipeline of maintenance engineering apprentices.

In addition to the four major domestic main route operators, Qantas, Jetstar, Virgin and Tiger Air, there are approximately 30 regional operators offering regular public transport (RPT) services. Some are networked to the main carriers, one (Rex) is independent but overseas owned, and others struggle for viability. Air operators also include the large and diverse General Aviation (GA) sector, which provides essential regional and rural infrastructure including non-regular public transport, charter and freight services and the aerial work that supports agricultural, pastoral, mining and fishing industries, land and oceanographic mapping, the maintenance of power lines, fire control and medical emergency services. Because of the importance of regional RPT to the national infrastructure, a 2014 NSW parliamentary regional aviation inquiry recommended that it be deemed an essential service.<sup>3</sup>

### **3.2.2 Third party MROs**

The stand-alone Maintenance Repair and/or Overhaul organisation (MRO) has long been the model for maintenance in the GA sector. In other aviation sectors, the number and range of stand-alone third party MROs in Australia has grown, as part of a global trend.

Third party MROs operating in Australia may service aircraft components or whole aircraft, and may be generalists or specialise according to group, category or type of engine, airframe or avionic system. Some have one site; others operate across a range of ports, and their clients may range from local to international air operators. Some provide maintenance to clients across the civilian airline, Defence or general aviation (GA) sectors. They range from completely independent businesses to tied contractors, with links either forward to aviation clients or backward to manufacturers of aircraft or components. Some supply one-off installations, upgrades or emergency repair/replacement services; others provide regular maintenance checks and repair/overhaul for a smaller range of regular clients. Some are multi-faceted, combining MRO work with their own air operations, whether regular public transport (RPT), charter or aerial work. Several tender for a succession of large-scale, long-term contracts with airlines, air service providers, aircraft leaseholders, or Defence arms, whether supplying ongoing airworthiness and maintenance management for whole fleets, or working on specialised projects such as the design and installation of integrated systems, or intensive fleet conversion and refurbishment projects.

The 262 MROs that we were able to identify in the GA sector in 2014 are the reason that GA operators remain flying. Their role is so critical to regional and rural infrastructure that some regional and rural airports and local government authorities have provided infrastructure and direct employment to support local hangars, workshops and licensed engineers.<sup>4</sup>

### **3.2.3 Aircraft OEMs, component OEMs and tiers of manufacturers**

Australia has participated in the global trend, discussed in Chapter 2, towards the increased entry of OEMs (Original Equipment Manufacturers), of both aircraft and components, into the aircraft maintenance market, based on though-life-service or afterservice maintenance contracts. They may conduct the maintenance in-house or devolve some of this work to approved sub-contractors or agents, including stand-alone MROs.

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<sup>3</sup> New South Wales Parliament, Legislative Council, 2014, p. 6,

<sup>4</sup> NSW Parliament Legislative Council, 2014, pp. 71ff.

The two largest global aircraft OEMs, Boeing and Airbus, have significant in-house MRO operations in Australia, sketched in Section 3.4 below. Also briefly sketched are the operations of a range of local and international component OEMs undertaking both research and development (R&D) and MRO work. Several innovative European and United States (US) aerospace manufacturing firms have acquired or partnered with MROs and OEMs in Australia to establish a South Pacific base. These technological partnerships are apparently not hampered by the tyranny of distance, leading us to challenge the assumption that logistical considerations pose a barrier to the integration of Australian MROs into global networks.<sup>5</sup>

The manufacture of parts other than those produced by OEMs is strictly regulated through the parts manufacturing approval (PMA) process of the Federal Aviation Administration (FAA) and bilateral recognition agreements based on it. OEMs may seek to impose restrictions on the use of alternative parts: there are debates between air operators and OEMs over the point at which concern for reputational fallout from safety breaches shades into defence against competition.<sup>6</sup>

OEMs, as relatively large and innovative employers, are likely to provide stable employment, training opportunities and possible career paths for maintenance engineers. The Australian aviation and aerospace industries stand to benefit from the transfer of technology and training expertise implied by the fact that international OEMs make up 11 of the 36 Maintenance Training Organisations (MTOs) that have gained Civil Aviation Safety Authority (CASA) accreditation as Part 147 type rating training providers.<sup>7</sup> Nevertheless this type-specific training lies outside the nationally-recognised system. It is privatised within the OEM and, formally at least, its “certificates of attainment” (type qualifications) are not transferable. A challenge is to find ways to transfer the expertise embodied in OEM-dominated type training to the national training system. There is also danger that reliance on OEM-based type rating training will over time contribute to undermining the national system of broad-based category training, and to a shift away from airworthiness oversight by independent license holders and towards manufacturer- and employer-approved training and maintenance certification.

### 3.2.4 Aviation business and professional services

Providers of aviation business services who either supply or use MRO services include sellers of new and used aircraft, charter brokers, private fixed base operators, and an increasing range of wet-lease fleet suppliers, some also supplying cabin crew and maintenance services, for example for business jets and helicopters. Other aviation business services include the sourcing of aircraft parts and accessories: such suppliers need considerable understanding of aircraft and components. Specialist labour hire firms supply aircraft maintenance staff at the insecure end of the MRO labour market. The failure of John Holland Aviation Services (JHAS) at Avalon in 2014<sup>8</sup> is perhaps an indicator of the need for MRO labour supply to be operationally embedded in the aviation/aerospace industry and its training and career pathways.

Aviation MRO-linked career paths include the supply of professional and supervisory services in regulatory, administrative and maintenance management roles. Importantly for the future of the

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<sup>5</sup> This claim has been made in relation to the B787 Dreamliner, but as Boeing Aerostructures Australia is the sole supplier of some airframe components, so it could become their repairer.

<sup>6</sup> The International Air Transport Association (IATA, 2012 pp. 21-22) has recognised both the safety and efficiency issues in the use of components subject to PMA and designated engineering representatives (DER) approval, and produced guidance designed to address what it argues are protective pressures from OEMs to make through-life maintenance contracts conditional on the use of more expensive original components.

<sup>7</sup> CASA, 2015b.

<sup>8</sup> O’Sullivan, 2014.

industry and occupation, professional services include the provision of maintenance training and maintenance support for flight training organisations. A key theme of this report is the need to secure the ongoing supply of qualified aeroskills educators and assessors in nationally registered training organisations (RTOs), in order to ensure an ongoing supply of qualified and licensed engineers and to take advantage of the opportunity to make Australia an Asia-Pacific training hub.

Other linked professional services, requiring varying qualifications and levels of technical skill, include maintenance and aeronautical engineering, engineering drafting, precision tooling, process management, testing, weighing, calibration, and the design and approval of structural modifications to aircraft.

After this scoping of the terrain within which Australian MRO work is located, the next step is to try to estimate the size and dimensions of its different demand, supply and utilisation elements.

### **3.3 The demand side – a mapping of Australian aircraft and air operators**

A picture of demand for MRO services can be gained by bringing together a count of civilian aircraft and their main characteristics, an estimate of the intensity of their use, and analysis of the maintenance strategies of air operators.

#### **3.3.1 Counts of civilian aircraft, classified by weight and age**

One indicator of the demand for MRO services is a count of VH aircraft on the CASA register.<sup>9</sup> Sorting these aircraft by size and age provides a clearer indicator of demand, based on generations of technology and also of cycles of demand for heavy maintenance overhaul.

Determining which of the 15,300 aircraft on the CASA register in August 2015 should be included in such a count, and how they should be classified, required a number of judgments that may influence the conclusions drawn. Our count was based on numbers and types of engines and so automatically excluded 1,390 gliders and manned balloons. It was also based on MTOW (maximum take-off weight), and included 1,443 aircraft weighing less than those in CASA's range for GA (681–5,700 kg). An unknown number of other aircraft on Recreational Aircraft of Australia (RA Aus) registration category of up to 680 kg MTOW were however not counted.<sup>10</sup>

Table 3.1 provides a breakdown of the age structure of the commercial fixed wing fleet – that is, international, main-route domestic and regional RPT and freight aircraft.<sup>11</sup>

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<sup>9</sup> All CASA VH-registered aircraft were included to reflect coverage by ICAO SARPs (the International Civil Aviation Association Standards and Recommended Practices).

<sup>10</sup> In interviews undertaken for this study, concern was expressed about a “regulatory twilight zone” whereby some aircraft registered with RA Aus fall outside the CASA registry and safety standards. Also included in the count were over 927 amateur built aircraft within the standard GA MTOW range. Some very old aircraft were included, such as DC3s, still used for tourist flights, or those re-engined with turboprops, for example for use in Antarctica. Warbirds and others in historic collections, requiring highly specialised maintenance, were not counted. The existence of an aircraft on the CASA register does not necessarily mean that it is still being flown.

<sup>11</sup> The word “commercial” is used to describe the fleet above 5,700 kg MTOW, corresponding to the ICAO's term “commercial – other” and the ARSA (Aeronautical Repair Station Association) term that excludes GA and business jets operated by their owners for internal company use.

Table 3.1 Commercial fixed-wing fleet on CASA register, August 2015, by age

| MTOW and engine configuration              | Examples                                   | Age in August 2015 and year range of manufacture |                         |                          |                          |                     |                          |
|--|--|--|-------------------------|--------------------------|--------------------------|---------------------|--------------------------|
|  |  | 0–5 yrs<br>(2010–2015)                           | 6–10 yrs<br>(2005–2009) | 11–20 yrs<br>(1995–2004) | >20 yrs<br>(before 1995) | Total in type group | Type group as % of fleet |
| <b>Over 100,000 kg turbofan</b>            | A330, A380. B777, B787                     | 31   | 22                      | 25                       | 7                        | <b>85</b>           | <b>8%</b>                |
| <i>% in age range</i>                      |  | 36%  | 26%                     | 29%                      | 8%                       | 100%                |                          |
| <b>50,001 –100,000 kg turbofan</b>         | A320, B737, B717, Embraer 190              | 116  | 79                      | 70                       | 10                       | <b>275</b>          | <b>27%</b>               |
| <i>% in age range</i>                      |  | 42%  | 29%                     | 25%                      | 4%                       | 100%                |                          |
| <b>20,001–50,000 kg turbofan/turbojet</b>  | Fokker F28; BAE /Avro, Bombardier – BD-700 | 5  | 12                      | 31                       | 58                       | <b>106</b>          | <b>20%</b>               |
| <i>% in age range</i>                      |  | 5%   | 11%                     | 29%                      | 55%                      | 100%                |                          |
| <b>20,001–50,000 kg turboprop</b>          | Bombardier DHC8-402; ATR; Fokker F27       | 25   | 20                      | 3                        | 15                       | <b>62</b>           | <b>12%</b>               |
| <i>% in age range</i>                      |  | 40%  | 32%                     | 5%                       | 24%                      | 100%                |                          |
| <b>20,001–50,000 kg piston</b>             | Fokker SP-2H                               | 0  | 1                       | 0                        | 5                        | <b>6</b>            | <b>1%</b>                |
| <i>% of type group</i>                     |  |  | 27%                     |                          | 83%                      | 100%                |                          |
| <b>5,701–20,000 kg turbofan</b>            | Learjet, Cessna CC, Bombardier CL-600      | 2  | 21                      | 32                       | 52                       | <b>107</b>          | <b>10%</b>               |
| <i>% in age range</i>                      |  | 2%   | 20%                     | 30%                      | 49%                      | 100%                |                          |
| <b>5,701 –20,000 kg multi turboprop</b>    | DHC-8-102 /315, SAAB, Embraer EMB-120      | 10   | 10                      | 91                       | 114                      | <b>225</b>          | <b>22%</b>               |
| <i>% in age range</i>                      |  | 4%   | 4%                      | 40%                      | 52%                      | 100%                |                          |
| <b>5,701–20,000 kg single turboprop</b>    | Air Tractor 802                            | 25   | 8                       | 27                       | 3                        | <b>63</b>           | <b>6%</b>                |
| <i>% in age range</i>                      |  | 40%  | 13%                     | 42%                      | 5%                       | 100%                |                          |
| <b>5,701–20,000 kg single/multi piston</b> | Cessna CC, Hawker Beechcraft               | 0  | 0                       | 1                        | 36                       | <b>37</b>           | <b>4%</b>                |
| <i>% in age range</i>                      |  |  |                         | 3%                       | 97%                      | 100%                |                          |
| <b>Totals</b>                              |  | <b>214</b>                                       | <b>173</b>              | <b>280</b>               | <b>300</b>               | <b>966</b>          | <b>100%</b>              |
| <i>Age range group as % of total</i>       |  | 22%  | 18%                     | 29%                      | 31%                      | 100%                |                          |

Source: CASA, 2015a

MTOW: maximum take-off weight

Broadly,

- There were 85 wide-bodied international route aircraft such as the Airbus A330 and A380 and the Boeing B777 and B787 Dreamliner; of these, 36% were less than 5 years old and 62% had been manufactured since 2005;
- There were 275 aircraft in the domestic main route fleet of aircraft such as the A320 and B737 and the smaller B717s used on lower-volume Canberra and Hobart flights; of these a quarter had been built since 2010 and 42% since 2005; some also used for flights to New Zealand and Asia-Pacific ports within range;
- Of the regional fleet of 106 turboprop aircraft in the 20,001–50,000 kg MTOW range, fully 84% were at least 11 years old. On the other hand, of the 62-strong regional turboprop fleet; used for economy on shorter routes and typically seating 60–100 passengers, 75% were less than 10 years old, predominantly Dash-8s, and the 15 post-2010 ATRs operated by Virgin;
- The term “commuter” – a Certificate of Airworthiness category— describes the 5,701 to 20,000 kg MTOW category in passenger transport. It encompassed viable regional routes using Embraers and Bombardiers seating up to 30 and the Rex fleet of 50 SAAB turboprops, all around 20 years old. The lower end included RPT and other passenger operations not regularly scheduled but publicly accessible. Such services used smaller aircraft seating around 9–12. Responding to rural demand for scheduled services based on aircraft with under 9 seats, currently debarred by air safety regulations from RPT operation, CASA in 2014 signalled a new combined RPT/charter category, “passenger transport activities”. Such aircraft would need to be maintained by Part 145 maintenance organisations.

Table 3.2 provides an estimate of the Australian GA fleet, drawn from the CASA database. Much GA sector MRO work is focused on ensuring the continued airworthiness of pre-1995 single-piston aircraft. Such work is important in its own right for rural and regional infrastructure, including freight and logistics, emergency fire services, oceanographic work, and medical services. GA maintenance calls for the resourcefulness, trouble-shooting skills and breadth of understanding to work across a range of aircraft types. Historically, GA has served as a training ground for other aviation sectors, including in deep maintenance and aircraft refurbishment. There is also a need for renewal, if GA is to play the vibrant role in regional development that it plays in the United States (US).

Finally, the rotary wing sector has shown a relatively high rate of growth and renewal, with 17% of the fleet under five years old and another quarter ten years old or less (Table 3.3). As in the GA fixed wing sector, the main concentration of aircraft was in the lighter MTOW single piston engine sector, but in the case of helicopters, the fleet was younger. Even where the basic structural design of a helicopter type is, there has also been an ongoing tendency to the installation of technological updates such as automatic stabilisers and navigation aids that arguably are becoming the industry standard.<sup>12</sup>

Statistics on fleet age and on waves of growth and acquisition serve not only as indicators of future patterns of technological demand that will be placed on maintenance engineers, but also as indicators of waves of demand for the different types of maintenance checks, from A to D. For example, where a high volume of aircraft has been acquired in the past five years, the next five years will see these aircraft move into their first heavy maintenance cycle. Table 3.4 and Figure 3.2 demonstrate the use of “renewal rate” indicators to help estimate maintenance demand. The

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<sup>12</sup> *Rotor & Wing International*, 2015, and correspondence with industry training provider, 1 September 2015.

civilian aviation sectors are arguably so different from each other that it makes little sense to compare their renewal rates against some assumed standard of technological development. New avionics equipment may be installed in older airframes, and advances in non-destructive testing of engines or landing gear, and in recoating may be applied to older aircraft. There have been generational shifts, such as composite technology. The regional sector currently faces a strong demand for upgrading, both in terms of fleet age and to meet the diversification of community demand noted above.

**Table 3.2 General Aviation fixed wing aircraft in the CASA register, August 2015, by category and age**

| Engine configuration   | Age in August 2015 and year of manufacture |                            |                             |                             |                       |               | Type group as % of all GA |
|------------------------|--|----------------------------|-----------------------------|-----------------------------|-----------------------|---------------|---------------------------|
|                        | 0–5 yrs<br>(2010–2015)                     | 6 to 10 yrs<br>(2006–2010) | 11 to 20 yrs<br>(1996–2005) | 21 to 40 yrs<br>(1976–1995) | >40 yrs<br>(Pre-1975) | Total         |                           |
| <b>Twin turbofan</b>   | 11   | 7                          | 8                           | 9                           | 2                     | 37            | 0.4%                      |
| % in each age range    | 30%  | 19%                        | 22%                         | 24%                         | 5%                    | 100%          |                           |
| <b>Twin turboprop</b>  | 16   | 31                         | 27                          | 146                         | 16                    | 236           | 2%                        |
| % in each age range    | 7%   | 13%                        | 11%                         | 62%                         | 7%                    | 100%          |                           |
| <b>Twin piston</b>     | 37   | 27                         | 24                          | 689                         | 458                   | 1,235         | 12%                       |
| % in each age range    | 3%   | 2%                         | 2%                          | 56%                         | 37%                   | 100%          |                           |
| <b>Twin diesel</b>     | 1  | 5                          | 0                           | 0                           | 0                     | 6             | 0.1%                      |
| % in each age range    | 17%  | 83%                        |                             |                             |                       | 100%          |                           |
| <b>Single turbofan</b> | 0  | 0                          | 0                           | 19                          | 1                     | 20            | 0.2%                      |
| % in each age range    |  |                            |                             | 95%                         | 5%                    | 100%          |                           |
| <b>Single turbojet</b> | 0  | 1                          | 0                           | 5                           | 23                    | 29            | 0.3%                      |
| % in each age range    |  | 3%                         |                             | 17%                         | 79%                   | 100%          |                           |
| <b>Single piston</b>   | 472  | 691                        | 1017                        | 3174                        | 3295                  | 8,649         | 85%                       |
| % in each age range    | 6%   | 8%                         | 12%                         | 36%                         | 38%                   | 100%          |                           |
| <b>Single diesel</b>   |  | 5                          | 3                           |                             |                       | 8             | 0.1%                      |
| % in each age range    |  | 63%                        | 37%                         |                             |                       | 100%          |                           |
| <b>TOTAL</b>           | <b>537</b>                                 | <b>762</b>                 | <b>1076</b>                 | <b>4042</b>                 | <b>3795</b>           | <b>10,212</b> | <b>100%</b>               |
|                        | 5%   | 7%                         | 11%                         | 40%                         | 37%                   |               |                           |

Source: CASA, 2015a.

**Table 3.3 Helicopters on CASA register, August 2015, by MTOW, configuration and age**

| MTOW           | Engine configuration | Age in August 2015 and year of manufacture (Number and % in age range) |                            |                             |                            |                       |       |                          |
|----------------|----------------------|--|----------------------------|-----------------------------|----------------------------|-----------------------|-------|--------------------------|
|                |                      | 0-5 yrs<br>(2010–2015)   | 6 to 10 yrs<br>(2005–2009) | 11 to 20 yrs<br>(1995–2004) | 21 to40 yrs<br>(1975–1994) | >40 yrs<br>(pre-1975) | Total | Type group as % of total |
| >5,700 kg      | Multi turboshaft     | 36   | 14                         | 1                           | 16                         | 0                     | 67    | 9%                       |
|                |                      | 54%  | 21%                        | 1%                          | 24%                        |                       |       |                          |
| Up to 5,700 kg |                      | 15   | 35                         | 39                          | 103                        | 1                     | 193   | 62%                      |
|                |                      | 8%   | 18%                        | 20%                         | 53%                        | 1%                    |       |                          |
| All <5,700 kg  | Single turboshaft    | 55   | 62                         | 57                          | 273                        | 94                    | 541   | 9%                       |
|                |                      | 10%  | 11%                        | 11%                         | 50%                        | 17%                   |       | 3%                       |
|                | Single piston/diesel | 255  | 443                        | 306                         | 234                        | 92                    | 1330  | 62%                      |
|                |                      | 19%  | 33%                        | 23%                         | 18%                        | 7%                    |       |                          |
| Total          |                      | 361  | 554                        | 403                         | 630                        | 187                   | 2,135 | 100%                     |
|                |                      | 17%  | 26%                        | 19%                         | 30%                        | 9%                    | 100%  |                          |

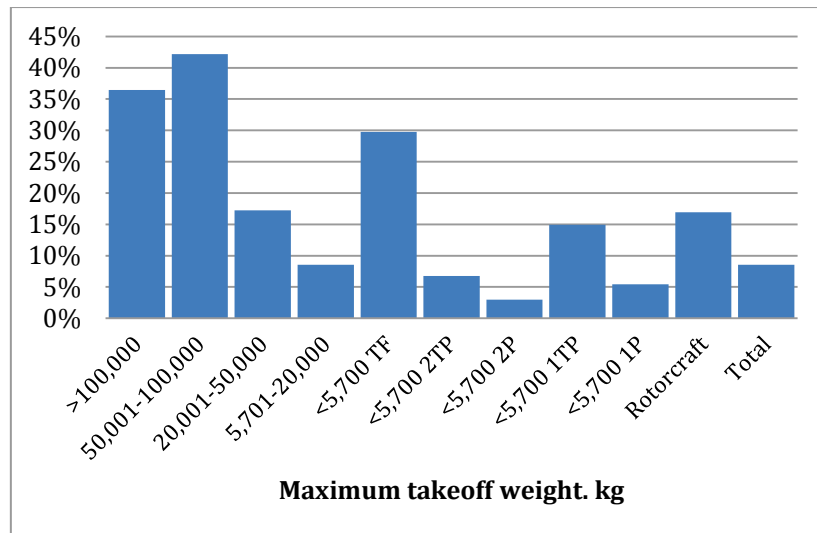
Source: CASA, 2015a

**Table 3.4 Aircraft aged <5 years in August 2015, by category**

| Category                             | Aged <5 years | Total VH-reg in category | % of category aged <5 years |
|--------------------------------------|---------------|--------------------------|-----------------------------|
| Widebody (over 100,000kg MTOW)       | 31            | 85                       | 36%                         |
| Single-aisle (50,001–100,000kg MTOW) | 116           | 275                      | 42%                         |
| Regional (20,001–50,000kg MTOW)      | 30            | 174                      | 17%                         |
| FW 5,701–20,000 MTOW                 | 37            | 432                      | 9%                          |
| GA 2-engine turbofan                 | 11            | 37                       | 30%                         |
| GA 2-engine turboprop                | 16            | 236                      | 7%                          |
| GA 2-engine piston (incl Diesel)     | 37            | 1237                     | 3%                          |
| GA 1-engine turboprop                | 50            | 335                      | 15%                         |
| GA 1-engine piston                   | 472           | 8657                     | 5%                          |
| Rotorcraft                           | 361           | 2135                     | 17%                         |
| Total                                | 1161          | 13603                    | 9%                          |

Source: Tables 3.1 to 3.3



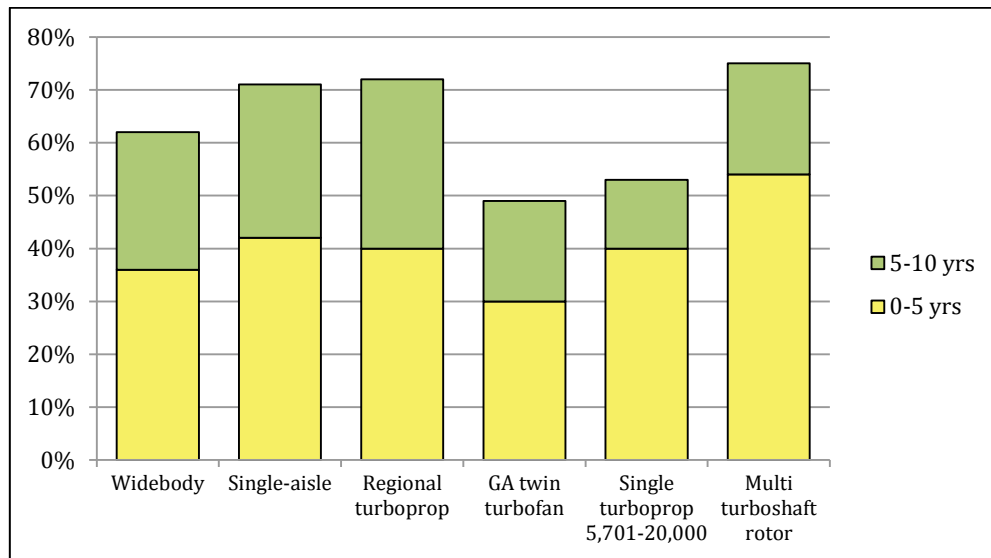


Source: Calculated from Tables 3.1 to 3.3

2TF = twin-engine turbofan, 2TP = twin-engine turboprop, 2P = twin-engine piston,  
1TP= single-engine turboprop, 1P=single-engine piston

**Figure 3.2 Five-year renewal rate (%) by category**

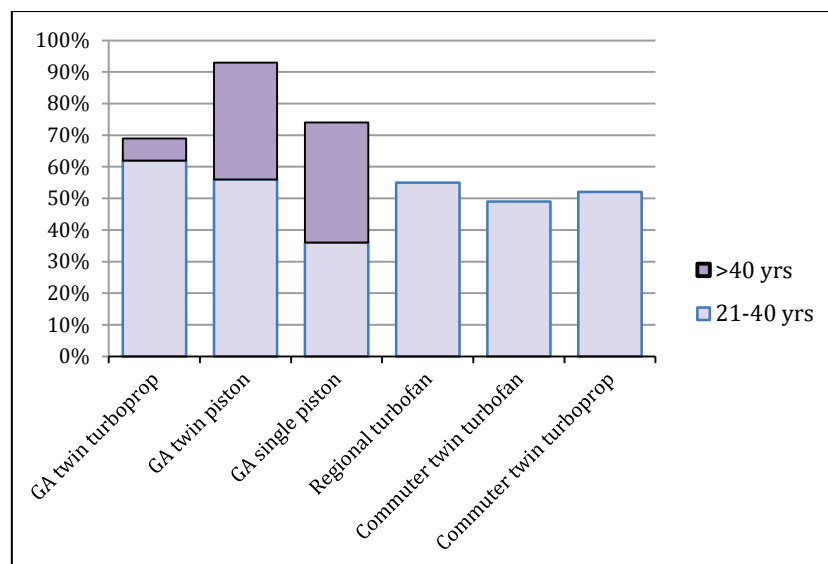
“Renewal rate” indicators are thus more meaningful at sector level than as measure of aggregate maintenance demand across sectors. Table 3.4 and Figure 3.2 use a renewal rate indicator based on aircraft aged 0–5 years to show that the highest rate of new aircraft acquisition over the past five years has been in domestic main-route airlines. Figures 3.3 and 3.4 provide further breakdowns of the aircraft categories with the highest percentages of aircraft under 10 years old and over 20 years old.



Source: Tables 3.1 to 3.3

Regional turboprop = 20,001 to 50,000kg MTOW

**Figure 3.3 Categories with highest percentages of aircraft less than ten years old**



Source: Calculated from Tables 3.1 to 3.3

Regional = 20,001 to 50,000 kg MTOW; Commuter = 5,701 to 20,000 kg MTOW

**Figure 3.4 Categories with highest percentages of aircraft over 20 years old**

As a way of estimating the overall volume of demand for maintenance services, simple aircraft counts cannot be used in aggregate or even for comparison across aviation sectors. The person-hours involved in a maintenance check, component overhaul or aircraft rebuild in the GA sector is very much less than that required for an airliner. Anecdotal estimates of the person-hours required for the D-checks of a single wide-bodied airliner range from a conservative 40,000 person-hours to 75,000 person-hours for B747s and typically such checks take several months to complete. The demand for maintenance services is a function of both number of aircraft and the frequency and distance they are flown. Manufacturer claims that D checks will be less frequent on next generation airliners are addressed in later chapters.

### 3.3.2 Estimates of intensity of aircraft use

One very rough indicator of intensity of aircraft use is the volume of civilian air traffic in Australia, based on movements of civilian aircraft through Australian airports monitored by Airservices Australia. This measure however includes international flights and does not include GA traffic using regional airports and rural airfields without control towers.<sup>13</sup>

Although the broad Airservices Australia category cut-offs differ from those used by CASA, wide-bodied aircraft operating in Australia are well over 136,000 kg MTOW, aircraft and so numbers in both categories represent the volume of international traffic.

The Airservices Australia 7,000 to 136,000 kg category includes both domestic and regional single-aisle aircraft, but excludes many of the low-volume “commuter” aircraft discussed above. At the upper end of the weight range, between 70,000 and 90,000, the A320, A321 and B737-800 have the range to provide services to New Zealand or South East Asian ports and to be ferried there for maintenance. Nevertheless, they are primary candidates for onshore maintenance, alongside the lower-weight regional “and commuter” aircraft that are definitely maintained here. It is noteworthy then that this weight range has accounted for the greatest increase in Australian monitored air traffic over the past decade (Table 3.5).

<sup>13</sup> Calculated from Airservices Australia, 2015.

**Table 3.5 Changes in monitored volume of annual aircraft movements, Australian airports, 2006 to 2014**

| MTOW                | >136,000 kg | 7,000 to 136,000 kg | <7,000 kg | Helicopters | Military | Total |
|---------------------|-------------|---------------------|-----------|-------------|----------|-------|
| Change 2006 to 2014 | 14%         | 31%                 | -21%      | 69%         | 51%      | 2%    |

Source: Calculated from Airservices Australia, 2015.

Monitored traffic in the under 7,000kg MTOW captures some GA traffic and low-volume commuter services to capital and regional hub airports, but it cannot be taken necessarily to reflect the volume of small aeroplane and helicopter traffic through rural airports not monitored by air traffic control, or those using private landing strips. The 21% decline in monitored traffic volume in this weight range may reflect trends towards the exclusion of GA aircraft from major airports, but it may also be linked to the differential trends in changes in aircraft numbers by sector discussed earlier. The increased volume of military aircraft movements reflects traffic in shared airports such as Townsville, and may also reflect the role of civilian contractors in undertaking Defence maintenance projects.

### 3.3.3 Australian Air Operator Certificate holder maintenance strategies

A third way of estimating trends in maintenance demand is by identifying the extent to which air operators have been performing their maintenance in-house or by contracting it out, and particularly whether the work is done on-shore or off-shore.

In February 2015, the CASA website database listed 936 Australian Air Operator Certificate (AOC) holders subject to its regulation, and 80 foreign operators over whom it had safety oversight. This list included all Class A air operators (airlines and GA operators approved to carry passengers on scheduled flights and medical airlift carriers) and some Class B (other GA) operators. Of the Australian AOC holders, 141 were identifiable from their websites as carrying out MRO work, either doing some at least of their own maintenance, or offering third-party maintenance as part of a range of services. Many of the remaining 795 AOC holders apparently relied on third-party MROs. Not included in this count were operators using aircraft for private or on-farm purposes, at least some of whom used MROs for 100-hours checks, maintenance and any repairs.

The following analysis shows that considerable heavy maintenance has continued to be done onshore in Australia, that the fastest-growing areas of heavy maintenance demand are those in aircraft type groups and categories most suited to onshore maintenance, and that there may be further scope for reversing recent offshoring trends.

#### *Airlines and freight carriers operating internationally*

Table 3.6 summarises the key recent maintenance strategies of Australian air operators with significant international operations. Aircraft most likely to be sent offshore for heavy maintenance are the wide bodied aircraft on the CASA register, almost half of which were shown (Table 3.1) to have been under ten years old in August 2015. The time between heavy maintenance checks for newer generation wide-bodied aircraft such as the B787 is expected to be double that for older aircraft.

In early 2015 Qantas entered a ten-year contract with Lufthansa Technik Philippines for the heavy maintenance of their A380 fleet.<sup>14</sup> They had retired all but one 767 and cited the phasing out of

<sup>14</sup> Australia Philippines Business Council (APBC), 2015.

B747s as justification for offshoring residual heavy 747 maintenance.<sup>15</sup> On the other hand, Qantas has undertaken a major onshore cabin refurbishment project for their A330 fleet in Brisbane, due for completion in 2016. Virgin Australia's 5 B777s were maintained by SIA in Singapore and maintenance of their 6 A330s was sent offshore after the JHAS Avalon contract fell apart in 2014.<sup>16</sup> As only 13 weeks' training is thought to be required to transition from the A330 to the A380, there is a basis for national capability on the latter, Virgin Australia has built the hangar space to maintain its small fleet of A330s and B777s in Sydney, and the goal of reversing the loss of Virgin A330 contracts from Avalon is one worth pursuing.

**Table 3.6 Main operators of aircraft >100,000 kg MTOW, by maintenance strategy, Australia, 2015.**

| Operator    | Aircraft             | Comment  |
|-------------|----------------------|--|
| Qantas      | Airbus A380-842      | 20-year lease on hangar at LAX for layover maintenance; Australian staff?<br>Maintenance off-shored: Base maintenance contract with Lufthansa Technik Philippines to 2023        |
|             | Airbus A330-202/203  | Heavy maintenance conducted in new Brisbane facility since 2010  |
|             | Airbus A330-303      |  |
|             | Boeing B767-338/381F | Upgraded on-shore in 2012; due to be retired except 2 assigned to Express Freighters   |
|             | Boeing B747-48E/438  | To be phased out; heavy maintenance withdrawn from Avalon to off-shore locations 2014  |
| Jetstar     | Airbus A330 -202     | Currently maintained in Singapore  |
|             | Boeing B787-8        | Qantas order for 14 larger 787-9, proceeding with option for 50  |
| Virgin Aust | Airbus A330-243      | Withdrawn from JHAS Avalon   |
|             | Boeing B777-3ZGER    | 2008–2013 contract with SIA for B777 maintenance; use of SIA subsidiary Aircraft Maintenance Service Australia; construction of Sydney wide-bodied heavy maintenance hangar 2011 |

Sources: APBC, 2015; *Australian Aviation*, 2014a; Chong, 2014; Freed, 2015; O'Sullivan, 2014, 2015; Qantas Airways, 2010; Virgin Australia, 2008, 2011.

### *Domestic/short haul airlines and freight carriers*

Table 3.7 summarises, current at 2015, the maintenance strategies of significant groups of Australian domestic main route operators of single-aisle aircraft such as the A320, A321 and B737, all with a MTOW between 70,000 and 90,000kg. By 2015, of the 275 such aircraft listed on the CASA register, 79% had been built in the last ten years (Table 3.7).

Qantas was conducting heavy maintenance of its 65 B737s at a newly consolidated three-line Brisbane facility: the taking-on of 30 apprentices, while welcome, does not offset the 535 job losses resulting from the closure of Tullamarine and Avalon wide-bodied heavy maintenance facilities.<sup>17</sup> Jetstar Airways, who in 2015 operated 53 Airbus A320s, opened a new multi-million dollar heavy maintenance base in Newcastle as part of its move to an all A320 fleet for short haul domestic and international operations. This generated 50 new engineering jobs, including new apprenticeship

<sup>15</sup> O'Sullivan, 2012; Qantas Airways, 2010; Qantas Airways, 2013.

<sup>16</sup> Virgin Australia, 2008; O'Sullivan, 2014.

<sup>17</sup> Qantas Airways, 2013.

positions, and there is the prospect of using this facility to support some of Jetstar's projected future A320-based growth in both Australian and some international markets.<sup>18</sup>

The Virgin 80-strong B737 fleet and two A320s had historically been maintained partly in New Zealand (NZ) and partly by JHAS. The opportunity to onshore more of this work, along with heavy maintenance on A330s and 18 Embraer EMB190-100 regional/main route aircraft, was lost in 2014, when Virgin cancelled its Avalon contract with JHAS, resulting in 125 redundancies. There is potentially hangar and employee capacity to bring some of this work to Australia, by building capacity. Tiger Airways (Virgin's LCC) operated 14 Airbus A320s in 2015. BAE Systems, the aerospace and Defence contractor, in what it described as a move into "adjacent markets", in 2013 signed a contract to provide base maintenance for Tiger Airways' A320s through to 2018, subsequently extending this agreement to include A320 line maintenance at Melbourne, Sydney and Brisbane.

There is considerable scope and capability for the further onshoring of heavy maintenance of these significant parts of the Australian-registered fleet.

**Table 3.7 Aircraft 50,001–100,000 kg MTOW - operator and maintenance provider, Australia, 2015.**

| Operator                    | Aircraft (numbers in CASA Register July 2015) | Maintenance   |
|-----------------------------|---|---|
| Qantas                      | 67 Boeing 737NG (600–900)                     | Heavy maintenance project in house, Brisbane  |
| Express Freighters (Qantas) | 4 Boeing 737 Classic (300 to 500)             | Maintained in-house Sydney  |
| Jetstar                     | 53 Airbus A320                                | Maintained in-house at Newcastle from 2015 – scope for A320/321 work for Asia-Pacific subsidiaries?   |
|                             | 6 Airbus A321                                 | Maintained offshore   |
|                             | 2 Airbus A320                                 | Maintained offshore   |
| Virgin Australia            | 80 Boeing 737NG (600–900)<br>18 Embraer       | Heavy maintenance mostly in NZ  |
| Tiger Airways               | 14 Airbus A320                                | Base maintenance by BAE Systems, Melbourne; line maintenance BAE Systems, Melbourne, Sydney, Brisbane |
| Skytraders                  | 2 Airbus A319                                 | Antarctic (& other govt) contracts  |
| Air Nauru                   | 6 Boeing 737NG (600–900)                      | Maintained in Brisbane  |
| Tasman Air Cargo (DHL)      | 1 Boeing 757                                  | Maintained in NZ  |

Sources: CASA, 2015a; BAE Systems, 2014; Chain, 2005; Creedy, 2013a; Jetstar, 2013; O'Sullivan, 2012, 2014; Qantas Airways, 2013.

### *Regional RPT/scheduled charter and freight services*

Table 3.8 summarises the maintenance strategies of some of the 30 regional operators identifiable in July 2015. In 2015, the regional RPT sector included 168 jets, turboprops and 6 legacy piston engine aircraft in the type range 20,000 to 50,000 kg MTOW range and the slightly heavier QantasLink fleet of 18 B717s, the latter purchased since 1999.

Virtually all these regional aircraft were maintained onshore, either in-house or by independent third-party MROs, sometimes on the basis of tied contracts. Some smaller regional and rural communities are losing their regular air services, if they cannot guarantee the annual passenger load

<sup>18</sup> Chain, 2005.

of 30,000 seen by operators as necessary for viability. In NSW by 2014, Rex was the only regional airline left in with Qantas, Jetstar, Virgin and most recently Tiger Air providing the remaining regional RPT services.

Operational consolidation of scheduled regional routes meant purchases, particularly through 2000–2009, of fleet additions at either the larger or smaller ends of the weight ranges listed above. Charter operators have been seeking to move into the resulting gap, regional airlines have acquired low-volume subsidiaries, or failed airlines have revived in smaller form, perhaps through employee buyouts (Fly Pelican). The CASA relaxation of the RPT/Charter operator boundary will require common maintenance safety standards and a resolution of issues of licensing scope.<sup>19</sup>

**Table 3.8 Examples —regional RPT operators, Australia, 2015.**

| Operator  | Aircraft (numbers in CASA register, July 2015)  | Maintenance   |
|---|---|---|
| National Jet Systems/<br>Cobham/QantasLink – CAMO, Pt 145 AMO | 18 Boeing 717-200 (53,000kg MTOW)   | To be maintained in-house in Canberra 2015–2020                         |
| Qantaslink (Sunstate, Eastern Airlines) – CAMO, Pt 145 AMO    | 48 Bombardier Dash-8 (16,000–29,000 kg)   | To be maintained in-house, Tamworth 2014–2019                           |
| Virgin Regional (formerly Skywest) – CAMO, Pt 145 AMO         | 14 ATR72–212A (22,000 kg MTOW, 68 seats)<br>8 Fokker F27 turboprop (20,000kg MTOW)<br>13 Fokker F28 turbofan (30,000kg MTOW, 100 seats) | ATR72 maintained by Toll.<br>Virgin Regional also operate 2 Airbus A320 |
| Regional Express (Rex)/Air Link-CAMO and Part 145 AMO         | 47 SAAB (22,700 kg MTOW)  | In-house maintenance – offers apprenticeships                           |
| Skippers WA – CAMO and Part 145 AMO                           | 10Dash-8 (29,000 kg MTOW, 70 seats)<br>7 Fokker F28/Fairchild) (c. 7,000kg MTOW)<br>6 Embraer (30 seat)<br>4 Cessna 441 (10 seat)       | Dash-8s some over 20 years old; Total fleet 27                          |
| Alliance Airlines Qld – CAMO and Part 145 AMO                 | 28 Fokker F28 Turbofan<br>7 Fokker F27 turboprop  | Maintained in-house in Brisbane   |
| Hardy/Fly Tiwi (NT) – CAMO and Part 145 AMO                   | 1 Embraer 120<br>Fairchild SA227 (19 seat)<br>22 Cessna<br>3 Beech  | Maintained in-house   |

Sources: CASA, 2015a; airline and aircraft manufacturer websites

<sup>19</sup> NSW Parliament Legislative Council, 2014, p. 16.

Examples of regional airlines and subsidiaries operating aircraft close to the GA boundary are:

- Pel-Air – Rex subsidiary; continuing airworthiness management organisation (CAMO) and Part 145 approved maintenance organisation (AMO) – operates small 18 Bombardiers, Learjets, and Hawker Beechcraft; has access to Rex SAABs
- Capiteq (Air North NT) – now 85% owned by Bristow – CAMO, uses ties maintenance contractor Aircraft Logistics; operates 9 Embraer 120-ER (c. 20,000kg MTOW, 30 seat) and 3 Fairchild SA227-DC (7,000 kg MTOW)
- Airlines of Tasmania (Par Avion) – CAMO and Part 145 AMO; operates a mix of 23 single/twin piston - Cessna 172, Beech 76, Pilatus, Piper, AeroCommander; maintained in-house
- Hinterland Queensland – CAMO & Part 145 AMO); operates a mix of 11 Cessna 208 and Beech B200; hangar at Cairns is a GA MRO offering modifications
- West Wing Queensland – CAMO which outsources all maintenance; operates a mix of 27 single/twin piston engine and turboprop aircraft. Mix of 27 single/twin piston and turboprop aircraft (Cessna 208, 208B, Beech B200 and Baron, Pilatus BN, Raytheon 1900, up to 19 seats, 7,700 kg MTOW).

The case of Cobham/Qantaslink illustrates the role of state and local governments, airports and airlines in working together to support the stabilisation of MRO capacity. Qantas provides regional services through the QantasLink network of subsidiaries and tied contractors. This network incorporates Sunstate and Eastern Australian Airlines, which operate a fleet mainly of turboprops in the eastern states, while National Jet Systems (trading as Cobham Aviation Services) operates Qantas' national regional jet network, supplying pilots, cabin crew, operations/management staff, and line and base maintenance technicians for the fleet of Boeing 717 jets, BAe regional jets and Bombardier Dash-8s. National Jet Express Pty Ltd (trading as Cobham Regional Services) also provides military and civil customers with services that include a "turnkey" charter fly-in-fly-out (FIFO) service, and a freight service (Australian Air Express). In response to the mining boom, in 2011 QantasLink opened a new subsidiary, Network Aviation, at Perth airport, operating both Dash 8-Q400s and Boeing 717s.<sup>20</sup>

In regional aviation, some Qantas outsourced operations are being brought back in-house, particularly where governments provide some financial support. In 2015, Cobham announced the return to Qantas of the heavy maintenance of 18 Boeing 717s in upgraded facilities at Canberra International Airport. Funding support from the Australian Capital Territory (ACT) government was expected to bring a return of \$5m per annum to the local economy. Maintenance checks on the B717 are reported to be required every 2 years, each taking 28 days or 5,500 person-hours, creating an estimated 40 maintenance jobs.<sup>21</sup> Moreover, at Tamworth Regional Airport, Qantas has opened and expanded an engineering and heavy maintenance facility employing approximately 100 staff, including 62 skilled engineers, to maintain the QantasLink fleet of 59 Dash-8 turboprops. Investment by the Tamworth local government and Qantas to build a second hangar was boosted by the New South Wales (NSW) government.<sup>22</sup>

### *General aviation – charter, corporate jets, helicopters and aerial work*

As an example of changing roles and relationships in this sector, Bristow Helicopters Australia, an affiliate of United Kingdom (UK)-based Bristow Group Inc, has CAMO status and is authorised by

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<sup>20</sup> Similarly, Virgin acquired Skywest Airlines in Perth.

<sup>21</sup> Australian Broadcasting Corporation (ABC) News, 2015a.

<sup>22</sup> *Australian Aviation*, 2014b; NSW Parliament Legislative Council, 2014.

CASA under Civil Aviation Safety Regulation (CASR) s21M to approve the design of modifications and repairs. Bristow operate 31 helicopters and employ 500 staff, specialising in FIFO and equipment transport to offshore oil and gas fields. In 2011 they partnered with Lockheed Martin to develop a rotary-wing training capability for Royal Australian Navy and Australian Army aircrews. Bristow also provide maintenance and logistics support to the Republic of Singapore Air Force helicopter fleet at Oakey Army Aviation Centre. In February 2015, the company moved into fixed-wing operation, taking over an 85% share in Air North, the largest operator across the northern part of Australia. This is a further instance of a realignment between the GA and RPT sectors, and also of Defence and civilian operations, again with implications for MRO activity and training.

### **3.4 The supply side – a mapping of the Australian MRO industry**

We turn now to an overview of MRO activities in Australia, identifying the role of both airlines and third-party providers, as well as providers of maintenance training and other regulated activities. Table 3.9 summarises types of MROs and related aviation and aerospace organisations listed by CASA in 2015, based on activities for which they have regulatory approval. Under CASR Part 42, every AOC holder in the Australian RPT sector is required to have an approved plan for managing the continuing airworthiness of its aircraft: in most cases RPT carriers manage their own plans in-house, and are responsible for airworthiness even when the administrative management is delegated to a third-party organisation.

MROs must transition to Part 145 AMO status by the end of 2015 if they are to provide maintenance services for aircraft or aeronautical products operating in the RPT sector. Table 3.9 indicates that some international airlines operating into Australia have gained CASA Part 145 approval. Some airlines in Table 3.9 have gained CASA accreditation as Part 42 CAMOs, but are not themselves Part 145 AMOs. Such airlines must be outsourcing all their line and base maintenance, because RPT operators are obliged to have Part 145 approval to carry out maintenance. Tiger Air is a case in point: it contracts maintenance to BAE Systems, one of the civilian contractors indicated in Table 3.9. This table confirms however that most airlines still conduct at least some of their maintenance work in-house and may also carry out third-party maintenance work for other operators. The gap between the number of regional airlines with Part 42 or Part 145 and the total number of such AOC holders (there are currently 30 regional airlines freight carriers) reflects not only the outsourcing of maintenance but the present fluidity between regional RPT and charter for some operators on low-volume routes.

Nevertheless, Table 3.9 also indicates the rise of third party MROs with Part 145 AMO status. 2015 is still a transition year in which those MROs seeking to work in the RPT sector may complete their Part 145 expositions, and there may also be MROs currently working on components for both RPT and GA aircraft who do not plan to transition to part 145: there is no requirement that they amend their Civil Aviation Regulation (CAR) 30 certificates to remove capability to maintain Class A aircraft and such arrangements are still under consultation. On the other hand, 17 MROs whose current work appears to be mainly on small GA aircraft have transitioned to Part 145, perhaps reflecting the move of some charter operators into more regular flights, as discussed above.

Of concern is the small number of Part 147-approved maintenance training organisations. To provide category training, it is necessary to be a Recognised Training Organisation, working within the Australian Qualifications Framework, as well as a CASA-recognised Part 147 MTO. Most of the Part 147 approvals for training are for specific aircraft types, not for category training, and are conducted by the manufacturer or by global providers such as CAE or Flight Safety International.

One of the central issues addressed in later chapters is the need for a restructuring and expansion of Australian maintenance training in the face of four challenges. The first challenge is a declining participation of airlines in the apprenticeship system, perhaps linked to trends towards offshoring



**Table 3.9 CASA-approved organisations, May 2015**

|  | Part 42<br>CAMO | Part 145<br>AMO | Part 147<br>Category MTO | Part 147<br>Type MTO | S 21M<br>Authorised<br>Person |
|--|-----------------|-----------------|--------------------------|----------------------|-------------------------------|
| Overseas airline                           | 4               | 9               | 0                        | 1                    | 0                             |
| Australian airline/freight                 | 7               | 4               | 0                        | 2                    | 0                             |
| Regional airline                           | 17              | 14              | 0                        | 1                    | 0                             |
| GA air operator                            | 2               | 2               | 0                        | 0                    | 0                             |
| Australian independent 3rd party MRO       | 7               | 53              | 0                        | 2                    | 6                             |
| Australian GA MRO                          | 0               | 17              | 0                        | 0                    | 1                             |
| Overseas MRO                               | 2               | 26              | 0                        | 1                    | 0                             |
| Civilian contractor                        | 0               | 2               | 0                        | 1                    | 0                             |
| Defence/civilian contractor                | 1               | 2               | 0                        | 1                    | 2                             |
| Aust OEM or branch of offshore OEM         | 0               | 7               | 0                        | 3                    | 0                             |
| CASA-approved offshore OEM                 | 0               | 9               | 0                        | 11                   | 0                             |
| Australia supply chain manufacturer        | 0               | 6               | 0                        | 0                    | 0                             |
| Aviation services - Logistics/parts supply | 0               | 2               | 0                        | 0                    | 0                             |
| Australian RTO                             | 0               | 0               | 4                        | 2                    | 0                             |
| Other Australian based training org.       | 0               | 0               | 0                        | 4                    | 0                             |
| Offshore training organisation             | 0               | 0               | 0                        | 9                    | 0                             |
| Professional/engineering services          | 0               | 0               | 0                        | 0                    | 21                            |
| <b>Total</b>                               | <b>40</b>       | <b>153</b>      | <b>4</b>                 | <b>36</b>            | <b>34</b>                     |

Source: CASA, 2015b, 2015c.

and the growing role of independent MROs and OEMs in the provision of maintenance services. The second is a perceived need for better alignment between Australian training pathways and the non-airline sector. The third is a question of the relationship of Australian qualifications to international training standards in a global industry.<sup>23</sup> The fourth is a move of training providers into the wider aviation market, by offering a training mix that covers maintenance, flight training and other aviation services, potentially to an international market.

The discussion that follows picks up on the strategic and conceptual framework set out in Section 3.2 and is based on a mapping of industry directories and organisations' websites, and on survey and interview data produced in the course of the research project on which this study is based. It is designed to provide concrete case study examples, and some quantitative data, supporting and illustrating this analysis.

### 3.4.1 Stand-alone MROs

The term "third party" is used in this report to describe stand-alone or independent MROs working on aircraft of a range of sizes and complexity or on the components of such aircraft, up to and including jetliners and including both fixed wing and rotary civilian aircraft. In Tables 3.7, 3.8 and 3.9, the term "independent third party" is reserved for MROs that provide services that extend beyond the GA sector. The majority of MROs identified were in the GA sector, with capabilities for work on aircraft up to 5,700 kg MTOW of varying age and complexity. A minority have tied contracts with one or several AOC holders. It is hard to determine the exact number of independent third-party and GA-

<sup>23</sup> For the first three challenges, see Cannane, no date but circa 2015.

specific MROs, because of the difficulty of drawing the line between those working on aircraft in airport hangars and those working in component overhaul shops. In 2014 we were able to map 345 stand-alone MRO organisations in Australia with verifiable listings in databases and current web pages.<sup>24</sup> Presumably, some of these would have had CAR30 approval to work on aircraft up to 8,000kgs.

In NSW, the main concentration of capital city MROs, both third party and GA, was in Western and Southwestern Sydney (see Table 3.10). In Victoria, the bulk of maintenance activity occurred at Tullamarine, Essendon and Moorabbin, with Avalon currently under-utilised. In Queensland, there was a high volume of both independent third party and GA maintenance organisations up and down the coast, from Townsville and Cairns to the Sunshine Coast and Gold Coast. In South Australia, MRO activity was concentrated at both Adelaide and Parafield. In Western Australia, most work took place either in Perth and Jandakot or in the north-west, servicing mining, oil, pastoral and tourism operators.

**Table 3.10 Stand-alone MROs, Australia 2014**

| State/Territory           | Region                  | Independent 3rd Party MRO | GA MRO     |
|---------------------------|-------------------------|---------------------------|------------|
| <b>ACT</b>                | <b>Total ACT</b>        | <b>2</b>                  | <b>0</b>   |
| <b>NSW</b>                | Capital                 | 18                        | 23         |
|                           | Regional/Rural          | 6                         | 44         |
|                           | <b>Total NSW</b>        | <b>23</b>                 | <b>68</b>  |
| <b>Northern Territory</b> | <b>Total NT</b>         | <b>2</b>                  | <b>16</b>  |
| <b>Queensland</b>         | Capital                 | 12                        | 20         |
|                           | Regional/Rural          | 14                        | 59         |
|                           | <b>Total Queensland</b> | <b>26</b>                 | <b>79</b>  |
| <b>South Australia</b>    | <b>Combined SA</b>      | <b>6</b>                  | <b>13</b>  |
| <b>Tasmania</b>           | <b>Combined TAS</b>     | <b>1</b>                  | <b>1</b>   |
| <b>Victoria</b>           | <b>Total Victoria</b>   | <b>15</b>                 | <b>53</b>  |
| <b>Western Australia</b>  | Capital                 | 8                         | 22         |
|                           | Regional/Rural          | 1                         | 11         |
|                           | <b>Total WA</b>         | <b>9</b>                  | <b>33</b>  |
| <b>Total Australia</b>    | <b>TOTAL AUSTRALIA</b>  | <b>84</b>                 | <b>262</b> |

Sources: AMROBA, 2015; AIU, 2014; Aviation/Aerospace Australia, 2015; CASA, 2015b; IS-BAH, 2014; SADIG, 2014.

<sup>24</sup> The figure of 345 is a conservative estimate: we began a survey of MROs with a list of over 700 but only half had websites, almost 100 envelopes in the survey mailout were returned as “not at this address” and a handful wrote to advise that they did no aircraft-related work. At most we could identify a sampling frame of 400, with 345 verifications.

Examples of specialised third-party MROs include:

- Engine overhaul firms such as TAE Aviation Ltd, the latter also providing through-life service for Honeywell and having FAA-recognised Australian parts manufacturing approval (APMA) replacement parts approval. Piston engine specialist Bilyara at Bankstown advertises the use of NDT (non-destructive testing) techniques;<sup>25</sup>
- Perth-based Aerospace NDI Ltd, which began by providing NDT services, and expanded into wheel and brake, undercarriage maintenance and repair and most recently precision tooling and machining;<sup>26</sup>
- The Hawker Pacific MRO facility, opened at Cairns International Airport in 2005, providing maintenance and aircraft on ground (AOG)/supply chain management services in Australia, Asia and the South Pacific, with OEM approval for through-life servicing and repair of a range of parts and equipment. It has CASA approval for heavy maintenance repair and overhaul of Boeing 737s and Airbus A320s, as well as line maintenance for wide-bodied A330s. Its subsidiary Australian Avionics has a large AOG rental/exchange pool and employs on-call tarmac service staff with electrical and avionics licences. The design engineering department has CASA Part 21M and Papua New Guinea (PNG) CASA Part 146 Design Organisation approvals for structural and avionics modifications and flight manual supplements, and carries out work ranging from avionics upgrades on aging aircraft, to installations and ongoing support for new first-of-type and customised avionics solutions.<sup>27</sup>

### 3.4.2 MRO work performed by OEMs: aerospace manufacturing and aviation industry linkages

Table 3.11 seeks to quantify the linkages in the conceptual model Figure 3.1. Particularly in the areas of aviation services and manufacturing, Table 3.11 is likely to represent a significant understatement of the true extent of the network of organisations in the MRO supply chain. Manufacturing Skills Australia (MSA) nominate a figure of 1,019 enterprises in this wider network and estimate that they generate 13,720 jobs and \$1.784 billion annually in revenue. These estimates are based on an assumption that MRO outputs account for 29.8% of the products and services of this network.<sup>28</sup> These products and services include the manufacture of aircraft engines, airframes, whole small aircraft and gliders and guided missiles, as well as the MRO of aircraft, engines and avionics. By contrast, Table 3.11 was compiled publicly available directories and website verifications. It is particularly likely to under-represent manufacturers in the supply chain.

The Defence contractors in Table 3.11 are restricted to civilian organisations identified as supplying aircraft and component MRO services, for example Australian Aerospace (now Airbus) providing deep maintenance of PC-Orion and Hercules aircraft, or in a range of large to small Defence suppliers such as BAE Systems, the Hunternet member Communications-Electronic Solutions, and ruggedized avionics suppliers such as South Australian-based APC Technology.<sup>29</sup>

Table 3.11 also takes account of the emerging maintenance, repair and overhaul role of OEMs, and the increasing difficulty of separating the supply chain into a simple model of manufacturing inputs, manufacture and assembly and afterservice. As well as links into the afterservice market, OEMs rely

<sup>25</sup> TAE, 2015; Bilyara, 2015.

<sup>26</sup> Aerospace NDI, Pty Ltd, 2015.

<sup>27</sup> Australasian Aviation Group, Cairns (AAG-C), 2015.

<sup>28</sup> Manufacturing Skills Australia (MSA), 2015a.

<sup>29</sup> BAE Systems, 2015a; Communications-Electronic Solutions Ltd, 2015; APC Technology, 2015.

on supply chain linkages with engineering manufacturers. Australia attractive to OEMs, both as a source of suppliers and also, drawing through to afterservice, as ongoing MRO providers and creators of the parts, components and processes that are inputs into MRO work. For example the design, precision processing, treatment, and additive manufacturing of materials, electronic components and integrated systems no longer has an end-point with the production of an aircraft. Rather, the ongoing diagnostic feedback from operational aircraft and components means that MRO is increasingly integrated into the production process.

**Table 3.11 Organisations undertaking aircraft maintenance and related aviation or aerospace activities, Australia, 2014 (a selective list)**

|  | ACT       | NSW        | NT        | QLD        | SA        | TAS      | VIC        | WA        | Total AUST |
|--|-----------|------------|-----------|------------|-----------|----------|------------|-----------|------------|
| Aust Main Route RPT/Freight              | 0         | 3          | 0         | 2          | 0         | 0        | 3          | 4         | 8          |
| Airline Operating Offshore (Air Nauru)   | 0         | 0          | 0         | 1          | 0         | 0        | 0          | 0         | 1          |
| Regional RPT                             | 1         | 2          | 3         | 4          | 2         | 1        | 1          | 2         | 16         |
| GA Air Operator doing some maintenance   | 1         | 27         | 8         | 33         | 7         | 31       | 16         | 23        | 116        |
| Defence contractor                       | 5         | 30         | 0         | 7          | 9         | 0        | 14         | 2         | 67         |
| Aust independent 3rd Party MRO           | 2         | 24         | 2         | 26         | 6         | 0        | 15         | 9         | 84         |
| GA MRO                                   | 0         | 67         | 16        | 79         | 13        | 1        | 53         | 33        | 262        |
| OEM                                      | 2         | 7          | 0         | 5          | 3         | 0        | 4          | 0         | 21         |
| Education/Training (Flight, Maintenance) | 1         | 13         | 0         | 7          | 2         | 1        | 19         | 4         | 47         |
| Aviation Services                        | 2         | 26         | 5         | 30         | 6         | 0        | 32         | 14        | 115        |
| Aerospace Manufacturer                   | 1         | 40         | 2         | 18         | 13        | 2        | 38         | 7         | 122        |
| Professional Services                    | 1         | 18         | 0         | 12         | 4         | 0        | 23         | 4         | 66         |
| <b>Total</b>                             | <b>16</b> | <b>257</b> | <b>36</b> | <b>224</b> | <b>65</b> | <b>8</b> | <b>219</b> | <b>98</b> | <b>923</b> |

Sources: AMROBA, 2015; AIU, 2014; Australian Defence Magazine (2014); Australian and New Zealand Defence Directory, 2014; Aviation WA, 2013; Aviation/Aerospace Australia, 2015; CASA, 2015b; IS-BAH, 2014; SADIG, 2014. This table excludes recreational aviation.

Some examples are worth citing, as indicators of strategic possibilities for integrating Australian MRO work into OEM supply chains, and as indicators of why Australia is now less subject to the tyranny of distance and is increasingly being seen as the Asia-Pacific hub for OEMs and Defence contractors. With the right support from governments and airports, there is now opportunity to embed maintenance within support for the life cycle of aircraft, and into a process of continuous aerospace innovation.

The examples begin with the two large aircraft manufacturers. Boeing has established a large footprint in Australia, and advertises the advantages of the link between its manufacturing and maintenance subsidiaries here. Following its acquisition of Hawker de Havilland, Boeing Aerostructures Australia became the sole manufacturer of structural composite components for the Dreamliner, the B737 and the B777, exporting them back to the USA for assembly. Relatively unusually for MROs, BACR (Boeing Australia Component Repairs) has direct OEM links, and hence ties to Boeing Research & Technology-Australia, the Aviall parts network supply and Boeing Defence

Australia.<sup>30</sup> Similarly in 2014, the OEM Airbus acquired an Australian foothold by taking over Australian Aerospace, as part of a global consolidation of Eurocopter, EADS and Airbus manufacture and afterservice. In the process, it has acquired MRO capabilities across civilian and Defence fixed and rotary wing operations, including in deep maintenance conversions of large aircraft. Three of the 36 type training organisations listed in Table 3.9 are Airbus subsidiaries.

In the small aircraft sector, Pilatus also appears to be positioning itself, not only as a Part 147 training organisation, but as an OEM of the PC-9 turboprop flight training aircraft, working with Australian advanced manufactures in its production. Lockheed Martin in 2011 signed a Global Supply Chain Deed with the Australian Government to survey local capabilities for incorporation into its global supply chain, and has forged links with a range of Australian manufactures and Defence contractors such as Bristow, which has secured Part 147 type training approval.<sup>31</sup> These OEMs would appear at the very least to be keeping their options open for engagement in significant maintenance workforce development in the Asia-Pacific region.

Chapter 11 and Appendix 3 provide further examples of firms that appear to see Australia, not as the end of the line, but as a hub of their Asia-Pacific operations. Thus Table 3.11 provides a reflection of the changing interface between the manufacturing, operational and service aspects of the aviation and aerospace industry. Afterservice includes work in the logistics supply chains of parts delivery, as well as in the sale, leasing, shared ownership and hire of aircraft. It requires varying degrees of technical knowledge, up to and including the full maintenance and repair qualifications required for rapid-response AOG (aircraft on ground) services.

On the one hand, as OEMs increase the flow of diagnostic data built into aircraft, the tighter integration of manufacture and maintenance seems likely, tending to “lock up” knowledge and maintenance work. On the other hand, this is only part of the story: it has been argued above that safety assurance and workforce development and mobility depend on the countervailing presence of strong MRO capability in the airline and independent MRO sectors, and on a publicly accessible maintenance training industry that is not tied to specific OEMs, but is able to serve all aviation sectors, including GA, within Australia and the Asia-Pacific region.

The final grouping in Table 3.11 the are 66 organisations and individuals providing professional services, such as auditors, manual writers and authorised approvers of design modifications under CASR S 21M. In terms of professional services, however, it is instructive to return to the statistics in Table 3.9 and to identify the extent to which it is OEMs, rather than airlines, who are setting themselves up to invest in maintenance training. National investment in strategically focused aeroskills training is more than ever needed to prove a matrix for the type training that is now on offer.

### **3.4.3 Perspectives of MRO managers, particularly in the GA sector**

As 262 of the 345 independent MROs identified in Tables 3.9 to 3.11 were in the GA sector which is the backbone of regional and rural working aviation, it is important to have an understanding of their business. We surveyed MRO owners and managers in 2013 and received 73 responses, mainly from the GA sector, with 30% providing services to charter operators. 66% engaged in component MRO and 11% in tied contracts with OEMs to service aircraft or components. Several firms carried out both these functions and a range of other servicing types. Of those who identified as specialists, the main service specialisations were: structure/airframe (68%), engines (59%), mechanical components (47%) and instrumentation 24%. The main components serviced or supplied were engines (32%) and avionics (23%). 67% of respondents were working on fixed wing aircraft, with

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<sup>30</sup> Boeing Australia Component Repairs, 2015.

<sup>31</sup> Lockheed Martin Australia, 2015.

Cessna (71%) and Piper (42%) being the main types serviced. Just on 48% of firms serviced their local region, with 24% servicing their own or an adjacent state and 23% servicing national customers. The profile of these firms' workforce indicates that 62% of them had between one and nine employees or contractors, 19% were sole traders, 9% employed between 10 and 29 people and just over 10% had 30 or more employees or contractors.

This 2013 survey of MROs revealed a mixed picture in terms of performance and expectations. The majority of respondents appeared to be more optimistic than pessimistic about their future trading performance. Compared against the last five years, 45% believed that business turnover in the next five years would be higher (6% much higher), just under 29% the same, and 21% that it would be lower (6% much lower). This extended to their assessment of their business's viability, with 33% expressing themselves reasonably confident that it would be viable in five years' time, 17% very confident, 21% not very confident, and 17% not at all confident. The majority of the firms surveyed (41%) had remained much the same size in workforce numbers over the past four years. However, 16% were much smaller, 15% were a little smaller, 21% a little larger and 6% much larger. On balance it appears the surveyed sector had contracted slightly over the period.<sup>32</sup>

### **3.5 The MRO workforce**

#### **3.5.1 Numbers and capabilities**

The 2011 Census (the latest accurate data) shows a total of 8,795 persons employed in the Aircraft Maintenance and Repair (Australian and New Zealand Standard Industry Classification (ANZSIC) 2394) industry class. However, this does not include aircraft maintenance workers who gave their industry as Air and Space Transport, who accounted for 36.31% of the 14,489 employed persons giving their occupation as Aircraft Maintenance Engineer (Australian and New Zealand Standard Classification of Occupations (ANZSCO) 3231), as opposed to 4,157 (33%) in aircraft maintenance and repair. A further 3,861 (30.7%) of persons working in that occupation gave their industry of employment as Defence, apparently indicating that they were employed in a Defence establishment, though not necessarily as serving Defence personnel. All indications suggest that this total has fallen significantly over the intervening period, with various official estimates putting the annual attrition at anywhere between 2.5% and 16%. These estimates are discussed in more detail in Chapter 9, where an attempt will be made to update them to the start of 2015.

The AME workforce is overwhelmingly qualified at the trades or technician level, and hence would presumably qualify as "technicians" in the FAA/CAVOK classification. The great majority of respondents in 2011 who gave their occupation as AME held qualifications at the Certificate level. 51.8% had a Certificate III as their highest level of qualification, and a further 15.3% were qualified to Certificate IV, at that stage the minimum level at which new recruits were expected to be qualified before they were able to study for a licence. Diploma, advanced diploma or associate degree qualifications, which correspond broadly to the current minimum requirement for grant of a B licence, were held by a further 12.2%. At the ends of the distribution, 5% held a bachelor's degree and a further 1.6% some kind of postgraduate qualification, while 11% reported holding no post-

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<sup>32</sup> We are cautious about extrapolating too strongly from these results, since the achieved sample was quite small (73 out of a sample frame that began with 700 but was reduced by elimination of apparently 400). The actual response rate may have been closer to 20%, as 50 of the forms sent out were returned to sender, the most likely explanation being that the businesses in question had ceased trading. While such a response rate is acceptable in principle for a business survey of this kind, we cannot be certain that the achieved sample was representative.

school qualifications.<sup>33</sup> Perhaps surprisingly, the share of respondents in the occupation who held certificate or diploma-level qualifications fell marginally between 2006 and 2011, a drop that was offset by a rise in the proportion who were university-qualified.<sup>34</sup>

### 3.5.2 Career mobility and skill transfer within and across aviation and aerospace sectors

Mobility of individual workers within and across the aviation and aerospace sectors identified above could help retain the widest possible pool of skilled workers, minimising skill wastage; and provide a buffering amidst industry restructuring. It could potentially contribute to a deepening of technical and process management skills, based on contextual understanding of the industry, resulting in innovation through cross-fertilisation of techniques and ideas.

The question of aircraft maintenance career paths was explored in 2012, when the project team surveyed a convenience sample of aircraft maintenance engineers (AMEs) and licensed aircraft maintenance engineers (LAMEs)<sup>35</sup> and received 708 responses, of which 697 contained usable answers to career path questions. The responses revealed some internal career paths, as well as ease of re-entering main MRO occupations after time out, and a degree of mobility across the areas identified above. Some skill wastage was also indicated, with scope for greater alignment between aeroskills and manufacturing skills.

Table 3.12 provides a broad indicator of individuals' movements along internal and external career paths within aviation/aerospace, by comparing their first job with their most recent job. For almost all of the respondents there was some form of career progression within aviation. The majority of respondents, 96%, reported starting their aviation careers as LAMEs, AMEs or apprentices with over half, 61%, progressing to become licensed aircraft maintenance engineers. A further 17% of respondents had progressed into roles in management, as professionals, in operations management or as supervisors.

In contrast only 20% of respondents either remained un-licensed or had let their licenses lapse and less than 2% of respondents moved from management, professional, operations management or supervisory roles to either LAME or AME.

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<sup>33</sup> These are likely to include many older licensees who were able to progress through to the grant of a licence and subsequent permissions through self-directed learning and experience, at a time when there were few or no specialist training courses for AMEs. Annex 1 to the Chicago Convention, which sets the requirements to qualify for a licence, still provides a legitimate pathway in which the necessary skills are learnt on the job, though the current Australian licensing scheme no longer allows this. (See chapter 8.)

<sup>34</sup> While the Census did not include questions on this matter, it seems probable that many of these would be migrants who got their initial training in countries where the standard preparation for an AME takes the form of a bachelor's degree.

<sup>35</sup> The sampling frame was compiled through the recruitment of volunteers by two project Partner Organisations. Thanks to all involved.

**Table 3.12 Career pathways – Australian maintenance engineers surveyed 2012**

| First job in aviation | Most recent job in aviation |                |     |      |            |                    |               |                  | Total valid |
|-----------------------|-----------------------------|----------------|-----|------|------------|--------------------|---------------|------------------|-------------|
|                       | Apprentice                  | Aviation other | AME | LAME | Supervisor | Operations Manager | Professional* | Aviation Manager |             |
| Apprentice            | 0                           | 0              | 16  | 106  | 19         | 14                 | 15            | 10               | 180         |
| Aviation other        | 0                           | 0              | 2   | 2    | 1          | 0                  | 0             | 0                | 5           |
| AME                   | 1                           | 1              | 120 | 128  | 9          | 5                  | 12            | 9                | 285         |
| LAME                  | 0                           | 0              | 4   | 157  | 1          | 2                  | 7             | 5                | 175         |
| Supervisor            | 0                           | 0              | 1   | 3    | 6          | 0                  | 0             | 0                | 10          |
| Operations Manager    | 0                           | 0              | 0   | 0    | 0          | 2                  | 0             | 0                | 2           |
| Professional          | 0                           | 0              | 1   | 2    | 0          | 0                  | 1             | 3                | 7           |
| Aviation Manager      | 0                           | 0              | 0   | 2    | 0          | 0                  | 1             | 1                | 4           |
| Total valid           | 1                           | 2              | 144 | 399  | 36         | 23                 | 36            | 28               | 669         |

Source: Survey conducted as part of Linkage Project LP110100335. Total responses: 708. Responses usable for this question: 669

\*Professional – any occupation so defined in ANZSCO (ABS, 2006b), eg teacher, engineer, auditor

Table 3.13 shows respondents' mobility between sectors of the aviation industry by comparing the sector of their first aviation employment to that of their most recent. One third of respondents, 33%, both started and finished their career with Qantas with an additional 20% beginning and ending their careers in airlines. Overall, 61% of respondents had started their aviation careers with airlines, 37% with Qantas. At the time of the survey in 2012, 73% of respondents were working for airlines, with over 60% working for Qantas.

Over 18% of respondents had started their aviation careers in Defence, with all but one respondent having moved into civilian aviation. While 28 respondents had started in aviation working for an OEM or OEM distributor/after-service provider, only two had remained in that role, most moving to employment with Qantas. Movement into and out of GA/helicopter appeared relatively fluid. About 11% of respondents had started their careers in the sector with 10% being employed in the sector in 2012. About one third of respondents working in GA/Helicopter had both started and continued to work in the sector, a third had started in GA and ended up at Qantas, with another 13% each moving to other airlines or independent MROs.

Table 3.13 reflects impacts of the expansion in stand-alone MROs. While fewer than 3% of respondents had started their aviation careers in the independent MRO sector, nearly 9% were working for independent MROs in 2012. They had come mainly from other Australian main route airline operators (20%), GA/ helicopter operators (32%), or a defence facility (32%).

In terms of occupational mobility into and out of aviation, the survey responses provided mixed evidence. Qualifications allowed a return to the occupation/industry, and some movement into other technician/trade areas, but there was also some evidence of skill wastage. Only half of the 161 respondents (23%) who stated that they had left aviation at some point in their career had actually made a clean break to another role. Of the 85 respondents who recorded their work history outside of aviation only six had not returned to aviation.

Most of those who had left (86%) had been employed as apprentices, AMEs or LAMEs prior to leaving. Of these, 51% had been able to redeploy their skills as technicians and trades workers while



8% worked as machinery operators and drivers, 16% went into labouring jobs and 8% went into community and personal service, and 8% into sales. Very few had found work as managers or professionals outside aviation. In terms of the main industries in which aviation leavers found work, one third moved into manufacturing (transport equipment manufacturing such as boat manufacturing or fabricated metal product manufacturing). Another third went into construction, transport, postal and warehousing, and retail trade, and 7% into the category “other maintenance service” (eg automotive, machinery and equipment repair and maintenance).

The main reasons given for leaving aviation included retrenchment (45%), better work opportunities elsewhere (44%), and dissatisfaction with conditions (42%). Over three-quarters found their qualifications and experience “of some use” in gaining and carrying out their new job, although the number finding these “very useful” was lower, at around one-third. It is notable that 47% of all industry leavers returned to work with airlines. Qantas had the highest attrition rate, with 14% of those leaving aviation coming from Qantas, but also employed the largest share of those returning to aviation (26% of all industry leavers). Both Qantas and the airlines overall employed more leavers than they lost, 26% of those who left employment with airlines returned to work with airlines, and 7% left work with Qantas only to return to Qantas. High attrition rates were also reported for Defence facilities (21%) and GA/ helicopter (14%), while sectors accepting returners included Independent MROs (17%) and GA/ helicopter (11%). These figures suggest a need to explore effective workforce management strategies in the face of aviation industry volatility.<sup>36</sup>

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<sup>36</sup> Sarina and Wright, 2015.

**Table 3.13 Sectoral mobility – Australian maintenance engineers surveyed 2012**

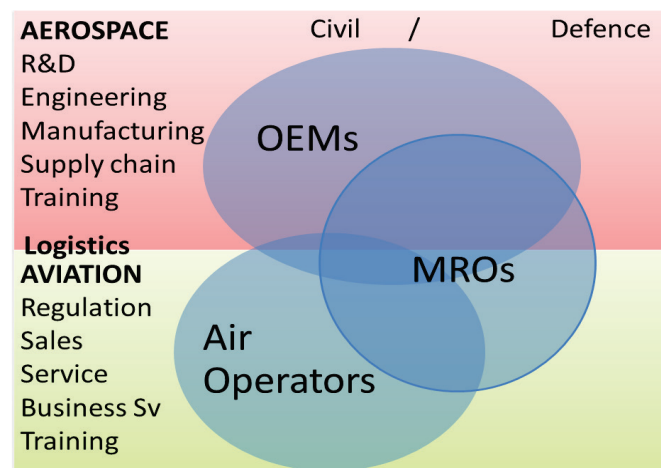
| Sector of employment – Most recent job in aviation |  |  |                             |                            |         |                |                 |                  |                  |                               |                        |                                |                            |                          |
|--|--|--|-----------------------------|----------------------------|---------|----------------|-----------------|------------------|------------------|-------------------------------|------------------------|--------------------------------|----------------------------|--------------------------|
| Sector of employment - first job in aviation       |  | Sector of employment – Most recent job in aviation |                             |                            |         |                |                 |                  |                  |                               |                        |                                |                            |                          |
|  |  | Airline operator Australian main route             | Airline operator - regional | Airline operator - foreign | Freight | GA/ helicopter | Independent MRO | OEM/ distributor | Defence facility | Defence contractor / Supplier | Government/ non profit | Education / Training/ research | Self Employed / contractor | Not employed in aviation |
| Qantas   |  | 220  | 3                           | 4                          | 1       | 4              | 3               | 0                | 0                | 1                             | 4                      | 1                              | 0                          | 3                        |
| Airline operator - Australian main route other     |  | 33   | 2                           | 0                          | 0       | 5              | 13              | 0                | 0                | 0                             | 1                      | 1                              | 0                          | 0                        |
| Airline operator - regional                        |  | 26   | 7                           | 1                          | 0       | 3              | 3               | 0                | 0                | 0                             | 0                      | 0                              | 0                          | 1                        |
| Airline operator - foreign                         |  | 22   | 3                           | 2                          | 0       | 6              | 1               | 1                | 0                | 1                             | 0                      | 0                              | 1                          | 0                        |
| GA/ helicopter                                     |  | 23   | 6                           | 1                          | 0       | 21             | 10              | 0                | 0                | 3                             | 6                      | 0                              | 1                          | 0                        |
| Independent MRO                                    |  | 7  | 1                           | 0                          | 0       | 0              | 9               | 0                | 0                | 1                             | 1                      | 0                              | 0                          | 0                        |
| OEM/ distributor                                   |  | 15   | 2                           | 0                          | 0       | 1              | 3               | 0                | 0                | 0                             | 1                      | 2                              | 1                          | 2                        |
| Defence facility                                   |  | 50   | 7                           | 1                          | 0       | 21             | 14              | 1                | 1                | 4                             | 7                      | 3                              | 3                          | 1                        |
| Defence contractor/ supplier                       |  | 6  | 0                           | 0                          | 0       | 1              | 0               | 0                | 0                | 1                             | 1                      | 0                              | 0                          | 0                        |
| Government/ non profit                             |  | 2  | 2                           | 0                          | 0       | 3              | 3               | 0                | 0                | 0                             | 2                      | 0                              | 0                          | 0                        |
| Education/ training/ research                      |  | 0  | 0                           | 0                          | 0       | 0              | 0               | 0                | 0                | 0                             | 0                      | 0                              | 0                          | 0                        |
| Self employed/ contractor                          |  | 0  | 0                           | 0                          | 0       | 0              | 0               | 0                | 0                | 0                             | 0                      | 0                              | 1                          | 0                        |
| Total valid  |  | 404  | 33                          | 9                          | 1       | 65             | 59              | 2                | 1                | 11                            | 23                     | 7                              | 7                          | 7                        |

Source: Survey conducted as part of Linkage Project LP110100335. Total responses: 708. Responses usable for this question: 673

### 3.6 Conclusion

This chapter has produced an overview of the Australian aircraft maintenance sector, and of its changing place within the Australian aviation and aerospace industries. As Figure 3.5 illustrates, MRO work is located both within the aerospace industry and the aviation industry, and is also, via the role of OEMs and contractors, spanning the Defence/civilian divide. Logistics work — particularly the ferrying of parts accompanied by mobile maintenance engineers — embodies the dividing line between aerospace and aviation. Increasingly, maintenance, repair and overhaul work may be performed in a range of ways:

- In house by international, domestic, regional and charter air operators;
- In dependent or independent contractor arrangements, including in the GA sector by MROs carrying out charter or aerial work;
- In stand-alone specialist or generalist MROs;
- By OEMs or their agents or Tier 1 suppliers, either on an independent contract basis or under through-life service arrangements.



**Figure 3.5 Emerging industry locations of MRO work**

Figure 3.5 seeks to represent the importance of education and training in the emerging MRO industry. It suggests:

- The importance of harmonising civilian and Defence Approved Maintenance Organisation recognition processes, as well as licensing procedures and requirements, because of increasing reliance on a common aircraft platform, because of the role of OEMs and contractors in providing MRO services and training to Defence arms, and to enhance workforce mobility;
- The need for a stronger articulation between manufacturing and maintenance training, and for ensuring access to relevant training for employees of stand-alone MROs as well as maintenance staff employed by airlines or working in Defence industries;
- The potential for bringing together flight and crew training and maintenance training as an education export industry;
- The need to keep a strong category training presence in the public vocational education sector.

Appendix 3 provides illustrations, from a range of Australian states and regions, of different aviation/aerospace clusters, suggesting how MROs could be part of hubs of innovation and regional development.

In debates about the future of aircraft maintenance in Australia, there has been a sense of pessimism resulting from the highly visible offshoring of maintenance of the newest aircraft, particularly the A380, as well as closure of the Tullamarine and Avalon facilities, which were devoted to the leftovers of the 747 fleet. In this restructuring Australia's only large RPT third party MRO was a casualty, accompanied by increased offshoring of B737s to New Zealand. Yet this impression could be misleading, as the overview of the industry produced in this chapter indicates. While the main airline has chosen to offshore A380 maintenance, the necessary capacity to onshore it remain in the Brisbane facility, where large twin aisle aircraft (in particularly the A330) are being refurbished competitively. Despite intensified offshoring, the bulk of single-aisle domestic carriers are maintained in Australia, along with the small plane RPT and irregular PT aircraft. This work exists alongside, and indeed networked to, a diverse sector composed of stand along MROs, component manufacturers and other organisational forms linked into component supply chains. One conclusion of this review of the industry is that the finding that the trend to offshoring is somewhat exaggerated in extent, although this point needs to be carefully put because simply counting numbers of maintenance checks offshored can understate the latter's importance in terms of employment losses.

The chapter sought to draw some indicators of future maintenance demand by inspecting the CASA register, as well as the extent of airplane use and age. Here, again, the picture that results is not exactly what might be expected from the assumptions built into the regulatory framework in which it is embedded. First, there are a large number of small planes, of similar characteristics, that are well encompassed within the former CAR 30 "group" system (see Chapter 8). The bulk of these are very old – 37% more than 40 years, and 40% between 21 and 40 years. These are well suited to "group" regulation and licensing. Yet the dividing line of 5,700 kg MTOW is based on assumptions that equate plane size with complexity that no longer necessarily hold. Some small planes (and an unknown number which feature retrofitted systems, eg avionics) are technically complex, and 12% of the 10,212 fixed wing small planes on the CASA register are less than 10 years old, with 43% of rotary aircraft the same age. There is also a section of aircraft below the former CAR30 8,000 kg MTOW dividing line that have been "caught" by the recent shift in the new CASRs to the 5,700 kg MTOW division, the licensing arrangements for which now require type ratings, and type training. Almost all of these aircraft are maintained in Australia – indicating again the need for the sector to be managed, and for national solutions to be put forward for training.

Later chapters will argue that a global shortage of aircraft maintenance capacity is both a threat to Australian aviation and an opportunity for building capability, self-reliance and national safety and security, and to move into the export of high quality MRO work, linked to an innovative aerospace manufacturing industry and potentially, the addition of maintenance training to our educational export portfolio. The Australian aircraft MRO industry, across civilian and Defence aviation and across existing and emerging aviation sectors can build a greater degree of national self-reliance, through cooperation among regulatory agencies, major airlines, manufacturers and independent MROs. Through closer integration with existing advanced manufacturing networks, it can also supply specialised Asia-Pacific MRO and maintenance training markets.

## Chapter 4 Safety Issues 1: The Dimensions of the Problem

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### 4.1 Introduction

One of the major research questions addressed by this study was the extent to which offshore maintenance was compromising the safety of Australian aviation. This chapter and the following one set a context for the more specific discussion of those risks in chapter 6, first by establishing whether significant safety risks still exist to the safety of passengers and aircrew despite the improvements in headline statistics on safety over the last two decades, and subsequently by using qualitative evidence and models drawn from safety science to establish where the significant risks are most likely to be found.

Within the industry and among the travelling public it serves, perceptions of aviation safety are complicated by a paradox which does not exist for most other areas of human activity. Statistically, main-route passenger aviation today is by far the safest of all modes of travel, as airlines and regulators keep reminding us. Intrinsically, though, flying is a dangerous activity. That several thousand kilograms of metal or composites, together with 300 or more human beings, can be kept continuously aloft for twelve hours or more some 13,000 metres above the earth, at speeds approaching the sound barrier, often seems hard to comprehend when we stop and think about it. A great many things need to go right, and if enough of them go wrong, the consequences can be immediate and devastating. Two or three times in a typical year, a major crash occurs close enough to home to remind us all starkly of that fact.

A legal adviser to the US Aeronautical Repair Stations Association (ARSA) put this paradox eloquently in response to the GermanWings tragedy:

... a simple truth is clear: to board an aircraft is an act of incredible trust. More than any other time in our daily lives, crossing a jetway means entering a world of unavoidable dependence on others.

Taking flight truly is an act of faith: faith in physics and Bernoulli's principle, faith in clear skies and tail winds, faith in the countless people – from the maintenance line to the control tower to the cockpit – that will bring you safely back to earth.

For the maintenance community, shared responsibility is embodied in half of a million men and women worldwide. Far too often their collective effort goes overlooked; most travelers think only of maintenance when the word is followed by "delay." The truth is you can't fly without it.<sup>1</sup>

Risk is a combination of the likelihood that something will go wrong, and the consequences if it does. Where the one is very low and the other very high, it can be difficult for the public at large to reach a consistent perception of the level of risk. On the one hand most of us today, when we get on a flight, will have worries on our mind – will we miss our connection, will we get any sleep before tomorrow's meeting, will our luggage be lost along the way – but they generally do not include worrying whether we will make it to the other end in one piece. Conversely, when there has been a cluster (however random) of fatal accidents

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<sup>1</sup> Levanto, 2015

involving many citizens of industrialised nations, passengers tend to be much more conscious of risk than the statistical probability warrants. Public risk-aversion therefore fluctuates cyclically and unpredictably, making it difficult to arrive at a long-term safety strategy which consistently meets user expectations.

Australia in 2015 found itself at the high point of one of these cycles of concern. The last twelve months had been an *annus horribilis* for aircraft-related deaths. The first seven months of 2014 saw two highly public disasters which took a total of 537 lives, more than the entire average world total of fatalities for each of the preceding five years and well over twice the world total for 2013. Though one of these was clearly not the result of an accident in the sense we use the word here,<sup>2</sup> it was this one (MH17) which probably made the greatest impression on Australians, because so many Australian lives were lost. Within the same month as MH17, two further crashes, one over Mali and one over Taiwan, took another 160 lives, and the December AirAsia crash over the Java Sea took 162 more, followed in February this year by a further well-publicised one in Taiwan (26 dead), and in March by the catastrophic destruction of GermanWings 4U9525 (also not an accident by the official definition) taking another 162.

Yet through all this, air travel on international and inter-capital routes in 2014 was the safest it had ever been. Not counting those from MH317, 641 lives were lost over the full year, three times the number for the previous year and more than a hundred above the five-year average, but lower than in 2009 and 2010. However, the number of fatal accidents was down to 12, from 19 in the previous year, and the number of fatalities per million flights was the lowest ever recorded. In the two decades since 1994, fatal accidents per million departures had fallen by two thirds, and accidents involving loss of the aircraft had halved.<sup>3</sup> Australia has had no fatal accident in high-capacity scheduled passenger transport since 1975,<sup>4</sup> and no fatality resulting from an actual crash in the whole 55 years since jet aircraft were first introduced.

As the ARSA representative went on to say, “Flying is the safest it’s ever been, but clear statistics will always give way to grief.” The disconnect between statistical risk and potential risk – the paradox that flying can be at once so safe, and so dangerous – is more than just emotional. On the intellectual level too, there is no logical map for making the leap from one to the other. This matters because it is a trade-off that has to be made every day by airline management: whether to err on the side of stricter safety precautions, which inevitably raise operating costs, or to rely on the statistical evidence and assume that the risk is too small to warrant the precaution. An operations manager could be forgiven for concluding that since her airline has completed five million flights without an accident, it has no reason to worry about accidents. But as Drees et al. point out in their work for IATA,<sup>5</sup> that evidence does not make it any more certain that it will complete the next five million without an accident.

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<sup>2</sup> The loss of the MH370 was classified by the Malaysian authorities as an accident, and hence it was treated as such in the IATA and ICAO statistics.

<sup>3</sup> International Air Transport Association (IATA), 2014. Note that this figure covers full-sized passenger and cargo aircraft in revenue service, and consequently includes fewer fatal accidents than the series analysed below.

<sup>4</sup> This accident involved collapse of the nosewheel gear on a Boeing 707 during pushback, which crushed and killed the driver of the tractor. See Australian Transport Safety Bureau (ATSB), 2013, p. 14.

<sup>5</sup> International Air Transport Association (IATA), 2014, p.81.

In industries where the risks are more visible and miscarry more often, it is possible for safety managers to develop statistically based risk management models which provide some guideline as to where the balance should be struck. But in an environment where very few serious accidents happen, evidence can be not only hard to find, but where it exists, too sparse to permit the kind of statistical inference on which such models are based.

This dilemma is addressed by discussing the two dimensions of safety in different chapters. This chapter looks at the available statistical evidence on trends in accident rates, and the specific issue of how far maintenance errors and omissions are associated with accidents. The next looks at the kinds of risks that affect aviation, and the particular ones which are important today, and which have been identified by independent expert assessments.

## 4.2 What the statistics tell us: Accident numbers

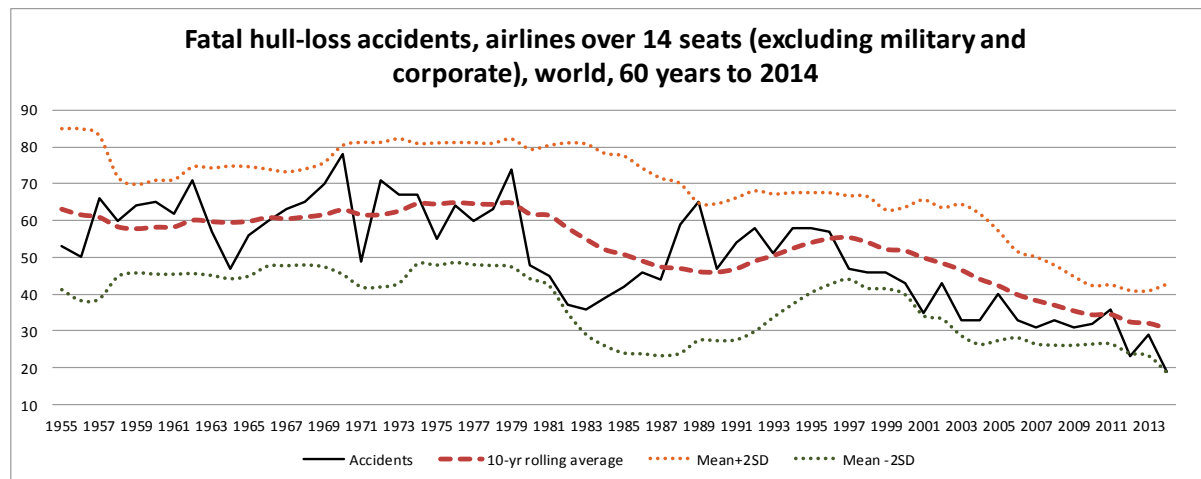
We begin by using some very basic probability theory to address the question raised two paragraphs back: how long does a safe record need to be before one can reasonably assume that everything will be safe from now on? To get a statistical perspective on this issue, we resorted to the longest run of data on accidents that was readily available. This dataset comes from the Aviation Safety Network, a subsidiary of the private Flight Safety Foundation, and runs back almost three quarters of a century, to 1942. Because it covers all airliners with 14 or more seats, excluding military and corporate aircraft, it embraces a section of the world fleet which is much larger than that covered by the ICAO or IATA statistics, and arguably includes planes which are more crash-prone than those of the main-route passenger fleet because of their size, age, operating conditions or all three. While this characteristic makes it more difficult to compare these statistics with other sets which provide more detailed information, it has at least the advantage of providing us with a larger “population” from which to draw statistical inferences.<sup>6</sup>

Figure 4.1 below tracks the number of fatal accidents, and the number of resulting deaths, over a 60-year period to 2014. In reality, it uses data points going back another 10 years, since the broken line shows the average number of fatal crashes in the 10-year period up to each year for which the actual total of accidents or casualties is shown. Consequently it looks right back to the end of World War II, which is as far back as the records can usefully be analysed, given how little civil aviation took place during the war. While the number of accidents actually occurring fluctuates considerably from year to year throughout the period, the 10-year rolling average (the broken line) shows a fairly clear trend, rising steadily up to around 1980 as might be expected given the growth in the total number of flights in each year, but tailing off from then on, despite the continuing and in fact rapidly increasing growth in activity.

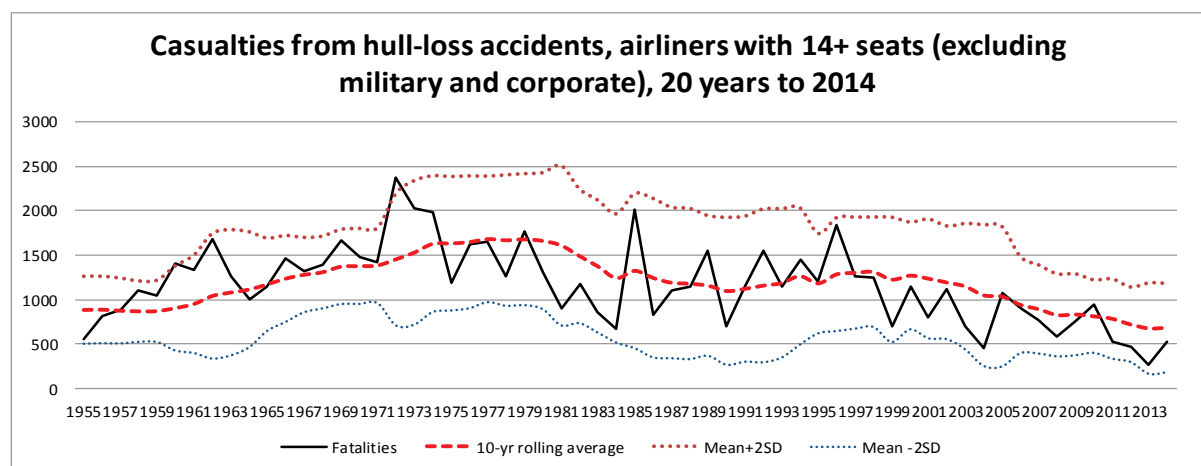
Remembering that we are looking here at the *number* of accidents rather than the *rate* of accidents (which is discussed later in this chapter), the variation over time is much smaller than might intuitively be expected. It rises again in the 90s, but then shows a strong and steady decline up to the present. In most years from 1996 onwards, the graph of actual crashes lies below the 10-year trendline, indicating that the number of crashes is going down faster than one would expect from experience over the past decade.

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<sup>6</sup> It also covers only hull loss accidents, i.e. those which result in the aircraft being destroyed or at any rate written off. This criterion excludes a certain number of fatalities which occur in accidents resulting in damage to the aircraft which can subsequently be repaired, but the number of excluded cases is arguably small enough to be ignored for these purposes.



Source: Aviation Safety Network, 2015



Source: Aviation Safety Network, 2015

**Figure 4.1 Fatal aviation accidents (over 60 years) and number of fatalities (over 20 years) to 2014**

From a run of data this long, it is possible to calculate the probability of an accident occurring in the present year using a measurement called the standard deviation, which measures how far a set of observations varies from the average reading. One of the most basic postulates of statistical probability is that in any normally distributed population, 95% of observations will lie within two standard deviations either side of the mean. This range is called the 95% confidence interval. The two dotted lines on each graph in the two Figures 4.1 show the upper and lower bounds of this confidence interval in each year.

Looking at the first graph in particular, it can be seen that two things are changing over time: the average number of accidents in a year, and the extent to which the actual number in any given year can be expected to differ from the trend figure. Over the last decade in particular, it is clear that the range of expected variation is getting narrower, indicating that predictions are growing steadily more reliable, and surprises – pleasant or unpleasant – less likely. This is what might be expected if the measures adopted across the world to prevent fatal accidents are growing more dependable.

Based on the confidence intervals for 2014, there is only a 5% chance that the number of accidents across the world in 2015 will be higher (in rough figures) than 40 or lower than 18, or that the number of deaths in aircraft accidents will be higher than 1200 or lower than



180. This calculation is obviously not of great practical use, and in any case it refers only to the statistical likelihood, without taking into account any of the many other factors which could result in a figure higher or lower than these theoretical limits. Nevertheless, it illustrates that a substantial risk does still exist in spite of all the improvements: it is foreseeable that there *could* be 40 fatal accidents across the world next year, taking a total of 1200 lives, simply through the normal amount of chance variation from year to year. Equally, there *could* be even fewer accidents than last year, and less than a third as many lives lost this year than last, but this would still not demonstrate (in terms of statistical probability at least) that all the hazards were on their way to being definitively controlled.

Two important practical implications emerge from this somewhat technical analysis. First, even if the current declining trend in fatal accidents continues, there is still a possibility that as many as 1200 lives could be lost in crashes this year – still very few by comparison with those lost on the roads of the world every month, but enough to be recognised by all parties as a serious risk. Second, a major change up or down from the trend figures in any one year is not evidence in itself either that the underlying problem is growing, or that it is being more effectively addressed. This is arguably the most critical implication for safety policy, since it implies that if any of the underlying factors should deteriorate markedly, their impact is likely to be masked for some years because it falls within the normal range of chance variation.

### 4.3 What the statistics tell us: Accident rates

Obviously, the figures just discussed tell only a small part of the story (even if it is the one that matters most to the public at large), because they take no account of the rapid growth over the last five decades in the number of passenger planes in the air at any given time, and the number of flights made in each year. When we turn to the accident *rate*, generally expressed in terms of fatal accidents or fatalities per million departures<sup>7</sup> (PMD), the progress looks a great deal more spectacular. For the purposes of this discussion, it is possible to move beyond just fatal accidents and look at data for accidents in general, which are not available in the ASN series.

Looking at this statistic for the larger jets used in main-route carriage, the period of really spectacular reductions appears to be over. The EASA 2013 safety report showed that the world fatal accident rate per 10 million departures halved from just over 40 to 20 in the decade to 1994, but fell by only half that amount in the following decade.<sup>8</sup> Statistics produced by Boeing for the world commercial jet fleet show that the total accident rate dived by around 90% in the single decade from 1960 to 1970, and the rate of fatal accidents by almost the same amount between 1959 and 1974.<sup>9</sup> Even this drop seems insignificant compared with statistics for the US (the only country in which the figures have been large

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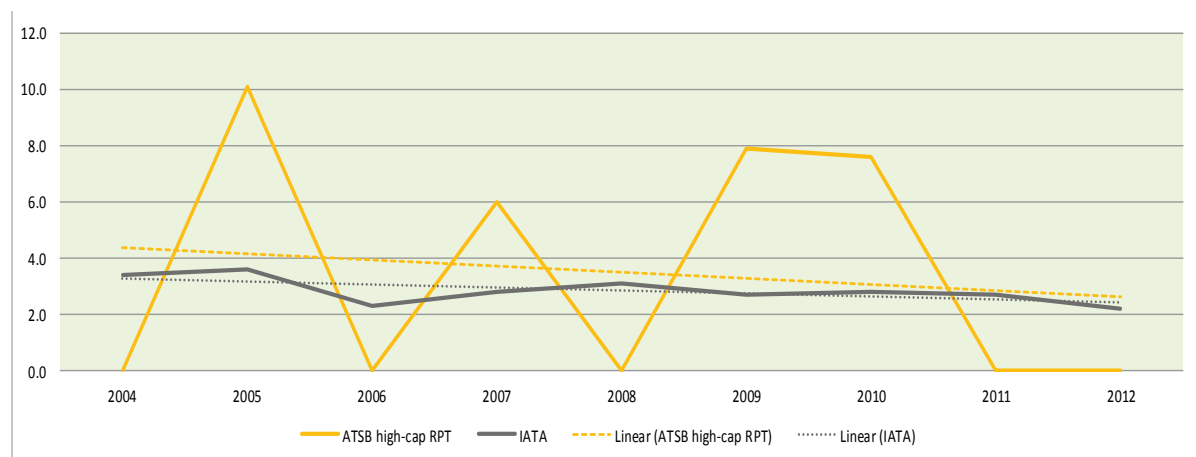
<sup>7</sup> Where commercial passenger aviation is concerned, it is preferable to use a measure based on the number of individual flights, as opposed to distance covered or time in the air, because the number of departures has been shown empirically to be much more tightly associated with the probability of an accident occurring. This reflects the evidence that most accidents in commercial aviation occur on takeoff, approach and landing, as against only 18% at cruise altitude (Boeing, 2015). In the case of GA, however, a distance-related measure makes more sense because the cruise segment of each flight is generally more hazardous than for large planes, and such a measure is generally quoted in addition to the departures-based accident rate.

<sup>8</sup> EASA, 2014, p.14. Three-year moving average, all scheduled passenger and cargo flights.

<sup>9</sup> Boeing Commercial Airplanes, 2015.

enough to support statistical inference for that long) which show that the number of fatal accidents per million aircraft-miles in main-route passenger aviation shrank by a factor of 1000 in the 70 years to 2001.<sup>10</sup> By contrast, the Boeing statistics cited above show that the overall accident rate has remained remarkably stable since the mid-70s, and even the fatal accident rate hovered around the same, admittedly very low, level from the early 90s through to around 2009.

As is generally the case in aviation, comparative statistics need to be approached with some caution because no two sets cover precisely the same segment of the fleet, and some are restricted to particular categories of accident. Despite this, different sources show remarkable consensus in describing a virtually flat trend in the accident rate over the last decade or more. Figure 4.2 compares the overall accident trends recorded by the IATA statistics and those by the Australian Transport Safety Bureau for high-capacity regular passenger transport (RPT), i.e. aircraft with more than 38 seats operating on scheduled services, which come closest to capturing the same segment of the fleet. The Australian data show much more variation from year to year, as would be expected from the much smaller “population” involved, including several years in which no accidents were recorded. Despite this, the trendlines remain remarkably close, and the very gradual convergence should probably be disregarded.



Sources: Australian Transport Safety Bureau, 2013; International Air Transport Association, 2014

**Figure 4.2 Aviation accidents per million departures — Australia and worldwide, 2004-12**

Broadly speaking, all sources indicate that the overall rate of accidents has hovered fairly consistently in the 3-4 PMD bracket for at least the last decade, and Boeing’s graphs (for which the raw numbers were not available) suggest that this trend goes back at least to the 80s, at any rate for that segment of the world fleet in which Boeing’s products compete. The accident data released by Airbus are not directly comparable because they cover only fatal and hull loss accidents, which are obviously much less common than accidents in general, and hence likely to show a larger chance variation. Despite this, they do show a reasonably flat trend from around 2004 onwards for fatal accidents, and between 2003 and 2010 for hull losses.<sup>11</sup> A study conducted by the UK Civil Aviation Authority in 2013 identified a declining rate for fatal accidents in the decade to 2011, but a breakdown of its findings

<sup>10</sup> Thomas and Forbes Smith, 2004, p. 96.

<sup>11</sup> Airbus, 2014.

suggests that this was largely due to a significant decrease in the incidence of fatal accidents in Africa and the Central America/Caribbean area.<sup>12</sup>

The UK CAA study just mentioned quantifies the risk in a more graphic way by showing that an average passenger would need to take 3.1 million flights (one every day for 8,505 years) before being killed in an accident. For jet aircraft the number increases to 5 million flights, or 13,573 years, though this decreases sharply for anyone flying with an African operator, who would need to take only half a million flights. The figure for operators over the whole of Oceania is slightly above the world average at 5.3 million flights.<sup>13</sup> However, these statistics are slightly counterbalanced by the finding that in each of the 250 fatal accidents analysed, an average of 70% of those on board were killed.<sup>14</sup>

From this we can conclude with reasonable confidence that the most important advances in passenger and aircrew safety have already been made several decades ago, and that accident rates in Australia as well as globally have effectively stabilised for some time. But while the primary interest in this chapter lies in accidents, it is important to note that the number of *incidents* reported to the ATSB grew by 90% for commercial aviation in general, and more than doubled for high-capacity RPT, in the decade to 2013. The ATSB points out that this growth is partly an artefact of different reporting requirements, and partly related to the overall growth in traffic. However, the growth of 135% over the decade for incidents reported in high-capacity RPT is just over twice the growth in the number of departures, suggesting that at least some of the increase must be real.<sup>15</sup>

We are talking here, of course, about only a small proportion of the world fleet. The situation changes markedly when we shift our attention to charter and general aviation (GA). While reliable world figures are difficult to find for these less sectors of aviation, the Australian statistics indicate a very different world where safety is concerned.

Figure 4.3 below compares the accident rates for commercial and general aviation over the decade to 2011. The trend rate for GA was around three times that for commercial aviation at the start of the period, and by 2011 the gap had widened to a factor of approximately four. It will be seen that even the rate for commercial aviation is higher than those shown by the previous two graphs, because it includes charter, for which the rate is generally 3-4 times as high as for scheduled services. In fact, the decline shown by commercial aviation largely reflects a decrease in charter flying over the period; this is illustrated by the third curve, for high-capacity RPT, which actually shows a marginal rise over this specific period.

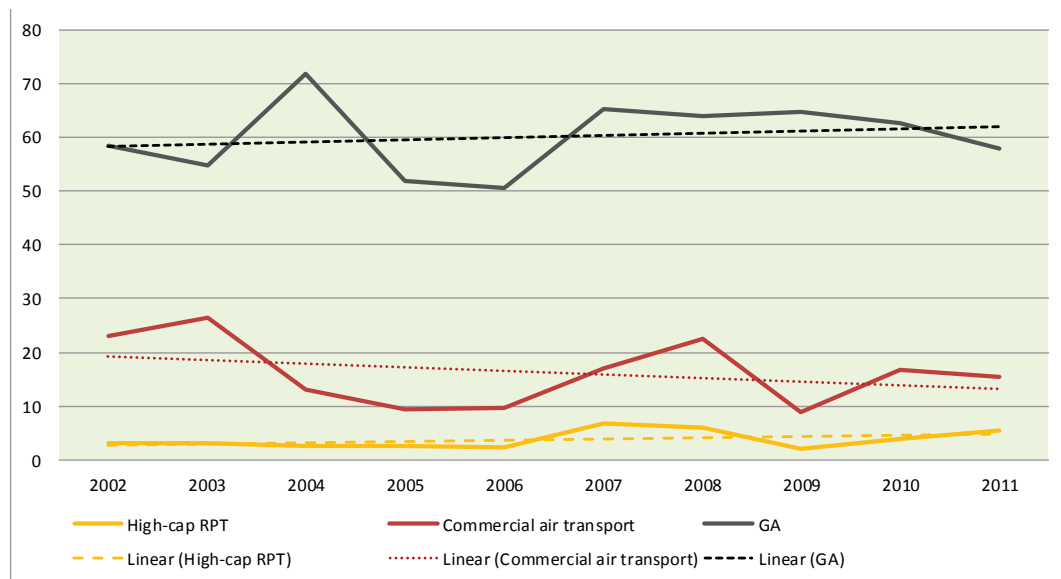
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<sup>12</sup> Civil Aviation Authority – UK (CAA), 2013, Fig. 23, p. 33.

<sup>13</sup> *ibid.*, Table 7, p. 34.

<sup>14</sup> *ibid.*, p. 1.

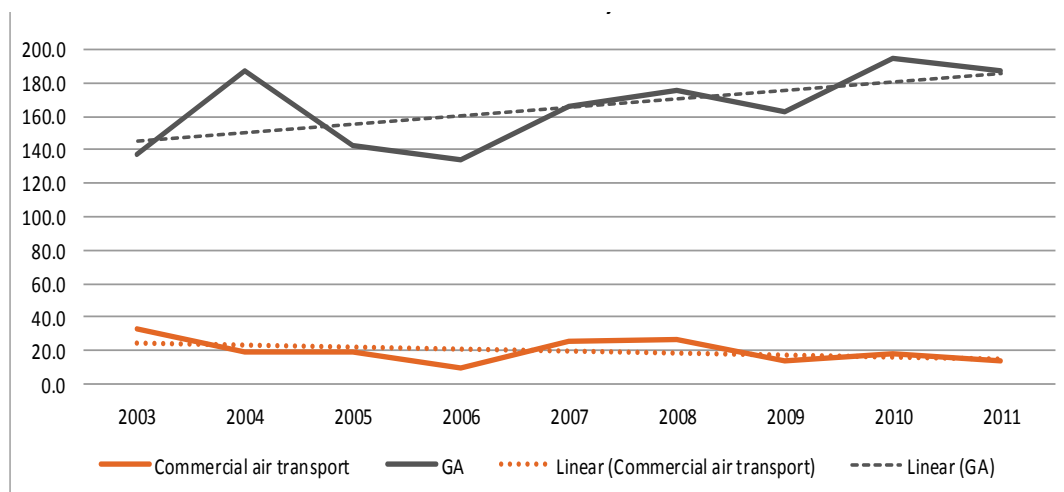
<sup>15</sup> Australian Transport Safety Bureau (ATSB), 2013, p.14.



Source: Australian Transport Safety Bureau, 2013

**Figure 4.3 Aviation accidents per million departures by sector, 2002 - 2011**

An even clearer indication of the contrast appears when we add to actual accidents the statistics for near misses (in standard ICAO terminology, “serious incidents”), where in the opinion of the expert accident investigators, “circumstances indicate that an accident nearly occurred”, and change the denominator from departures to hours flown. Although Figure 4.4 below covers a shorter period than Figure 4.3, it shows a much steeper growth trend for serious occurrences (accidents plus near misses) in GA, ending the period over 13 times as high as for the whole of commercial air transport (including charter).



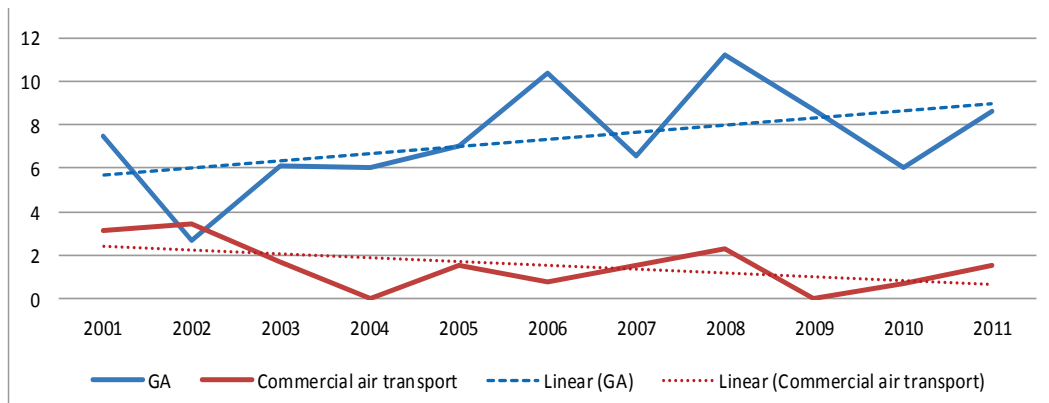
Source: Australian Transport Safety Bureau, 2013

**Figure 4.4 Accidents and near misses by aviation sector, 2003 - 2011**

The contrast here is admittedly exaggerated by the fact that the GA figures include many helicopters, for which the accident rate is higher, and the fatal accident rate considerably

higher, than for fixed-wing aircraft.<sup>16</sup> This is especially the case in the two most dangerous sub-segments, agricultural and private and business flying.

Where fatal accidents are concerned, the pattern is broadly similar, though once again with greater fluctuations because fatalities are less common across the board. Both fatal accidents and fatal accidents per million departures (Figure 4.5) show a clearly rising trend for GA and a falling one for commercial aviation (partly, once again, because the more dangerous categories of charter and low-capacity RPT are less strongly represented over time). Where the raw number of fatalities is concerned (graph not shown), the trend is essentially flat for GA, while for commercial aviation the trend figure fell from ten to less than two.



Source: Australian Transport Safety Bureau, 2013

**Figure 4.5 Fatal accidents per million departures, general and commercial aviation, 2001-2011**

By way of comparison, the latest US statistics prepared by the private Aviation Safety Institute (an offshoot of the Aircraft Owners and Pilots Association) show a declining trend in the overall number of GA accidents in the ten years to 2014.<sup>17</sup> The trend was most pronounced in non-commercial GA, and more consistent for fixed wing aircraft than for helicopters. For non-commercial fixed wing aircraft, the 2013 accident rates (overall and fatal) were the lowest in the 25 years covered by these statistics, and the fatal accident rate fell below one in every 100,000 hours flown for the first time. In the case of helicopters, non-commercial operations showed a slight downward trend over the decade while the rate for commercial operations rose fairly sharply in the two years to 2013. The statistics suggest that the rising rate in Australia may not necessarily reflect a global trend, and that there may be factors specific to Australian GA which are causing the accident rate to rise here.

On all of these measures, it is painfully clear that public awareness of aviation safety has tended to focus on the least risk-exposed part of the aviation industry. So while the remainder of this report gives relatively little consideration to safety issues in GA, it needs to be kept in mind at all times that the risk there is real, significant and steadily increasing.

<sup>16</sup> Detailed comparisons can be found in ATSB, 2013, p. 71.

<sup>17</sup> Aviation Safety Institute (ASI), 2015, pp. 1-6.

## **4.4 The problem of small numbers**

Statistical analysis of top-level, global (i.e. population-level) data can offer a quantitative estimate of the likelihood of an accident occurring. However, once we try to drill down to a more useful level of detail, such as would enable us to quantify the risk of a particular kind of accident, or an accident occurring in an individual airline or even country, or of an accident occurring within a given timeframe, such analysis becomes uninformative, because the absolute number of serious accidents over a year or even five years, when set against the number of passenger miles flown, is too small to support reliable inference.

There are four aspects to this problem. The first is simply that traditional inferential methods cease to produce statistically significant results once the number of observations falls below a certain threshold level, relative to the base rate for the “population” of interest. Analysis of such small “samples” can be informative in a qualitative sense, but it cannot provide statistically rigorous guidance for practice.

The second is that it becomes much harder to identify consistent patterns of causation across different accidents. Since we are dealing with a context in which accidents seldom if ever involve a single, direct and clearly demarcated causal chain, and each results rather from the coincidence of a large number of disparate factors, each accident is effectively one of a kind, resulting from a combination of events and circumstances which is unlikely ever to be precisely repeated.

The third problem is that the observed number of accidents reflects a combination of deterministic (or at any rate probabilistic) factors, which in principle are capable of being identified and provided against, and simple randomness. This needs to be understood in the light of Perrow’s theory of “normal accidents”,<sup>18</sup> which has been highly influential in safety science where complex technological and organisational processes interact. This theory holds that once the level of complexity gets high enough, there will be a threshold level of accidents which occur by simple chance, even assuming perfectly conscientious and reliable individuals working in highly reliable organisations. Since this class of accidents is difficult to provide against, short of ceasing the activity altogether, any conscious planning to minimise known risks must be capable of distinguishing between the probabilistic and random elements of causation. This becomes even more difficult than the simple identification of causal patterns once the absolute number of accidents becomes very small.

The fourth difficulty is that where so few actual serious crashes occur over a decade or longer, some of those which are available for analysis will no longer be recent enough to be still relevant to present technology and practices.

Since the data that exist on actual accidents are insufficient to support useful inference, it becomes necessary to base these calculations on things which occur more commonly – in the internationally adopted terminology used by the ATSB, “serious incidents” (i.e. near misses) and “incidents” – or on factors within the environment, the organisation or human psychology that can be shown or hypothesised to be associated with those accidents which have occurred. If the scope of analysis can be expanded to embrace these more commonplace events, there is a chance that the kind of common patterns which were once observable in real accidents will start to emerge once again.

This is what Drees and his colleagues have set out to achieve in their contract work for IATA. Their initial output, reproduced as an appendix to IATA’s 2014 safety report, provides a

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<sup>18</sup> Perrow, 1984.

detailed conceptual framework which among other things, operationalises Reason's concept of "latent factors" to create a basis for the statistics to be discussed in the final section of this chapter.<sup>19</sup>

#### 4.5 The role of maintenance

Of the statistical studies available to this project, only two attempted specifically to quantify the role of maintenance in air accidents. The more comprehensive analysis is found in the aforementioned UK CAA report, which covers 250 crashes worldwide over the ten years to 2011. It identifies errors in maintenance or repair as the *primary* causal factor in only seven of these (3%), though even at this level maintenance/repair error still represented the fifth most common of the causes listed, only slightly behind environmental conditions (5%), aircraft systems and components (5%) and engine failures (4%).<sup>20</sup> In terms of the number of people killed, it was a slightly more significant factor, accounting for 4% of total fatalities. It was most likely to be the primary factor in the case of business jets (7%), accounting for only 1% of fatal crashes involving commercial passenger jets, and was also most likely to affect positioning or ferry flights. When the statistics are broken down by region, maintenance/repair error was most likely to be the primary cause in North America (11%), with the important qualification that this represented only three accidents.<sup>21</sup>

The UK study further identifies errors in maintenance or repair as one of the *contributory* factors in another four crashes, while "oversights" in maintenance and repair contributed to one additional crash, and "inadequate maintenance or repair" to a further seven. "Failure to carry out due maintenance" was the primary cause in one additional case and a contributing factor in another. Depending on whether the partial contributory factors referred to the same or different accidents, this could bring the total number of fatal accidents attributable in some way to maintenance to as many as 20 (8%) or as few as 11 (4.4%). Other practices commonly viewed as risk factors, including bogus parts, use of unqualified workers and worker fatigue, were not identified as contributory factors within this period (bearing in mind that the study refers only to crashes which resulted in fatalities).<sup>22</sup>

IATA in its latest safety report takes its statistics from the same database, but for the period 2009-2013. It identifies specific maintenance incidents as a direct contributory factor in 10% of accidents worldwide, and 9% of fatal accidents. It was most likely to be a factor in crashes involving cargo flights (12%) and perhaps significantly, in countries that had adopted the IOSA reporting framework (14%), suggesting the possibility of significant under-reporting elsewhere. Maintenance was also identified as a significant "latent" factor in 8% of all non-fatal crashes, 13% of those involving cargo planes, and 9% of all accidents occurring within the IOSA reporting area. Disaggregating crashes by type, maintenance was a direct contributory factor in 30% and a latent factor in 23% of accidents involving landing gear failure, 21% (15%) of those involving in-flight damage (around half of which were engine failures) and 11% of those which involved a loss of control in flight.<sup>23</sup>

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<sup>19</sup> International Air Transport Association (IATA), 2014, pp. 81-87.

<sup>20</sup> Civil Aviation Authority (CAA), 2013, p. 35. It should be noted, however, that 26% of the accidents covered did not have sufficient information in the investigation reports to allow a primary cause to be assigned.

<sup>21</sup> Civil Aviation Authority - UK (CAA), 2013, pp. 39-41.

<sup>22</sup> *ibid.*, p. 111.

<sup>23</sup> International Air Transport Association (IATA), 2014, pp. 30-35.

It is not entirely clear from the published data whether those cases in which maintenance was identified as a “latent” factor were additional to those where a specific maintenance event was part of the direct causal chain leading to an accident. If the two categories are meant to be additive, then maintenance would seem to be a much more significant contributor than suggested by the CAA analysis, contributing to almost a quarter of accidents involving cargo planes and nearly 20% of those within the IOSA area. However, it is possible that the categories overlap – i.e. the “latent” cases were ones where poor maintenance procedures or facilities were “an accident waiting to happen”, and in some of those they resulted in an actual, observed mistake which led to that accident happening. In either case, the importance of maintenance as a contributor to landing gear failure, in-flight damage (the fifth most common type of accident) and especially loss of control in flight, which is the second largest cause of fatal accidents and leads to the highest number of fatalities,<sup>24</sup> would appear to suggest that it deserves serious priority in safety management systems.

Looking at the breakdown by region, maintenance over this period was most likely to contribute to an accident in the CIS (i.e. the former core republics of the Soviet Union) and in the Middle East/North Africa (14% each), followed by the Asia/Pacific region and Latin America (11%), the last mentioned being the only region in which it is shown as a significant latent factor.<sup>25</sup> It would be tempting to see this as a commentary on the standard of maintenance in the regions concerned, but such a conclusion is probably not justified by this evidence alone, given firstly that the IATA regions are very large and far from homogeneous, and secondly that the breakdown has been done by state of registration, so is not necessarily informative about where the maintenance in question was actually carried out.

Comparing the CAA analysis with that of IATA, maintenance shows up far more strongly as a contributor to accidents in the latter. Given that the dataset used by IATA (though drawn from the same database) covers a somewhat later period than the CAA one, could one see this as evidence that the standard of maintenance has deteriorated between the two periods? Probably not, as IATA apparently takes a slightly different cut of the fleet and uses a different analytical framework; besides which, the CAA study is silent about non-fatal accidents.

Nevertheless, CASA in a recent *Flightsafety* bulletin argues that there is some evidence for an increase in maintenance-related aviation accidents. It cites Boeing data giving maintenance as the primary cause for 6% of all accidents over the last 10 years, whereas over the full 40 years it averaged 3.4%, and also mentions that the number of maintenance errors reported to the UK CAA has increased significantly over the last couple of years. The same bulletin quotes airline data showing that between 20% and 30% of in-flight engine shutdowns occur after maintenance problems, and around half of the engine-related flight delays and cancellations are the result of maintenance errors.<sup>26</sup> In any event, we cannot confidently dismiss this possibility, and the differences between the CAA and IATA are sufficient to suggest that any future studies using the same frameworks should be scrutinised carefully for signs of change over time.

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<sup>24</sup> International Air Transport Association (IATA), 2014, p. 29; ICAO (2013, p.32) describes it as “the major killer in civil aviation during the years 2006-2010”.

<sup>25</sup> International Air Transport Association (IATA), 2014, pp. 52-59.

<sup>26</sup> Civil Aviation Safety Authority (CASA), 2013c. The original article dates from the March-April 2013 edition. It is not made clear whether the airline data quoted relate only to Australian operations, or are global figures.



It is also quite possible that there were some accidents to which poor maintenance contributed, but where no specific departure from good practice was observed at the time or identifiable after the event. In the IATA analysis, the proportion of accidents attributable to aircraft malfunctions of one kind or another ranges from 20% in the case of runway excursions up to 75% in the case of landing gear failure, averaging somewhere between 30% and 40% for most classes of accident. There is of course no way of telling whether maintenance was involved in any of these cases other than those specifically identified, but these figures represent a kind of upper limit to the proportion of accidents to which maintenance practices *might* have contributed. This point needs to be made simply because our other statistical sources do not specifically identify the contribution of maintenance, so its role can only be deduced from the number attributed to mechanical, airframe or aircraft systems failure.

This is particularly the case for the Australian statistics. The most recent ATSB published figures show that the four areas of failure to which maintenance is most likely to be relevant (motive power, airframes, aircraft systems, and smoke/fumes/fire) made up around 20% of the factors identified behind accidents or serious incidents in commercial air transport in the decade to 2012. There is no indication of how many individual occurrences were affected by these factors, nor does the publication give statistics for actual accidents. However, the report states that the number of incidents related to aircraft systems grew by a factor of two and a half over the ten years to 2012, with flight control problems now most commonly reported on high-capacity RPT aircraft. The report also adds that:

In 2012, aircraft systems issues most commonly reported to the ATSB were avionics and flight instrument-related, or affected air conditioning and pressurisation systems. Electrical, flight control, fuel, and hydraulic system issues all made up more than 10% of incidents.<sup>27</sup>

The estimates discussed above vary from one another to an extent which makes it clear that the process of attribution is neither straightforward nor consensual. The best that can be said is that statistics alone do not make it possible to resolve the differences of opinion, at least with the datasets currently to hand. Following the normal rule in cases of uncertainty where the public welfare is potentially at risk, the lack of consensus suggests the need for a precautionary approach until more conclusive data become available.

## 4.6 Conclusions

Given the improving safety record of the last decade, is it now possible to say that air travel is “safe”? Is it, at any rate, safe enough that many of the precautions traditionally applied – especially in the case of maintenance – are no longer relevant and can now be substantially relaxed? And if so, how far is it “safe” to relax them?

In the case of GA, the answer is clearly: no. The safety record in GA has not improved noticeably so far this century, and indeed shows every sign of deteriorating. The record in mainstream commercial aviation is far more encouraging. After several decades of spectacular decline, the accident rate has reached a level so low that much of residual variation can be attributed to simple chance.<sup>28</sup> However, it is premature to say that the risk has disappeared completely. Simple inference from the trend over the last ten years shows

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<sup>27</sup> Australian Transport Safety Bureau (ATSB), 2013, p. 85.

<sup>28</sup> Airbus (2014) has nevertheless identified meaningful patterns of change by disaggregating the data into “generations” of commercial aircraft, defined mainly by their avionics.

that chance alone could account for the numbers of people killed in accidents rising over the 1000 mark this year, or falling below 200, without indicating any substantial change in the underlying factors. A further reason for caution is that the trend has reversed in the past after some years of improvement, and the simple existence of a declining trend is not sufficient evidence that it will be permanent.

The role played by maintenance is somewhat controversial, as shown by the surprising level of variation between estimates based on essentially the same data. On all but the most dismissive of these, it remains a significant factor in accidents, but not among the most pressing concerns – it is notable, for example, that the ICAO does not include maintenance in its priority areas for safety reform.<sup>29</sup> On the other hand, the muted note of warning sounded by CASA, in conjunction with a number of other individually inconclusive indications, gives cause to monitor the records carefully for any evidence of a resurgence in maintenance-related accidents as new waves of data become available. Given that it would take some years for any growth in maintenance-related serious occurrences to emerge from the normal annual variation, it should be treated at the very least as something of a “sleeper” among the factors that lead to accidents.

Above all, we point once again to the finding from the CAA study that those few fatal accidents which do still occur take on average 70% of the lives on board. Passenger aviation thus falls into the “low probability, high impact” category of risks where statistical inference provides very little guidance and complacency can all too easily take over. It is at this point that we need to move beyond statistical evidence and look to safety science.

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<sup>29</sup> International Civil Aviation Organisation (ICAO), 2013b, p. 23.

## Chapter 5 Safety Issues 2: Where do the risks lie?

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In mainstream passenger aviation which is the main focus of this report, the main threat to passenger and crew safety is arguably the threat of complacency. With rare exceptions like the two Malaysia Airlines disasters, and the odd clearly alarming near miss like QF32, it is often hard today for many of those involved with an airline – passengers, management, shareholders, sometimes even aircrew – to remember that a risk exists. This is important in the context of the dominant threat to the safe conduct of air transport – what James Reason, perhaps the most respected of current writers on aviation safety, refers to as “the inevitable conflict... between the goals of safety and production”.<sup>1</sup>

With the unrelenting pressure on airlines today to contain their costs, an operations manager in a typical airline finds herself constantly stretched between, on the one hand, feedback on emerging risk conditions which may be blurred, lagged, diffused over several locations which do not necessarily communicate with one another, and above all sparse and very infrequent;<sup>2</sup> and on the other, feedback on business performance which is continuous, unambiguous, unavoidable, and high-risk so far as her own professional future is concerned. In such circumstances it is only to be expected that in Leveson’s words, “the redundancy and other precautions added to protect against human error often degenerate over time as work practices adapt to increase efficiency within the local environment”.<sup>3</sup>

In such an environment, statistical evidence is not enough to change behaviour, and the only way to maintain awareness of risk is through a better understanding of the causal factors that can lead to an accident. These factors and precursors occur far more often than actual accidents and consequently can be observed on a regular basis, providing the basis for qualitative causal models. While the subject is a complicated one and much of it of interest only to serious safety scientists, an introduction to some of the basic concepts may be useful to explain why we believe a significant risk still exists, and is capable of escalating in the future.

### 5.1 Two kinds of accident

Reason distinguishes between two kinds of industrial accident.<sup>4</sup> The first category occurs in “traditional industries involving close encounters between people and hazards”. As examples he offers mining, construction, oil and gas, railway infrastructure and road transport – to which we would add General Aviation (GA). Hazardous work in these industries typically involves continuous and fairly direct contact between the worker and the sources of risk, creating frequent and generally short-cycle feedback. Accidents in such industries tend to happen frequently, the path between the initiating event and the actual accident is usually short, and partly because of this, those who work in them can be expected to remain constantly alert to the risks involved and maintain a focus on minimising and/or responding to them, even if (or maybe

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<sup>1</sup> Reason, 1998, p.331.

<sup>2</sup> The quality of feedback is one area which is likely to be addressed more effectively by the regulatory shift to safety management systems, to be discussed further in chapter 7. However, while these remain in their infancy, it has yet to be demonstrated that they will result in safety considerations receiving greater prominence in day-to-day commercial decisions taken in the back office.

<sup>3</sup> Leveson, 2004, p.247.

<sup>4</sup> Reason, 1998, p.293.

because) they are not always successful. Reason refers to these later in the same paper as “close encounter” industries.<sup>5</sup>

The second category involves what he calls “modern, high-tech, well defended technologies”, which include nuclear power plants, chemical process plants and commercial aviation. They differ from the first type in that while the actual hazard may be just as great, it is possible to manage it to reduce risk, and usually with great success. The efficient cause of most accidents in such industries lies not so much in the pre-existing hazards, as in vulnerabilities inherent in the measures employed to manage them and to reduce risks – and, paradoxically, in the normally high effectiveness of those measures.

The “well defended” aspect means that numerous redundant safeguards are built into the system and usually block the process leading up to an accident before it reaches the point of catastrophe, often without conscious human intervention. The fact that they nearly always work creates a new risk of its own, in that those who work at the “sharp end” tend over time to lose their sense of present danger. Such safeguards typically involve high levels of complexity where the causal chains leading to an accident are often neither easily traced back after the event, nor easily detected in their early stages; the initiating event often takes place remotely from the actual accident site, and the intervening incubation period can be extremely long. This last characteristic was graphically illustrated by the loss in 2002 of China Airlines flight 611, a Boeing 747 operated by Taiwan’s national carrier which “unzipped” and broke up in mid-air with the loss of all on board because of an undetected error in repairing panels after a tailstrike 22 years earlier.<sup>6</sup>

An important group of causal models consists of barrier models,<sup>7</sup> where the hazard is seen as a given which lies beyond the power of the organisation to change, and attention is concentrated on the barriers or safeguards which can be deliberately inserted either by organisations or by the designers of the technology to block the otherwise inevitable causal chain leading from the hazard to an accident. One of the most popular models for aviation is Reason’s “Swiss cheese” model (SCM),<sup>8</sup> which envisages a series of protective layers interposed between the pre-existing hazard and the accident which would otherwise result from it. Reflecting the concept of defences-in-depth, these contribute sequentially and redundantly to blocking the accident trajectory. However, each has gaps in its protection – the holes in the slices of cheese – which let a potential accident through to the next layer, and occasionally the “holes” will line up, allowing a completed “accident trajectory” which results in a loss. Some of the “holes” represent problems or inadequacies in organisational design, institutional regulation and management control, while others occur randomly and their consequences can be contained only by increasing the number of redundant defences.

Central to this model is a distinction between *active errors* – the mistakes, oversights and malpractices setting off the causal chain towards a given accident – and *latent errors or conditions*, which are persistent characteristics or practices of the organisation that in themselves are not obviously dangerous, but create the continuing conditions for unsafe acts to

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<sup>5</sup> Reason, 1998, p.296.

<sup>6</sup> International Aviation Safety Association (IASA), 2005.

<sup>7</sup> Hollnagel, 2008.

<sup>8</sup> Reason, 1990, 1997, 1998; Reason, Hollnagel and Paries, 2006. It is generally believed that the then director of Australia’s Bureau of Air Safety Investigations (predecessor of the ATSB) first invented the label “Swiss cheese” (Reason, Hollnagel and Paries, 2006, p.4), though perforated armour plate would probably be a more appropriate analogy.

occur, and for these to result in accidents. More recent versions of the model envisage a process running from latent failures at the organisational level, through intervening factors (“local traps”) specific to a given task environment, to active failures (unsafe acts originating with individual people), which trigger a process that will lead to an accident unless the defences are sufficiently robust and redundant to block it.<sup>9</sup>

Over time the emphasis of the SCM has evolved in line with changes in the problem it addresses. Up until around the time when Reason developed his first version of the SCM, traditional airlines were highly integrated enterprises which looked after not only their own maintenance, parts sourcing, ground support, training and catering, but in earlier days their own terminals at both the airport and the city end, and even their own ground transport. Thus most of the factors likely to contribute to accidents were more or less within the airline’s sphere of control, so that it was in a position to take a strategic approach to both commercial and safety considerations, built around coordination of these directly owned inputs.

But just as in the last two decades it has become almost universal practice to outsource catering, it is rapidly becoming the norm to outsource maintenance, and airlines in most centres compete for terminal, runway and tarmac space at shared airports which are increasingly commercial operations, while the different categories of services located within them, e.g. ground handling support, security and baggage handling, are further outsourced to specialist businesses, many of them covering more than one airport. Maintenance repair operation itself is becoming increasingly diversified and specialised, with parts supply brokerage (including parts recycling and remanufacture, known sources of risk) emerging as the province of a separate class of enterprises. Aircrew and ground crew training in most parts of the world is moving away from the old model of apprenticeship/cadetship with a particular airline and becoming the province of public or private training organisations.

The result of this fragmentation is that the individual airline has come to depend for its safety management, as well as for its commercial performance, on an extended and complex supply chain, effectively a *system* of organisations, generally lacking the shared ethos, sense of mutual loyalty and common information base which characterise the best kind of individual enterprise. These networks can result in lengthy information paths, slow or imperfect feedback, and strategic constraints on the sharing of important information. (We will cover these failure points in more detail in the next chapter.) Together these often end up in a *coordination problem* where no one airline is able either to identify emerging threats or to respond comprehensively to them on its own, and the system as a whole lacks the responsiveness and perhaps the motivation to provide a holistic response to the threat conditions emerging for any given airline within it.

This growing element of *system risk* forces safety managers to concentrate increasingly on the defences as the only part of the safety system which still lies mainly within the control of the individual airline. Defences are also important because they are the only element in the safety system which can be effective against the random element of causation – which, as noted above, probably grows in relative importance as many of the past risks are successfully contained.

To be effective, defences have to be available before the initiating event occurs, even if they come actively into play only after it has occurred. They can include physical defences (e.g. armoured cockpit doors, over-engineering of vulnerable components, removing potential obstructions close to runways), technological defences (e.g. simplified cockpit instrumentation,

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<sup>9</sup> Reason, Hollnagel and Paries, 2006.

automated failsafes, fly-by-wire controls), rules and protocols (e.g. airworthiness directives by the regulator, minimum qualification requirements to work on an aircraft, signoff requirements for return to service after maintenance), information (e.g. notices and manuals, automatic warning devices, self-monitoring equipment), and personal and motivational factors (e.g. a professional ethos, a culture of continuous learning, or the right and willingness of workers even at lower levels in the hierarchy to stop a process if they see a risk arising).<sup>10</sup> In the terms of the SCM, they represent the final slices of cheese before the loss occurs.

Foremost among the defences is the engineering of the modern commercial jet, itself a very complex and well-defended system. Considering some of the disturbing maintenance practices discussed by interview participants in our research, of which we give a sample in Chapter 6, the low accident rate is a testament to the levels of robustness and fault-tolerance built into the modern airframe. Even compared with superficially similar models from the 1990s, today's passenger planes not only fly for much longer without intensive maintenance, but appear to be capable of withstanding less rigorous maintenance standards. This is due in part to the advanced self-monitoring and self-correction capabilities which are increasingly being built even into long-established models as new series come into service.

Many defences lie with the flow of airworthiness directives issued by regulators.<sup>11</sup> Many lie within the control of the individual airline and involve practices, protocols and the values embodied in them, which interact with the prevailing regulatory system to create its safety system. Reason characterises an organisation's safety system as being driven by "a continuing respect for the many entities that can penetrate, disable or bypass the system's safeguards. In short, it means not forgetting to be afraid."<sup>12</sup> But where the safeguards, at least collectively, nearly always work, being constantly alert to danger does not come naturally. In a well-defended system, building a safety culture requires willpower and cognitive effort; and so an effective safety system is often counter-intuitive. Maintaining that kind of counter-intuitive culture becomes difficult when commercial pressures not only dominate day-to-day decision-making but also form the most common rationale for major shifts in corporate structure and strategy.

In theory, the likely commercial consequences of a fatal crash ought to provide some kind of countervailing incentive even for the most cost-focused management. In practice, however, that incentive is severely diluted by the normal tendency to discount heavily for very low probabilities.<sup>13</sup> This, incidentally, is why it is so important to continue work on the development

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<sup>10</sup> This practice has been recognised as one of the key characteristics of a high reliability organisation (HRO) as far back as the pioneering research on nuclear aircraft carriers in the 1980s. See Roberts, 1990, p.171: "... Decision-making is pushed to the lowest level possible at least in the sense of vetoes... even the lowest level participant can abort landings... when anyone sees a foreign object on the deck he can call a halt to flight operations."

<sup>11</sup> For example, see the synthesis of Airworthiness Directives issued since 2007 by the Federal Aviation Administration relating to various generations of the B737: Federal Aviation Administration (FAA), 2015b.

<sup>12</sup> Reason, 1998, p.294.

<sup>13</sup> Even where a major crash has occurred, some recent evidence suggests that it may not have a lasting impact on the trading performance of the airline concerned. Bloomberg data accessed on line show that the crash of Air France flight 447 into the Atlantic off Brazil in 2009 had only a short-term impact on the airline's share price, which remained on a stable or slightly rising trend over the four years it took to recover the wreckage and identify the causes of the accident, with the frequent fluctuations bearing no obvious relation to the release dates for different tranches of the inquiry's findings. In the case of Asiana flight 214, which clipped a wall while landing in 2013 and burned on the runway with the loss of the aircraft and three passengers, the share price dipped by 25% a month after the accident, but returned to its normal (albeit gently declining) trend over the full year (Bloomberg, n.d. but c. 2009).

of quantitative accident models capable of providing credible figures which can be set against the financial numbers. In their absence, it is all too easy for redundancy to be dismissed as gold-plating and for complacency to become a corporate virtue, enforced by numerous incentives within the corporate culture, including both espoused and in-use employee performance criteria and advancement within the company hierarchy.

A critical conflict can be expected to occur between redundancy as a tool of risk management and a focus on efficiency, since redundancy by definition violates simplistic concepts of efficiency. One of the most predictable consequences of this conflict is that the presence of multiple, redundant defences will become a rationalisation for weakening an individual defence – i.e. a blind eye will be turned to an unsafe practice at one point in the system, in the belief that some other part of the system will catch and fix anything that goes wrong as a result. But redundancy does not work unless each of these defences is taken as seriously as if it were the only one standing between the hazard and an accident. As noted earlier, redundancy provides the most reliable defence against the randomness of human error (i.e. the possibility for mistakes to occur even when all the risks are apparently controlled). Its dilution, especially if it occurs at multiple points in the system unbeknown to one another, opens up opportunities (often very difficult to detect) for accidents to occur even in an otherwise well designed and conscientiously administered system.

A more general consequence is likely to be a gradual, imperceptible loosening of the fabric of safeguards across the whole system, such that most of its elements remain formally in place, but each is enforced less strictly and with more flexibility as time goes on. This progressive decoupling of the safety system can easily extend to the system of regulatory oversight, even where national regulatory authorities resolutely withstand the market and political power of corporate interests. Governments for whom deregulation has become a touchstone of political virtue may afford limited support to regulatory agencies. Continual funding cuts may make it harder to investigate accidents as thoroughly as they deserve, and the focus of monitoring and audit may be shifted away from actual practice towards documentation of process – a trend noted with concern by International Air Transport Association (IATA) in its 2013 Safety Report.<sup>14</sup>

At the same time the international regulatory scheme, though comprehensive in its coverage and regularly updated, vests practically no enforcement powers in the International Civil Aviation Organisation (ICAO), works largely through consensus and delegation, relies heavily on the discretion of individual member nations to implement its provisions in detail, and is increasingly diluted by bilateral agreements which override and effectively soften its provisions. The average rate of implementation for basic safety reforms, as identified in the latest ICAO audit, is a less than encouraging 61%. We examine the strengths and weaknesses of international regulation in more detail in Chapter 7.

Signs of a deterioration in safety culture have emerged on a number of occasions over the last few years – for example, in a number of recent accident investigations (most notably AF 447<sup>15</sup> and Asiana 214<sup>16</sup>) which have exposed breaches of safe practice that one would not expect of such reputable airlines; and in the need in 2014 for both major aircraft manufacturers and the National Transportation Safety Bureau (NTSB) to issue warnings, within weeks of each other,

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<sup>14</sup> International Air Transport Association (IATA), 2014, p. 74

<sup>15</sup> Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) (n.d. but c.2012) "Flight AF 447 on 1<sup>st</sup> June 2009, A330-203, registered F-GZCP: Final Report", <http://www.bea.aero/en/enquetes/flight.af.447/rapport.final.en.php>

<sup>16</sup> National Transportation Safety Board (NTSB), 2014.

against pilots relying too much on the avionics to fly the plane for them. Even the apparent complacency shown by many airlines (including carriers like SAS and Lufthansa, not known for taking unnecessary risks) about overflying the conflict zone in the Ukraine, together with the failure of the ICAO to reach consensus on a new protocol immediately after the MH17 disaster, could be seen as evidence of such a decline. The record number of incidents reported to the ATSB in 2012 (in the case of high-capacity regular public transport (RPT), growing over twice as fast as the number of departures over ten years) is a possible indication that while the defences remain effective for the present, the number of threats or initiating incidents may be on the rise.<sup>17</sup>

We stress that we have not been able to produce conclusive evidence of a general decline in safety culture, and thus are in no position to predict a resurgence in the accident rate. Nevertheless, there is evidence to suggest that it could occur, and once under way, could escalate rapidly. For the present we can only identify the risk factors in the hope that they will be monitored more closely, and fall back on the words of the Roman poet Lucretius: “Let it be logic that convinces us, not the actual event.”<sup>18</sup>

## 5.2 Known risk factors

We move now to more practical areas of risk which have been identified in the literature or through our qualitative research. Some of these have been part of the industry culture for years and already apply to the kinds of aircraft currently in service, while others are likely to grow in importance as aircraft of the next generation become more common. These risks can be expected to apply regardless of whether the theoretical risk factors discussed in the last section play out in reality, but in cases where they do, the consequences can reasonably be expected to manifest themselves in areas such as those listed below.

**Pressure, disorganisation, regulatory failure:** The Lead Investigator for this project has conducted extensive research over several decades on accidents in a range of industries, and has found that these three factors are present, and interact to reduce safety, in a high proportion of accidents across both close-encounter and highly defended industries.<sup>19</sup> The model is based on a combination of *financial pressures*, causing workers and managers to cut corners and work too fast; hazardous forms of *disorganisation*, including weakened training, induction and supervision regimes, the fracturing of formal and informal information flows amongst workers, dissonance between multiple employers or different parties in a subcontracting chain, and the isolation and inability of subcontracted workers to organise to protect themselves; and *regulatory failure*, including insufficient coverage, shortcomings in implementation and relaxed enforcement.<sup>20</sup> This failure is exacerbated by difficulties in ensuring minimum legislative standards, allocating employer responsibility, and monitoring and enforcing laws in diffuse or multi-employer work sites. Subsequent research identified, in addition, spillover effects arising from such factors as competition of casual workers for permanent jobs, eroded conditions, pay and allowances, and

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<sup>17</sup> Australian Transport Safety Bureau (ATSB), 2013, p. 12. The qualified conclusion stems from the ATSB’s caution, in regard to commercial air transport generally, that reporting requirements have changed during the period. However, this is less likely to affect the statistic for high-capacity RPT, which has always been closely monitored and where incidents tend to be much more publicly visible.

<sup>18</sup> De Rerum Natura V: 109

<sup>19</sup> The literature supporting this model is reviewed in Quinlan, 2014.

<sup>20</sup> On safety along supply chains, see Gregson et al., 2015.



work-life conflict.<sup>21</sup> A historical survey of aircraft accidents in the US has shown strong evidence that the same combination of factors applied in those cases.<sup>22</sup>

**Work intensification and extended work hours:** This was one of the most common problems in Australian-based maintenance to be reported in our interviews and the free-response section of our survey. Given what is known about current staffing levels in Australia, and shortfalls in the supply of fully qualified staff in many other countries, it is only reasonable to expect that the consequences of overwork will appear more often over the next decade or so.

**Use of unqualified or inadequately trained workers:** Australian Licensed Aircraft Maintenance Engineers (LAMEs) whom we interviewed commented frequently on the use of unskilled or at any rate unqualified workers to do many of the more routine tasks in overhauls they had inspected or supervised at overseas Maintenance Repair and/or Overhaul Organisations (MROs). Some of the mistakes they made (notably scribelines) could have had serious impacts on the airworthiness of the plane.<sup>23</sup> Another feature commonly reported, even among reputable overseas providers, was the very high ratio of unlicensed to licensed workers, meaning that it became difficult or impossible for the person who certified the maintenance to make sure by personal observation that it had been carried out properly. Further examples from the ICAO discussed in Chapter 10 attribute this issue to the training of insufficient workers to meet ICAO benchmarks for maintenance staffing ratios. It is thus important in Australia to ensure that the recent decline in training effort does not similarly eventuate in such shortages of skilled workers, flowing through into a relaxation in safety oversight.

**Ageing aircraft:** While most aircraft now in service are capable of operating safely over a very long lifespan if properly maintained, it is generally recognised in the industry that the accident record of any given type follows what is known as a “bathtub curve”. There tends to be a high incidence of accidents and maintenance problems in the period immediately after the introduction of a new aircraft type to service, falling away rapidly into an extended period in which accident rates and maintenance problems plateau at a level where routine scheduled maintenance is adequate to ensure their airworthiness, but rising sharply again at a certain point, beyond which it eventually becomes uneconomic to keep the plane in service. Recent analysis by Airbus of four generations of jet design (defined largely by their avionics) shows a classic bathtub curve in both fatal and hull loss accidents for the second generation (roughly speaking, those which had their engines mounted at the rear), calculated on the basis of ten-year rolling averages, with the third (early 737 models, etc.) and fourth generations also showing a classic pattern for the first half of the curve.<sup>24</sup> Based on this analysis, the older models represent an airworthiness risk which will need to be addressed by intensified and more frequent maintenance. The problem is less likely to emerge for main-route passenger aircraft in countries like Australia, since hardly any of the first or second generation aircraft remain in service here except in freight or charter service, and there is a growing trend for operators in advanced countries to sell off their aircraft at a fairly early stage in their design life – increasingly, before they fall due for their first D check.<sup>25</sup> However, for just that reason, it can be expected increasingly to affect operators in less wealthy countries who often lack the resources

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<sup>21</sup> Quinlan et al, 2013.

<sup>22</sup> Quinlan, 2013.

<sup>23</sup> On scribelines, see also Department of Civil Aviation Malaysia (2005).

<sup>24</sup> Airbus, 2014, p.9

<sup>25</sup> Holland and Davies (2103, pp. 4-5), cite a comment by Brown that “the market is awash with rottables from newer aircraft being broken up for spares”.

to keep up maintenance to the level required. Needless to say, the problem is as pronounced in Australia as anywhere else for GA, and to a lesser extent for the lower-capacity element of regional services.

**Longer intervals between checks:** As noted in Chapter 2, the generation of passenger aircraft now coming into service will continue the long-established trend of requiring ever-greater intervals between major scheduled overhauls. In many cases, as just noted, even current-generation aircraft may pass through their entire service life in an advanced nation without falling due for their first D check. It is reasonable to assume that they have been adequately engineered to perform reliably for these extended periods without stripping and disassembly. However, the long intervals between major inspections mean that if a mistake is made in one check or overhaul, it may be years before the opportunity arises to locate it by systematic inspection, creating a new risk factor of dimensions that have yet to be determined.<sup>26</sup> Possible uncertainties created by changing service intervals may be increased by the trend to re-bundle aspects of the B and even the C check into expanded A checks, which are generally classified as line maintenance, and potentially open to being carried out by staff who cost less to employ because they are less well trained.

**Overreaching:** The growth in world demand for air travel, and hence for new passenger aircraft, continues to outstrip earlier predictions. As the projections continue to grow, more doubts arise as to whether the capacity exists for manufacturing and maintenance supply to keep pace with the demand without severely affecting quality. At the manufacturing end, questions have begun to be raised about whether either Airbus or Boeing will be able to increase capacity sufficiently to handle even the existing order books, let alone the proliferation of new models scheduled for release this decade.<sup>27</sup> Doubts also exist about the capacity of component suppliers to step up their output to the level required while still maintaining acceptable quality standards.<sup>28</sup>

Any systemic problems that emerge with the quality of manufacture (especially the manufacture of parts) will need to be met by tighter maintenance schedules and more frequent inspections, possibly frustrating the common expectation that maintenance demands will fall rapidly from now on. At the same time, the supply of adequately skilled maintenance personnel is already at crisis level in many parts of the world, and current indications are that the demand will continue to grow faster than the capacity of the global training system – a major theme of Chapter 10. To the extent that supply can keep pace with demand, an ever-burgeoning expansion of aviation activity seems to fit poorly with the current trends throughout the world to loosen regulatory requirements and reduce the funding available to enforce those which remain.

The risk of labour supply falling behind demand is one of the main reasons for viewing maintenance as a “sleeping” factor that could lead to a rise in accidents in future. Already industry newsletters<sup>29</sup> make increasingly frequent mentions of a growing shortage of pilots and cabin crew, especially in Asia, and of efforts being made to increase the training effort, and/or to reduce the times spent in training. It is hard to believe that the similar shortage has not begun to affect maintenance labour supply as well – indeed, some of the observations reported in Chapter 6 seem to confirm that this has been the case for some time. A clumsy pilot or a poorly trained flight attendant will be readily obvious to most people on board. But it may be much

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<sup>26</sup> See for example, *Al-Jazeera*, 2014 on reports of manufacturing faults in new aircraft.

<sup>27</sup> *The Economist*, 2014.

<sup>28</sup> See for example Gates, 2013, as one example of a larger conversation around the role of subcontracting in B787 electrical system and battery issues.

<sup>29</sup> For instance, *AviationCV.com*, 2015.

harder for passengers to notice a decline in the quality of maintenance. Such a decline may continue to be neglected until something goes seriously wrong.

As we point out in the final sections of this report, the exploding demand can be seen from one point of view as providing massive opportunities for Australian industry. However, the flipside of these opportunities lies in the dangers they create if they are not adequately taken up.

### 5.3 Independent assessments of risk factors

IATA is the only reporting body, of those cited in the previous chapter, to provide a narrative section on specific risks underlying maintenance-related accidents. In its 2013 Safety Report<sup>30</sup> it notes outsourcing as a key risk factor, reporting that

...very few MROs are capable of completing a large work package ... to a high standard under normal time pressures. *MRO certification is not a guarantee of work quality.*

This report argued that maintenance certification, including Certifying for Release to Service (CRS), is a risk area because the required procedures for clearance do not necessarily guarantee the quality of the maintenance itself:

In many cases, too much effort and legislation is put into oversight of the documentation trail, rather than the repair work being physically performed on the aircraft. For example, whoever certifies an aircraft is airworthy must be certificated, however those who perform maintenance work do not necessarily have to possess any licensing credentials.<sup>31</sup>

It added that “there are some anecdotal cases where the primary concern was that the paperwork for a work package was not done, when in reality the work itself had not been completed.”

The IATA 2013 safety report also expressed concerns over sourcing of parts, including what it called “bogus parts” and “rogue parts”, “reused without being properly certified or checked for serviceability.” These were said to include very old parts, inappropriately refurbished and put back into service, and parts used to prolong the interval until the next scheduled major service. The IATA report cited human error as a “leading factor in maintenance aircraft incident events” and recommending closer investigation of the causes of human error and tighter auditing of human factors.

A United Kingdom (UK) Civil Aviation Authority (CAA) safety overview report classified maintenance-related causes of fatal accidents under a number of headings.<sup>32</sup> In contrast to the IATA report, it ruled out bogus parts, unqualified workers, incompetence and fatigue as factors contributing to the accidents it reviewed.

Further reviews of maintenance concerns were carried out by the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA), independently in 2010, and on a coordinated basis in 2014. As it appears that this research has yet to be fully written up for

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<sup>30</sup> International Air Transport Association (IATA), 2014, pp. 74-5. Emphasis added and typographical errors corrected.

<sup>31</sup> Ibid.

<sup>32</sup> Civil Aviation Authority - United Kingdom (CAA), 2013.

publication in a scholarly journal, we have been forced to rely on a summary published in a bulletin by a senior FAA official.<sup>33</sup>

In the two FAA and EASA surveys carried out in 2010, three common themes emerged across both continents as the most frequently mentioned: worker fatigue, the inadequacy of safety cultures, and how to measure the impact of human factors training programs. Other factors to make the top five in North America were difficulties in using technical publications, and problems with a system of voluntary reporting (or possibly, disincentives to reporting in a non-mandatory framework). In Europe, the remaining two places were taken by European Union-specific problems: how to arrive at standard regulation across 28 separate national regulatory authorities, and the need to expand human factors training into those nations where it was not yet readily available.

In 2014, when a single online survey was used on both continents, the top five concerns in order of frequency were “culture/leadership” (presumably meaning management attitudes towards safety), problems with technical publications, worker fatigue, voluntary reporting, and measuring the impact of human factors training. Together these made up 67% of the combined responses, with technical publications and fatigue mentioned by half or more of the respondents on each continent. Taking the response sets separately, oversight and regulations made up the list in Europe, while “human factors training”, “pressure/stress” “measuring impact” and “voluntary reporting” tied for fourth place in North America.

The 2014 survey included a free-response section which appears, based on the summary, to have produced some very enlightening feedback. As coded and summarised by an FAA employee, the additional challenges identified in this section included “managing to outcomes rather than process” which was said to have led to a perception by the workforce that “our procedures aren’t important enough to adhere to”; management making a conscious decision to lower the bar on safety culture; difficulties in applying Reason’s concept of a “just culture” (presumably meaning an ongoing tendency to tackle identified mistakes by punishing individuals); poor compliance with officially specified processes and procedures; the need to set legally enforced maximum hours of duty for aircraft mechanics; and a tendency to bypass the maintenance manual in operations that had become very routine, e.g. tyre-changing.

It would be unwise to place too much reliance on these surveys, given that the sampling strategy appears to have been reasonably unstructured (a combination, apparently, of volunteer and convenience sampling) and the achieved sample in 2014 was a mere 51, with North America heavily over-represented. However, it is impossible to overlook the strong similarities between these findings and the concerns which have arisen out of our own research, suggesting that the problems faced by Australia are common ones shared by other advanced nations.

## 5.4 Conclusions

The qualified reassurance emerging from the previous chapter is somewhat offset by the arguments summarised in this one. In estimating the likelihood of an accident, the main difference from the past is probably that a great many more things now need to go wrong simultaneously before really serious consequences ensue. Thus, the things going wrong will be now increasingly be ones that could not have been easily foreseen. This means that the risk still exists even in the most sophisticated and consciously protected system.

The main argument for continuing vigilance is that the opportunities for multiple things to go wrong at the same time appear to be gradually increasing. This circumstance is due to a steady

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<sup>33</sup> Johnson, 2014

but mostly unremarked growth across the board in the amount of slack being introduced into the various systems that protect aircrew and passenger safety. This word needs to be treated with caution, since *organisational* slack (in the sense of having more people and time than the bare minimum required to do the job in hand) is recognised as a necessary precondition for a high-reliability organisation<sup>34</sup> — and appears to be noticeably on the decline in both airlines and contract MROs today. However, in a system made up of different organisations, with different interests and motivations, interacting through intermeshed supply chains, *system* slack (used here in the different sense of progressive decoupling) is more likely to manifest itself in a growing number of loopholes through which mistakes can slip.

What we seem to be witnessing (though it cannot yet be conclusively demonstrated) is some ongoing erosion of “collective mindfulness”, to use Weick’s term.<sup>35</sup> In part, admittedly, this erosion appears to be a rational response to the continually improving statistics, but equally it appears to be a response to growing pressures at the management level to prioritise efficiency over safety. The trend implies that the often sincere attempts of some organisations within the system to develop characteristics of a High Reliability Organisation (HRO) face the risk of degenerating into espoused values or processes that exist mainly on paper – a trend matched by a regulatory system which seems increasingly focused on paperwork rather than practice.

As protective systems become more loosely coupled, the defences at the “sharp end” need to become more effective in detecting and responding to the threats which pass through the emerging gaps. Airlines are fortunate today in that the most important currently available defences come packaged with the plane. However, the human element remains, and with it the need to become more agile, alert and informed in order to recognise and effectively manage the unique, unprecedented combinations of events which increasingly make up the preconditions for a fatal accident.

In these circumstances, airlines (and their customers and employees) are becoming more dependent on the quality of the human defences at the “sharp end”. In the area of maintenance, which is less visible to the passenger, the key strength or risk (as the case may be) lies in the quality of inspections and tests to which a plane is submitted before being put back into regular service. In this environment it is vital that those doing the checking are sufficiently trained to detect and make sense of non-routine problems, but just as importantly, that their technical expertise is respected by management and their informed judgements are not overruled.<sup>36</sup>

However good the original intentions of an organisation may be in this regard, the practical commitment will be vulnerable in times of commercial stress unless it is backed up by some kind of institutional support. In Australia, as in most other national systems of aviation regulation, this has traditionally been provided by the licensing mechanism which equips the LAME with the delegated authority of the state, even while working within an employee relationship. As we will argue in Chapter 7, this mechanism could come under challenge within Australia as a result of the current process of national regulatory reform, and becomes markedly less effective once the maintenance moves offshore.

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<sup>34</sup> See Hopkins, 2007, p.9.

<sup>35</sup> Weick et al. describe collective mindfulness as the characteristic of an organisation which “captures discriminatory detail about emerging threats and creates a capability to swiftly act in response to these details” (Weick et al., 1999; Weick & Sutcliffe, 2006)

<sup>36</sup> Weick and Sutcliffe, 2001, p. v; Hopkins, 2007, p. 10.



# Chapter 6 Offshored Maintenance and Safety

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## 6.1 Introduction

Over the past decade, the outsourcing of maintenance beyond national boundaries has ceased to be a departure from established practice, and become increasingly the norm in all parts of the world. As this has occurred, the ability of national aviation safety regulators to manage the quality and safety issues for which they have responsibility has been increasingly challenged, while the emerging risks have also served to highlight inadequacies in the international regulatory scheme. Describing the risk factors and the regulatory challenges, and looking for possible means of remedy, is our main focus in this chapter and the next.

This underscores that since 2006, the issue of offshoring, particularly of the heavy maintenance of large wide-bodied aircraft has become a contested one. On the one hand is the business case argument that heavy maintenance is better concentrated in the large hangars of maintenance repair organisations (MROs) such as Hong Kong Aircraft Engineering Company Ltd (HAECO) and subsidiaries of those airlines such as Lufthansa and Singapore Airlines (SIA) who have moved into the heavy maintenance market. High-volume heavy maintenance providers are thus thought to have the scale advantage of a continuous workload. Though their cost advantages are diminishing with the global realignment of exchange and wage rates – such MROs at present tend to be located in areas where labour is cheaper.

Against these considerations are the safety issues raised by the offshoring of aircraft. This chapter reviews some of our evidence on such issues. It argues that the instances of safety problems we describe are sufficient to raise concerns in the context of the weakening of the safety oversight regime described in Chapter 7. The two chapters together argue that we cannot be confident in the safety oversight of offshored maintenance, and it follows, of the quality of work performed in some offshore MROs. These concerns will only increase because countries in our region will be the hardest hit by a growing global shortage of skilled maintenance personnel, a point which forms the substance of Chapter 10. The immediate remedy lies in an adequate system of regulation. The medium term solution is to start rebuilding Australia's own maintenance capacity, and the longer-term solution is to become a new exporter of maintenance and maintenance training, to take advantage of the Asia-Pacific maintenance shortfall, which will begin emerging in the next ten years.

The central focus of this chapter and the next is thus the growing difficulty of regulating maintenance safety and quality, including across national borders. These issues are analysed within a broader framework of agency and risk management theory, in which offshore maintenance is seen as a subset – albeit a particularly problematic one – of the issues that are commonly recognised to arise from outsourcing, and from supply chains in general.<sup>1</sup> The chapter begins by setting out, at a theoretical and conceptual level, the potential issues that may arise in the management of outsourced contracts – issues to do with agency, the balancing of interests, and information. It then moves on to provide empirical examples attributable to these issues. These examples highlight instances of the dilemma of maintaining the integrity of national safety management systems whilst respecting the sovereignty of other nations. The examples are provided in an effort to pinpoint areas where divergences in standards and oversight have created either safety or jurisdictional dilemmas.

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<sup>1</sup> Quinlan et al., 2013; Gregson et al., 2015

While the impact of this evidence is diminished because it is old, on the other hand it *is* significant because it shows that there have in the past been serious violations of safety protocols, and the vacuum of similar reportage does not mean that serious safety problems are not occurring right now.

It is also unfortunate from a research perspective that the best available evidence of potentially unsafe practice in offshore maintenance shops was provided by workers who can be seen as having a vested interest in protecting their future livelihoods from the threat of offshoring. In the absence of rigorous and up-to-date academic research, and in view of the difficulty researchers had in gaining access to overseas MRO shopfloors, it has been necessary to rely on such information, as well as that gleaned from a variety of industry sources. In this instance the self-interest is at least clear and identifiable, and can be balanced against the reality that the best people to provide information about what happens on the workshop floor are those who have worked there. This said, we have been rigorous in filtering the large body of narrative evidence which has come our way, and in using only those accounts which are most clearly the product of direct observation or participation within a reasonably recent timeframe.

The examples are cited primarily as evidence that poor practice *can* occur, and that when it occurs offshore, the existing regulatory framework – in Australia, in the source countries and in the international arena – has been less than fully effective in containing it.

## **6.2 Agency and information problems in contract maintenance**

In moving to contracting-out maintenance, the air operator gives up much control over the maintenance of its planes. It loses the sense of direct responsibility for the quality of the work that goes with working on its aircraft, and at the same time the maintenance provider may lack the sense of end-of-line accountability which would exist if it were flying the plane and directly responsible for the welfare of crew and passengers. The operator loses the specialised knowledge of particular systems and processes, including the history of particular components, that would normally reside on the shop floor or in company information systems. All these factors mean an arm's length relationship between the operation of the aircraft and its maintenance, in which moral (if not legal) accountability can easily fall through the gaps.

In the past, decisions about which maintenance operations were to be performed, and how, were taken from the air operator's perspective. Now, whether the third-party contractor is onshore or offshore, maintenance decisions are increasingly shaped through the relationship between the operator's continuing airworthiness management processes and those of the maintenance vendor. The relationship operates through the mechanism of a contract where, by definition, the interests of the two parties do not always coincide. This discrepancy of interests results in what is called a *principal-agent* or *agency* problem. (Where an independent continuing airworthiness management organisation (CAMO) is involved as an intermediary, there may obviously be more than one agency issue.)

The most common manifestation of this problem is a *compliance approach* in which the contracted provider does only what is precisely set out in the contract. This approach can be a particular hazard where a contract specifies work to be done within a particular timeframe – given that each day a plane is out of service is costly to the airline, it wants the work done as quickly as possible, and if the work is not completed within that time, heavy penalties may apply. The discovery of unexpected maintenance issues, like a piece of corrosion or cracking, may cause problems if the extra work and the time it takes fall outside the scope of the contract. To perform new work may require contract renegotiation and/or lengthening of the time the plane is out of service. In some circumstances, the vendor might find it less trouble to abide strictly to its contract obligations and ignore the work needed. Alternatively, it may go through the motions by “pencil-whipping” the additional work required (signing it off as completed when



it has not been), or performing it too quickly to be effective (for example by not properly removing corrosion but covering it up with filler and paint) in order to meet a deadline which it sees as its primary contractual obligation.

An alternative risk is that either party to the contract, or in some cases both parties, may have both the opportunity and the incentive to *game* it. Where there is pressure to return the plane to service, both sides may have an interest in deciding to “bury” the offending defect by agreeing to not *define* it as a defect, or to defer dealing with it. Conversely, if the maintenance is ahead of schedule and there are no other contracts in the pipeline, the vendor has an incentive to define minor imperfections as defects in order to over-service and create work for itself. Our industry informants have provided evidence that this kind of gaming is not as fanciful as it might sound:

*The contract was written at a fixed price for routine work, but all work arising was charged extra, so the MRO workers would spend more time on those jobs as they made more money, the majority of these were minor cabin appearance issues, not airworthiness issues.<sup>2</sup>*

Another risk that arises in the first kind of situation is a loss of the whole-of-plane approach to maintenance. Since the maintenance provider sees its responsibility as beginning and ending with the contract specifications, it may feel that it has no responsibility once the work is done to check it in conjunction with the functioning of the remainder of the aircraft, as would generally be the case if the operator were doing the maintenance in its own workshop.

*A straight contract maintenance to do just what they're told to do, they can give you back an aircraft with a cracked frame.<sup>3</sup>*

*The contract maintenance does exactly what's in the contract. If you're going in there to just do a certain task and it's not an inspection, irrespective of what damage is around there, they do the task and close it up because that's the contract.<sup>4</sup>*

We must repeat that we have no reason to believe such cavalier interpretations of contract responsibility are general or even common. However, we have had ample evidence presented to suggest that they do happen, and will set that evidence out in the next section of this chapter. The important point to make is that the contract relationship may provide inbuilt incentives for such malpractice unless either the contract is very carefully written, or the activity of the provider is adequately monitored.

During the first wave of regular Qantas offshoring, which ran roughly from 2006 to 2009, such monitoring was common practice. Teams of licensed aircraft maintenance engineers (LAMEs), professional engineers and managers were sent overseas with the planes to check on safety and the quality of maintenance, as well as to safeguard the airline's interests in the case of conflict. This practice continued until about 2012, when LAMEs reportedly ceased to be included in the inspection teams. It is not clear how much of this activity Qantas still carries on, or the extent to which other Australian airlines that outsource to overseas vendors carry out a similar inspection regime. However, in the absence of LAMEs who might have been prepared to report on their experience, our evidence on practice in overseas shops is effectively limited to that six year period.

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<sup>2</sup> Survey respondent #10350.

<sup>3</sup> Interview, former Inspector and Maintenance Manager, 2011.

<sup>4</sup> Interview, former CASA official, 2012.

Another important consequence of outsourcing, unrelated to the agency problem but often exacerbating its impact, is that the airline loses its own capacity, not only to do the kind of work in question, but to determine whether it has been properly done. One common consequence is the loss of corporate memory about particular aircraft, their individual quirks and known failure points as well as particular knacks required to keep them operating safely, which would normally accumulate within the airline's own workshops. This problem is likely to get more acute in future as the maintenance on new-generation aircraft becomes wholly outsourced and the workforce remaining in the operator's own shops never gets the opportunity to become familiar with the technology used in these types.<sup>5</sup>

A case in point from the recent past involves one of the most widely acknowledged success stories of the previous maintenance regime, the engine line at Sydney. Qantas used to be regarded as having world's best practice in the maintenance of Rolls-Royce RB211 engines, and Rolls-Royce engineers would visit this line to learn about the techniques used there. However, Qantas closed the line in 2009, outsourcing the work to Singapore and Hong Kong to save costs, with the loss of 360 jobs. The Australian Licensed Aircraft Engineers Association (ALAEA) in its submission to a Senate inquiry in 2011<sup>6</sup> listed a series of relevant events, starting with a Federal Aviation Administration (FAA) airworthiness directive (AWD) for the RB211 Trent series engine, which required work on these engines – used by Singapore Airlines and Lufthansa – to correct a tendency to fail. Five such failures, with degrees of severity ranging from “massive uncontained” through “uncontained” to “contained”, occurred in Qantas planes between August 2010 and October 2011. By then Qantas lacked the ability to correct this problem itself, and the overseas MROs to which it would have otherwise outsourced the work were fully occupied doing work for Singapore and Lufthansa.

*The engines that had failed on Qantas have been all done outside of Australia. If you look back through Qantas' history, tell me the last time an Australian maintained overhauled engine failed.*<sup>7</sup>

Given the growing evidence of an emerging skill shortage in MRO throughout the world, which we cover in more detail in Chapter 10, we see this as a precedent that is likely to be repeated increasingly often over future years.

### **6.3 Evidence of quality problems in offshored maintenance**

The more important C and D checks on a metal airframe require very labour-intensive stripping-down of the aircraft in order to inspect for cracks and corrosion. Although hull inspection and the rectification of structural, mechanical and other faults clearly require skilled and suitably certified labour, many parts of the preliminary stripping-down and subsequent refitting, including much of the removal of the interior, along with cleaning of parts and similar work which is not in itself critical to airworthiness, lend themselves to being carried out by workers with lower levels of formal qualification, provided adequate qualified supervision takes place.

However, to take one example, mature, advanced paint removal technologies use non-hazardous processes such as blasting with starch or plastic, or lasers, accompanied by non-destructive materials testing (NDT) processes, or most recently use of robot/unmanned aerial

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<sup>5</sup> Increased use of rotables (parts from reasonably new aircraft taken out of service) may also contribute to loss of knowledge of an aircraft's performance and maintenance history. See Holland and Davies, 2013, pp, 4-5.

<sup>6</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2011, pp.37-38.

<sup>7</sup> Interview, CASA Inspector, 2013.

vehicle (UAV) surface scanners. Paint removal can have important impacts on airworthiness if it is not done carefully and under knowledgeable supervision, as faults can lie dormant for many years before producing catastrophic results.

The most commonly encountered instances involved what are called scribelines, small scratches made in the aircraft hull as a result of using inappropriate tools to remove sealant from panel joints or around external fittings, or paint from the hull surface. The problem is that approved tools (soft scrapers made from perspex, which will not scratch metal) are not as efficient for paint removal as prohibited tools like paint scrapers, screwdrivers, pocket-knives and even angle-grinders – all tools that our interviewees have reported as having been used in offshore facilities. With repeated cycles of pressurisation and depressurisation, such apparently trivial and inconspicuous scratches can eventually develop into cracks and tears, and/or cause fatigue cracks and aircraft disintegration.

According to an Airworthiness Notice (AWN)<sup>8</sup> issued by the Malaysian Department of Civil Aviation, concern about scribelines goes back to a 1988 incident in which an American-registered Boeing 727 “experienced cabin decompression after the fuselage skin peeled off from its stringers. The National Transport Safety Bureau (NTSB) concluded that the skin failure was the result of “scribe mark” scratches which was [sic] introduced during the aircraft maintenance”. The AWN went on

It is obvious that such “scribe mark” scratches, if not repaired, will initiate fatigue cracks and resulting in widespread multi-site fatigue damage (MSD), which would result in rapid decompression and loss of aircraft in flight.

Boeing in 2004 required special inspections on its 737s, made changes to its structural repair manual and issued AWDs to take extra care with scribelines. The Malaysian AWN explicitly required MROs to take special care to avoid generating scribelines with unapproved tools. However, despite the existence of a current AWN and the fact that scribelines were by now one of the most commonly recognised hidden faults in heavy maintenance, Australian inspectors supervising maintenance only a couple of years after its issuance continued to find instances of unsafe sealant removal practices. In the case described below, workers were subject to time imperatives, they cut corners with the process, and only the efforts of a diligent manager with a commitment to safety found the poor quality work and demanded it be redone to standard.

*They were just walking around with knives cutting sealant off skin panels, leaving these scribe — quite heavy scribelines in some cases and when we were finding these and bringing it to their attention they were in that case definitely just hiding the defects. ... Well, they were told to rework it in accordance with the SRM (Structural Repair Manual) and then allow us to inspect it...*

*I returned the next day, ... the sealant was on and the paint was already applied. I said well, hold on a sec guys, I asked for us to inspect this. Oh no, that was going to take too long because we did this on the night shift and you were going to hold us up and I said well, I don't care, take it off and it started a whole hoo-hah. ... I had to sit down with the managers, I had to sign ... a customer agreement form basically that said I agree to the extra man-hours*

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<sup>8</sup> Department of Civil Aviation Malaysia, 2005. This Airworthiness Notice claims that one Boeing 737, having experienced scribeline damage in the mid-1990s, went on to develop a 10-inch crack, and that one operator has decided to retire a similarly affected aircraft early.

*required to remove this and we'll pay the bill and everything else. So I insisted they pull it off, when I pulled it off the scribelines hadn't been repaired.<sup>9</sup>*

In the following case, inspectors had to uncover the causes of slow decompression on one of two Boeing 747s Qantas had purchased from another airline immediately after they had undergone D checks.<sup>10</sup> The two became known within the industry as the “Ugly Sisters” because they were plagued with faults. The cause of the decompression turned out to be a long vertical (around the body) crack in the frame, which was deemed to be the consequence of the use of non-approved tools in paint removal. The scribe line had subsequently been covered up with sealant, which had started to lift from the frame as a result of the pressure exerted from within the fuselage. The crack in the frame resembled a pencil line, visible as a crack only through prior knowledge. The incident is a dramatic “free lesson” in the dangers of using non-approved tools in paint removal.

In other areas of heavy maintenance, informants had found examples of pencil-whipping, often under management pressure. The instances reported were picked up by observant inspectors, but it seems reasonable to assume that many similar occurrences of non-compliant work may have passed undetected.

*I noticed several incidents in which systems tests were signed off as done when there was no test equipment available to carry out the tasks. I noticed the pressure applied from management to certifying staff to “just do it”.<sup>11</sup>*

*All four engines were off the wing on engine stands with easy access inside and out – zero defects were found on all four engines! This is impossible! I personally redid the inspections myself and found approximately 80 defects, 11 of which were engine disconnect plug replacements. They missed a migrated truck pivot bearing that resulted in the L/H body gear having to be removed. They installed an entire galley before the waterproofing was completed. They lowered the aircraft off jacks on a work stand, damaging an engine cowl. They used angle grinders to remove corrosion without covering up other areas... i.e. metal shards sprayed all over exposed wiring, etc.<sup>12</sup>*

After a check at an overseas facility a plane was returning to Australia when the galley came loose in flight because it had not been secured properly. The galley is a large structure weighing upwards of 200kg.

*Those guys hadn't done it up and what was happening was in flight this galley was going boom, boom, boom and it pulled all the bonding jumpers off — ... So it wasn't bonded. It's made of metal and it's got 115 volts of power going to all the ovens and the boilers and all of that sort of stuff. It was live and it delivered a couple of electric shocks to one of the hosties when they grabbed a hold of*

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<sup>9</sup> Interview, Former Airline Maintenance Inspector, 2014. Another inspector remarked, “Some Boeings [were sent]... [offshore] to get painted and then the engineers started finding cracks and the [offshore workers] were using steel scrapers instead of — what do you call it — Perspex because it's quicker. Now, the FAA ends up grounding 44 Boeings around the world”.

<sup>10</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2014a, pp. 10ff; interview, former Quality Inspector, 2014.

<sup>11</sup> Survey respondent, #10350.

<sup>12</sup> Survey respondent. #10595.

*the handrail - boom. At the same time ... I'm pretty sure it damaged all the tops of the equipment at the same time. So it caused severe damage.*<sup>13</sup>

ALAEA claimed in a submission to a parliamentary inquiry<sup>14</sup> that after a D check carried out on a B747 in Hong Kong, a number of the engine mounting bolts were found to have been installed upside down. The ALAEA clarified in its verbal and supplementary documentary evidence that it was in fact the washers on three of the engines that had been installed upside down, while a witness representing the Civil Aviation Safety Authority (CASA) claimed that the problem was a trivial one and affected only one bolt on one engine. The ALAEA argued in reply that the incident had not been properly reported, and if it had been, an Airworthiness Directive would have needed to be issued requiring new checks to be done on all the engine installations done by the MRO to be checked.<sup>15</sup>

On the one hand, it is hard to think of any component in the whole of mechanical engineering which suffers more intense stresses than the bolts attaching an engine to a large passenger jet. On the other hand, this was an area in which each of the rival parties had a legitimate claim to speak with authority, and there is no way of determining objectively which of the two conflicting perspectives to believe.

One reason for departures from standards appears to be a strong undersupply of qualified and especially licensed supervisory personnel. According to ALAEA,<sup>16</sup> a desirable ratio of supervision in Australia is 1:2 – that is, one LAME supervising the work of 2 aircraft maintenance engineers (AMEs). In Europe, on average, the ratio is estimated at 1:5.<sup>17</sup> The International Civil Aviation Organisation (ICAO) benchmark, which is based on representative observed practice across all member nations, sets the ratio for a large passenger or cargo jet at 1:3. However, the ALAEA claims that LAME/AME ratio in a Singaporean MRO, to which Qantas planes were being offshored for heavy maintenance, was 1:11. In Hong Kong, it was found to be 1:8, and in the Philippines 1:22.<sup>18</sup> The supervision problems are often compounded by language difficulties:

*You might have one LAME who's overseeing 20 or more AMEs, some of who have no English at all because I know, particularly in [name of MRO deleted]; I had a lot of trouble communicating with guys.*<sup>19</sup>

Some informants suggested a systemic link between safety outcomes and national differences in regulatory requirements. One maintenance inspector remarked that

*If we were seeing a lot of unusual defects or defects that were unusually severe in their extent we would go back and look at the previous check and nearly always the previous check would've been done at a foreign MRO.*

*I've actually worked on the [de-identified] aircraft in our maintenance facilities before. We used to do some of their engine maintenance and we found some rather unnerving things. We found drills broken off inside fuselage [pins] and a rivet head had basically been cut from the rivet and glued over the top of the*

<sup>13</sup> Ibid.

<sup>14</sup> Australian Licensed Aircraft Engineers Association (ALAEA) 2014a, p.8.

<sup>15</sup> Australian Licensed Aircraft Engineers Association (ALAEA) 2014b.

<sup>16</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2007.

<sup>17</sup> Personal e-mail communication, President and Vice President Air Engineers International, 7 June, 2014; 4 November, 2014.

<sup>18</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2014, p. 8.

<sup>19</sup> Interview, former Quality Inspector, 2014.

*rivet hole. ... So they X-rayed the panel and we found a drill bit stuck inside the fuselage. ... once again whether that was done by [de-identified] Airlines maintenance itself, or whether it was done by an MRO that they used, obviously we can't find that out.*<sup>20</sup>

If, as has been suggested, observance of safety standards is linked to the local availability of sufficiently qualified maintenance and supervisory staff, the impending global shortage of aircraft engineers may see such examples multiply, with no country in the region, including Australia, immune. Whilst the critical need is to address the skills gap, it will also be increasingly important, in a global labour market, for governments to address the dilemma of overcoming national jurisdictional boundaries in the interests of aviation safety. This will mean addressing some of the regulatory issues outlined in the next section.

#### **6.4 Jurisdictional issues and the need for effective regulatory oversight**

As the supply chain for maintenance becomes longer and more international, so the problems of oversight increase, well beyond the designed capacity of the present system and arguably well beyond its capacity to adapt in its present structure. Unfortunately, all the evidence so far suggests that the regulatory presence, and monitoring activity in general, have been declining over recent years where Australian airlines are concerned.

As mentioned earlier, the first wave of Qantas offshoring involved numerous Qantas managers, engineers, inspectors and licensed personnel in monitoring the contractors' work practices. Our admittedly limited evidence suggests that even at this time, CASA inspectors were thin on the ground, and confined themselves to desktop audits rather than visiting the shop floor.<sup>21</sup> As argued in the next chapter, the auditing function appears to be shifting from actual practice towards documentation of process – a trend already noted with concern by the International Air Transport Association (IATA) in its 2013 Safety Report.<sup>22</sup> and remarked upon by the ASRR<sup>23</sup>. It also seems that in subsequent offshoring, fewer licensed personnel found themselves performing inspecting and supervisory roles on these expeditions. Thus, more and more of the burden of safety assurance has fallen on the airlines' own quality inspectors and professional engineers.

In saying this, we do not mean to play down the responsibility which the airline itself carries for the safety of its own operations. Nor should it be forgotten that ultimate liability at law for any harm coming to aircrew, customers or their belongings or consignments rests with the carrier. However, as pointed out in Chapter 5, when a carrier is under severe competitive pressure it can often be tempting to relegate this responsibility beyond the first rank of priorities, given the very low statistical risk of a disaster. More to the point, once the number of outsourced providers passes maybe half a dozen, strict periodic inspection of all the contract MROs, to say nothing of their subcontractors and parts suppliers, quickly escalates to a substantial inspection load. Equally, a provider who may have dozens or even hundreds of customers would find it a substantial encumbrance to productivity if all of them had their own inspectors present in the workshop at regular intervals. Given these factors, it seems inevitable that sooner or later inspection must become a collective responsibility, and given the degree of public interest in the

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<sup>20</sup> Ibid.

<sup>21</sup> Interviews, Airline Quality Manager, Airline Engineer, CASA inspector, Former CASA official, 2012-2014.

<sup>22</sup> International Air Transport Association (IATA, 2014), p. 74.

<sup>23</sup> Australian Government, 2014.

consequences, that part of that collective responsibility must be borne by national and international regulators.

On the other hand, the real cause for concern may be not with those airlines which still attempt to carry out their own inspections, but with those which leave it to trust and rely solely on the regulator. In the view of one insider, it is not unusual for a contracting airline simply to rely on the approvals of its own national aviation authority (NAA) and the NAA of the country where the MRO vendor is domiciled, without doing any checking of its own on the ground.<sup>24</sup> As the evidence in this chapter has shown, such trust may well be fatally misplaced in today's regulatory environment.

Within Australia, CASA inspectors once visited the shop floor with some regularity, and would inquire into actual real maintenance processes. Now, inspectors rarely do this, instead conducting paper audits. Although according to the ASRR<sup>25</sup> this is consistent with present "best practice", there is some concern about its use in the industry, as the following quotations attest. The problem is that paper audits do not directly reach the workplace, where faults could lie that were not picked up in the company's safety management system.

*We only look at paperwork now. We very rarely actually look at an aircraft to see if the work's done properly. Only look at the processes. If the paperwork's fine then if something goes wrong then you just blame the company.*<sup>26</sup>

*I think CASA could be so good for the industry, doing what they're supposed to do, which is getting out there, regulating and inspecting. You can't find out what's wrong with a system if you don't audit that system adequately. And just opening the book up and making sure all the boxes are signed is not adequate. That's all they do, desk top audits.*<sup>27</sup>

*When I started in the industry, ... they spent the morning going through the job records and poor procedures manual and that sort of stuff. The afternoon the surveyors wandered the workshop and he'd come up to your bench and he'd say: What are you doing there and you'd have to explain yourself, what you were doing. You'd show him the data that you're using, how you're drawing your parts out and it was actually a hands on assessment of the way things were going. These days...*<sup>28</sup>

*CASA comes in to do an audit on me now and the surveyor will normally grab a whole stack of files and things, he'll come in here, he'll stick his head in the window and say I'm going to have lunch, come back afterwards and he'll stick his head in and say I'm going home. Then he'll pop his head in the day after and say: It's all good, no major issues, a couple of little things, it will be in the report.*<sup>29</sup>

*You know four weeks in advance or six weeks in advance when they're going to be here. There's this charade that goes on around the place where we'll put all*

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<sup>24</sup> Interview, Qantas Engineer; Senior Maintenance Manager, 2012

<sup>25</sup> Australian Government, 2014.

<sup>26</sup> Interview, CASA Inspector, 2013.

<sup>27</sup> Interview, GA LAME, 2009.

<sup>28</sup> . Group interview, GA Employers, 2011.

<sup>29</sup> Ibid.

*this stuff in the back room and get rid of that and hide all this stuff, we've got a CASA guy coming here. It's just a joke.*<sup>30</sup>

*Previously CASA had field officers at just about every airport. There were three surveyors based here at [de-identified] and they knew every engineer by name and at least once a week they'd do a bit of a wander round, a quick look through the hangars, talk to you about any problems you were having. That's all gone.*<sup>31</sup>

The 2014 Aviation Safety Regulation Review (ASRR) report,<sup>32</sup> while generally upbeat about the performance of the major airlines, was not reassuring about the effectiveness of CASA's current practices. It argued that while there is a worldwide shift in the nature of safety oversight and inspection from direct inspection of workplace processes and systems, to one of auditing workplaces' safety management systems, CASA inspectors' capabilities to perform these audits is lacking – points we take up in the next chapter. While this view was expressed in relation to the domestic sphere, we can only conclude that it applies equally or more to offshore inspections.

The burgeoning offshore maintenance industry has left CASA with an enormous increase in its potential monitoring load, and no recent government has shown any inclination to adjust its resourcing to accommodate that increase. As in the case of airlines conducting their own monitoring and due diligence, there is a strong argument that it needs to adopt radically new approaches in order to meet user expectations within a context of growing fiscal austerity. However, its room to move – or even its freedom to carry out its original remit – has been constrained in recent years by developments in the framework of international law within which it is bound to operate. More than CASA alone, it is a case of the international regulatory system struggling to accommodate a radically new environment, which has exposed the vulnerabilities that were inherent in it from the start. The next chapter looks in more detail at what that international framework entails, and where it is currently failing.

## 6.5 Conclusion

Detailed evidence of a future shortfall of appropriately trained and licensed engineers in the aviation industry will be presented in Chapter 10. One outcome is likely to be work intensification. In this context, it will be critical to manage the tension between profit and protection, through licensing and industrial relations regulatory regimes that can safeguard the independence of engineers seeking to ensure. Another response to the shortfall may be to reduce qualification and training times (indeed, the IATA foreshadowed this in 2009)<sup>33</sup> and to allow certification work to leak to less qualified personnel. We need certainty that the industrial relations, training and licensing regimes of the countries to which Australia off shores its maintenance, adequately safeguard the capacity to perform the socially protective roles that are at the heart of aviation safety. Only then can we rest easy about both present and future safety performance in offshore maintenance regimes.

Safety performance in offshore maintenance facilities is, however, quite likely to fall off as a result of the looming skills shortage, as airlines and MROs alike seek to maintain levels of production and profits in face of personnel shortages. For all the reasons mentioned above, it is

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<sup>30</sup> Ibid.

<sup>31</sup> Ibid.

<sup>32</sup> Australian Government, 2014, pp 1, 28.

<sup>33</sup> International Air Transport Association (IATA) (2009).



highly desirable that Australia should retain the capacity to perform its own heavy maintenance on its own planes – including the emerging generation of twin aisled planes on the leading edge of passenger aviation technology. However, to argue this is to encounter the cruel reality that for the present it is very difficult, if not impossible, to compete economically with the large facilities, centrally located in Asia and the Middle East, characterised by formidable economies of scale. The challenge therefore becomes, how to retain the capacity to “reboot” Australia’s heavy maintenance capability as the skills shortfall begins to bite, and to nurture and build on the capacity that is already there. The first step, ensuring the integrity of the Australian licensing system across all aviation sectors, is taken up in the next chapter.



# Chapter 7 Regulation and Safety Oversight of Offshore Maintenance

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## 7.1 Introduction

On the surface, the quality of offshored maintenance is safeguarded by a highly comprehensive and detailed international regulatory scheme. This scheme is based on a treaty (the Chicago Convention), which has the force of international law, and flows down through Annexes and Standards and Recommended Procedures (SARPs), to manuals which set the detail of how these SARPs should be observed. In practice, however, this international scheme is a loose and largely consensual one which contains no independent powers of enforcement and relies on the cooperation of signatory nations for its observance. In this it reflects a key principle of international law – that of national sovereignty. The result is that flexibility built into the international regulatory model allows scope for considerable variations between member nations in quality and consistency, at the same time as it effectively constrains the power of individual nations to exercise quality control over maintenance outside their national borders.

While the International Civil Aviation Organisation (ICAO) regulatory scheme is central to the international aviation safety system, the latter appears to be entering a period of “regulatory reform” and quite significant change. It is not our task in this report to comprehensively explore this change, but it can safely be said that there are potentially very powerful challenges to the ICAO-based global aviation safety oversight system emerging. In particular, the International Air Transport Association (IATA) has set up a new safety audit programme known as the IATA Operational Safety Audit (IOSA), which promotes a different approach from that of ICAO.<sup>1</sup>

To return to a point made in the last chapter: there is no reason to believe that the standard of maintenance performed outside Australia is uniformly or even predominantly poor. The problem which needs to be addressed is simply this: we can be reasonably certain from evidence so far that mistakes are made from time to time, and unsafe practices condoned, even in maintenance repair organisations (MRO) which are normally considered to be highly reputable, and the important thing is to find out when they happen, ensure that the consequences are attended to, and exert some pressure on the provider to ensure that such unsatisfactory practices do not recur.

This chapter argues that the existing approach to regulatory oversight is not up to such a task.

A committee of aviation experts recently reviewed Australia’s general approach to aviation safety. The resulting report of the Aviation Safety Regulation Review (ASRR) argued that internationally leading regulators employ what they call a “trust and verify” approach.<sup>2</sup> It can be argued that, in respect of the safety oversight of offshored maintenance, the Civil Aviation Safety Authority’s (CASA) current approach trusts too much and verifies too little. It delegates offshore too much responsibility for the safety oversight of offshored maintenance.

This chapter begins by setting out how the international scheme works, and within that context explaining, and where necessary criticising, what often appears as the ineffectuality of

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<sup>1</sup> Hodgkinson. 2005

<sup>2</sup> Australian Government, 2014. The term comes from a reference to policing adherence to arms control treaties during the cold war – “doveryai no proveryai”, ironically, was a Russian proverb used by President Reagan, meaning “trust but verify”. That is, to be sure people are playing by the rules you (or someone you trust) have to go and have a look at what they are doing.

Australia's response to the regulatory oversight challenge of global MRO. This is done in part by contrasting Australia's approach with that of the United States (US), which over the last seven years has gone further than any other advanced Western nation in controlling the access of its nationally registered carriers to the less satisfactory elements of the international industry.<sup>3</sup> The chapter concludes by examining certain findings of the 2014 Aviation Safety Regulation Review report, which support suggestions for an improvement in the safety oversight of offshored maintenance.

## **7.2 The international system of safety oversight**

The international aviation safety oversight system is based in the Chicago Convention which was signed in 1944, at a time when the Allies confidently looked forward to a post war period in which air transport between nations could flourish free of the politically motivated restrictions which had held back its pre-war development.<sup>4</sup> Thus, Article 37 provides that:

Each contracting State undertakes to collaborate in securing the *highest practicable degree of uniformity* in regulations, standards, procedures, and organisation in relation to aircraft, personnel, airways and auxiliary services in all matters in *which such uniformity will facilitate and improve air navigation.*

To this end the International Civil Aviation Organisation shall adopt and amend from time to time, as may be necessary, international standards and recommended practices and procedures... (emphasis added)

The standards and recommended practices (SARPs) of most relevance to aircraft maintenance are "licensing of operating and mechanical personnel" (Annex 1), "airworthiness of aircraft" (Annex 8), and "safe operations of aircraft" (Annex 6). It is these SARPs, in conjunction with the recent Annex 19 (Safety Management), that constitute the substance of ICAO regulation with regard to maintenance and associated licensing.<sup>5</sup>

Annex 1 defines each category as follows:

Standard: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognised as necessary for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38.

Recommended Practice: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest of safety,

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<sup>3</sup> Baretto, 2002. Notably, while the US Federal Aviation Administration (FAA) runs its own international regulatory review system, known as the International Aviation Safety Assessment (IASA), it is ICAO-based insofar as it assesses the compliance of countries whose airlines fly into the US against ICAO standards.

<sup>4</sup> To quote an example close to home, when full through services between England and Australia commenced in 1935, the first two days of the outbound journey consisted of a brief flight from Croydon to Paris, followed by two nights and a day on trains between Paris and Brindisi, because several of the European powers would not permit British-registered aircraft to overfly or land on their territory. Hooper, 1985.

<sup>5</sup> International Civil Aviation Organisation (ICAO), 2011a. Supporting material for these Annexes is contained in International Civil Aviation Organisation (ICAO), 2008a/2013 and International Civil Aviation Organisation (ICAO), 2013b.

regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention.<sup>6</sup>

It will be noted that the standards are not mandatory, but a state which chooses to make different regulations must inform the ICAO of this decision under Article 38. Indeed, the standards could not be mandatory as well as compliant with a key principle of international law – that of national sovereignty. Although the ICAO system is, in the words of one commentator, a “watertight system” that “does not allow for a situation where States do not comply and do not file differences”,<sup>7</sup> in fact the origins of the ICAO Universal Safety Oversight Audit Program (USOAP) lie in precisely that situation.

This is important in light of Article 33, which states that

Certificates of airworthiness and certificates of competency and licences issued or rendered valid by the contracting State in which the aircraft is registered, shall be recognized as valid by the other contracting States, *provided* that the requirements under which such certificates or licences were issued or rendered valid are *equal to or above the minimum standards* which may be established from time to time pursuant to this Convention. (Article 33, emphasis added)

There is an unresolved logical tension here. Article 31 specifies that a certificate of airworthiness is “issued or rendered valid” by the state in which the aircraft is registered. Annex 8 underlines this responsibility:

The State of Registry also has the responsibility to make certain that every aircraft on its register is maintained in an airworthy condition throughout its operational service life... Although methods of discharging the foregoing State airworthiness responsibilities may vary, and in some cases, may involve the transfer of certain tasks to authorised organisations or other States, *such arrangements do not relieve the State of Registry from its overall responsibility*.<sup>8</sup>

Yet, following offshored maintenance, a plane is certified as airworthy in the other country according to that state’s own processes. The state of registry is obliged to accept the other country’s procedures despite difficulties of verification posed by sovereignty. Annex 8 requires that the state of registry must have an on-going inspection regime, and that this should not be delegated to another state. Yet Article 33 not only allows but in normal circumstances arguably *requires* reciprocal recognition arrangements which effectively permit the transfer to other countries of certain functions of a national regulator – including safety oversight.<sup>9</sup> This can be read as effectively putting all contracting states on the same footing so far as the validity of their certificates or licences goes, subject only to the proviso already cited, “that the requirements under which such certificates or licences were issued or rendered valid are *equal to or above the minimum standards* which may be established from time to time pursuant to this Convention”.

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<sup>6</sup> International Civil Aviation Organisation (ICAO), 2011a, Annex 1, Preamble, p. viii.

<sup>7</sup> Kotaite, 1995, cited in Huang, 2009, p. 66.

<sup>8</sup> International Civil Aviation Organisation (ICAO), 2010a, Annex 8, Part II, Chapter 4, “Continuing Airworthiness of Aircraft, 4.2.3, State of Registry”. Emphasis added.

<sup>9</sup> Jennison, 2013, p.335.

The mechanisms by which the ICAO standards are monitored and verified are obviously crucial to the working of the system. While it can “bring infractions of the Convention to the notice of the Contracting States and the Assembly”,<sup>10</sup> there is not much else ICAO can do, as Barreto<sup>11</sup> points out,

The Convention does not provide for a safety compliance and enforcement authority, and its effectiveness in guaranteeing aviation safety is based on the assumption that each contracting State adheres to the organisation’s safety standards.

Article 38 imposes an obligation on member states to declare differences if they do not comply with ICAO standards. This created a major safety concern in the mid 1990s, as it became apparent that some states were not observing standards, nor were they filing differences. Thus in 1998 the ICAO established the Universal Safety Oversight Audit Program (USOAP), the aim of which was to

Determine States’ capability for safety oversight by assessing the effective implementation of the critical elements of a safety oversight system and the status of States’ implementation of safety-relevant ICAO Standards and Recommended Practices, associated procedures, guidance material and safety-related practices.<sup>12</sup>

ICAO officials would conduct USOAP audits, following the signing of a Memorandum of Understanding between ICAO and the audited state. This was taken as confirming the principle of sovereignty, despite an element of compulsion or pressure on states to accept the audits. Certain states pushed back on any suggestion that ICAO should “police” nation states’ safety systems. Against this, Huang argues that a nation state’s obligations to enforce safety oversight in its territory are obligations to all (*erga omnes*) that justify the role of just such a centralised international institution as ICAO to enforce them. Others argue for “decentralised enforcement”, in which states can act against a non-compliant state, even if they are not directly affected.<sup>13</sup> According to Huang,<sup>14</sup> however, Article 33 entails that certificates issued by *non-compliant* states can be refused recognition by other contracting states. This is in accord with actual practice of, for example, the Federal Aviation Administration (FAA) IOSA system,<sup>15</sup> as well as the European Aviation Safety Agency (EASA).

The first safety audits concentrated on the host government and regulator’s ability to implement the SARPs contained in Annexes 1, 6 and 8. The first “round” of audits took place from 2000, and by 2006 ICAO reported significant progress in the implementation of state corrective action plans and a decline in non-implementation of the key elements of a safety oversight system. Yet there were concerns about transparency – the initial proposals for the USAOP were for broad publication of the results, yet this did not eventuate, with only general disclosure available on the ICAO website.

Following the end of its initial series of audits around 2009, there were concerns about the relative infrequency of audits. USOAP was accordingly “upgraded” and replaced by a continuous

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<sup>10</sup> Kotaite, 1995, in Huang, 2009, p. 66.

<sup>11</sup> Barreto, 2002, p. 654.

<sup>12</sup> ICAO Doc. 9735, AN960, in Huang, 2009, p. 68.

<sup>13</sup> Ibid.

<sup>14</sup> Ibid., p. 72.

<sup>15</sup> IATA Operational Safety Audit. Jennison, 2013, p. 335.

monitoring approach (CMA), which seeks to gather information on an ongoing basis precisely because of this problem of the gaps between audits.<sup>16</sup> Australia was last audited in 2008.<sup>17</sup> The extent to which Australia has implemented the CMA is not known at time of writing, and no mention of it could be found on a recent search of the CASA website.

Despite their limitations, the ICAO programs have identified “fundamental weaknesses in the safety programs of many States, resulting in significant differences in safety standards around the globe”.<sup>18</sup> In its 2013 Safety Report, the ICAO put the average level of compliance in implementing the “critical elements” of safety oversight at only 61% across all nations audited (96% of its membership), though the average score for airworthiness oversight was somewhat higher (if still not encouraging) at 73%.<sup>19</sup> The “significant differences” identified have not resulted in any amendment of the default requirement to treat all national licences and certificates as equivalent.

To sum up, the international regulatory scheme is one in which the international body has no substantive powers to act on its own initiative against even a serious breach of the SARPs, the enforceability of the scheme depends on the willingness of individual nations to apply sanctions (which themselves are of an all-or-nothing character), and the provisions can be overridden by bilateral or multilateral agreements between individual member countries. Moreover, any initiative to tighten up requirements can only be achieved through lengthy processes of diplomacy.

The increasingly global nature of maintenance suggests a need for international institutions to play a more active regulatory role. The lack of coercive powers at the level of the international organisation increases the responsibility of each National Aviation Authority (NAA), the ability of which to enforce the necessary standards and processes in another country is limited by the principle of national sovereignty. As the international environment changes, it becomes increasingly important to scrutinise the performance of CASA and the adequacy of its existing policies and practices to cope with new imperatives and constraints.

### 7.3 Australian regulation of offshore maintenance

To protect Australians against the kinds of malpractice mentioned in the previous chapter, a strong regulatory framework is necessary. How well does Australia’s regulatory framework measure up? The framework of Australian international safety regulation is based on the ICAO model, which, despite the emerging competition to the latter (mentioned in the introduction), is the model to which Australia is committed by treaty and its own internal legislation.

Australia’s National Aviation Authority was a department of state until 1988, when an independent Civil Aviation Authority (CAA - AU) was established within the Transport portfolio. In 1994 CAA-AU was replaced by the present Civil Aviation Safety Authority (CASA), whose remit is confined to safety-related regulation.<sup>20</sup> The responsibilities of CASA include registering and assuring the airworthiness of Australian aircraft, authorising organisations to carry out maintenance, and flight crew and maintenance engineer licensing. This last-mentioned function includes the accreditation of educational institutions and other organisations which train

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<sup>16</sup> See International Civil Aviation Organisation (ICAO), 2010b, 2010c.

<sup>17</sup> See International Civil Aviation Organisation (ICAO) 2008b.

<sup>18</sup> *ibid.*, p. 3-4-1.

<sup>19</sup> International Civil Aviation Organisation (ICAO), 2013c, pp. 12-13

<sup>20</sup> Innes and Watson, 2004, p.17; The ASRR (Australian Government, 2014, p. 23) agreed that it is inappropriate for CASA to be engaged in industry policy.

maintenance personnel, and (until the advent of the reforms examined in the next chapter), administering the final examinations known as the “CASA Basics”, as well as certifying that candidates for a maintenance licence had adequate experience. CASA operates through a complex set of regulations, originally the Civil Aviation Regulations (CARs), but since 1998 a new set of Civil Aviation Safety Regulations (CASRs) has been implemented. These flow down through documents called Manual of Standards (MOS), while advice as to how to comply with the MOS is contained in documents called Acceptable Means of Compliance (AMC), Guidance Material, and Advisory Circulars.

The *Civil Aviation Act (1998)*<sup>21</sup> requires that:

CASA shall perform its functions in a manner consistent with the obligations of Australia under the Chicago Convention and any other agreement between Australia and any other country or countries relating to the safety of air navigation. (s.11)

Under Annex 19, the most recent addition to the ICAO SARPs, ICAO requires all signatory states to have a “State Safety Program” (SSP), with specified components that take us beyond our immediate concerns here.<sup>22</sup> Again, this particular requirement gives a good deal of latitude – “the acceptable level of safety performance shall be established by the State” [3-1], but each State “shall establish and implement a safety oversight system in accordance with Appendix 1”.

Australia’s SSP reinforces that “CASA is responsible for the safety regulation of both civil air operations in Australian territory and Australian aircraft operating outside Australian territory”.<sup>23</sup> According to CASA’s own understanding

The *Civil Aviation Act* 1988 places responsibility on CASA to conduct the safety regulation of civil air operations in Australian territory and the operation of Australian aircraft outside Australian territory, by means that include “developing effective enforcement strategies to secure compliance with aviation safety standards” (CAA - AU 9(1)(d)).<sup>24</sup>

Yet these “enforcement strategies” include what amounts to automatic acceptance of other countries’ standards, consistent with Article 33. This tradition has a history. For example, and with respect to licensing under CAR 1988 Division 5, CASA has long treated licence approvals given by an ICAO contracting state as being, to all intents and purposes, equivalent to those in Australia. The relevant regulation reads as follows.

**42ZN Certification of maintenance outside Australian territory**

(1) The holder of the certificate of registration for an Australian aircraft on which maintenance has been carried out outside Australian territory must not fly the aircraft, and must ensure the aircraft is not flown, if each of the following requirements is not satisfied:

(a) the completion of the maintenance has been certified by:

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<sup>21</sup> Australia, Civil Aviation Amendment Act 1998.

<sup>22</sup> International Civil Aviation Organisation (ICAO), 2013a. Annex 19, Safety Management, has applied from November 2013.

<sup>23</sup> Australian Government (2012).

<sup>24</sup> Civil Aviation Safety Authority (CASA) (2013b), p. 2-1.



- (i) a person who would have been permitted by regulation 42ZC to carry out the maintenance if the aircraft had been in Australia; or
- (ii) if the maintenance was carried out in a Contracting State — a person who would be permitted under the law of the Contracting State to certify the completion of the maintenance if the aircraft were registered in the Contracting State;

The effect of (a) (ii) is to make the quality of Australian aircraft maintenance hostage to the training, licensing and approval processes of another country. While it is noted that this regulation is a Civil Aviation Regulation (CAR 1988), and has been or soon will be superseded by the Civil Aviation Safety Regulations (in particular, CASR 1998 part 145), CAR 42 ZN does give a flavour of past approaches to international safety regulation. It appears partially to shift responsibility for the regulation of offshored MROs to the airline, as well as to the NAA of the MRO's host country. This is consistent with the following communication from CASA.

The introduction of Part 42 of CASR establishes that a registered operator is responsible for the continuing airworthiness of an aircraft used for Regular Public Transport (RPT) as described under CAR 206(1)(c). Further Part 42 of the CASR has set up legislative requirements under clause 42.295 of Subpart 42 D - Maintenance which states that all aircraft involved in RPT Operations must be maintained by a Maintenance Organisation that is approved by CASA under Part 145 of CASR.

All offshore maintenance work for aircraft conducting RPT operations is governed under the requirements in Parts 42 and 145 of CASR. Any offshore organisation conducting maintenance work for an RPT aircraft has to go through an identical process as applicable for a domestically located organisation.<sup>25</sup>

Recent tendencies are to treat the regulation of offshored maintenance the same as onshore maintenance, to the extent that “offshore” has no meaning since the “regulatory space” is identical.<sup>26</sup> It is unclear whether this means that overseas approvals would need to be granted by CASA on the advice of its own inspectors following inspection, as is the case for a domestic MRO – or whether an “exchange” of approvals would suffice. In fact CASA has issued a number of similar approvals in the past (under CAR 30, and recently, CASR Part 145). Ongoing supervision is another issue, required by Annex 8. Thus, in the earlier days of maintenance offshoring by Qantas, CASA sent its own inspectors to supervise the work of the overseas shops, though Qantas inspectors who were present at the time question the rigour of that inspection:

*The {Australian Airline, de-identified} auditor when he was there said he saw the CASA auditors from a distance and they were taken nowhere near the {Airline's} aircraft in that hangar during the CASA's audit. ...The chief CASA inspector for that region, in charge of that region, became aware and read that {Australian Airline, de-identified} audit report, but still chose not to go back and have another look at the facility until there was a media story on an escape path lighting that had been stapled together to make it work... Well, I mean in all of the times that I was away I only ever saw, or knew of and essentially didn't really see CASA at one site and there apparently were guys there, I saw*

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<sup>25</sup> *ibid.*; e-mail communication from CASA to one of the authors, 27 November, 2013..

<sup>26</sup> Cox, 2015.

*some gentlemen walking around, never spoke to them. They did a general walk-around and then disappeared and that's the only time that I ever saw any input from CASA at any of these MROs.*<sup>27</sup>

In these cases, CASA had at least the potential authority to withdraw Part 145 approval or (as it was at the time, approval under CAR30) or more broadly, under the “equal to or above the minimum standards” provision of Article 33, had it become aware of a particularly grave breach of minimum standards. However, even this last line of redress is removed when reciprocal approval takes place under the terms of a *Bilateral Aviation Safety Agreement* (BASA) negotiated between Australia and another country. In such a case, the intent of the Chicago Convention is overruled by the specific provisions of the bilateral agreement, generally removing all scope for Australia to withdraw an approval – since the approval process has been delegated to the NAA of another country. (The same section of the Act which obliges CASA to regulate “consistent[ly] with the obligations of Australia under the Chicago Convention” also requires it to comply with “any other agreement between Australia and any other country or countries relating to the safety of air navigation”.) The 2013 Technical Agreement (TA) between Australia and Singapore illustrates the scope of such agreements and the absence of any escape clause even in the event of demonstrated unsafe practice:

By signing the TA, CASA acknowledges that maintenance organisations, approved in accordance with SAR 145 and qualifying under the terms of the TA are considered equivalent to an Australian AMO approved under the Part 145.<sup>28</sup>

Since June 2005 Australia has also entered into a BASA with the US and a Memorandum of Understanding on airworthiness certification with China, and was expected to complete the same process with Canada and Hong Kong by the end of 2013. By contrast, the European Union at the time pronounced itself “unable to move” on a bilateral arrangement with Australia on safety until approval had been provided by the European Commission.<sup>29</sup> This failure to proceed has placed Australia at a considerable disadvantage because, as mentioned in the Chapter 5, it has blocked European recognition of Australian aircraft maintenance engineers’ (AME) qualifications, and possibly European Part 145 approval of Australian maintenance providers.

This example raises an increasingly prevalent issue of Realpolitik: for countries like Australia which have very limited global market power, and whose standards of training and licensing may not be widely understood outside its region, bilateral agreements are fast becoming a de-facto prerequisite for the mutual recognition of qualifications which would allow Australian AMEs to retain the currency of their skills while demand in Australia remains in a slump. More generally, while Australia feels constrained to remain within the spirit of the Article 33 provisions, larger nations whose trade and labour markets will be important to the survival of an Australian MRO industry are in a position to hold out on their supposed obligation to offer mutual recognition unless it can be negotiated bilaterally, with the inevitable trade-offs. And to be fair, CASA is far from the only regulator going down this path. Even the US, despite its current very stringent requirements which will be discussed below, is moving in this direction, which can be presumed to be the preferred position of the FAA in the absence of Congressional *force majeure*:

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<sup>27</sup> Interview, former Airline Quality Inspector, 2014.

<sup>28</sup> Civil Aviation Safety Authority (CASA), 2015d. SAR - Singapore Aviation Regulation; in this case covering Singaporean AMOs - Approved maintenance organisation.

<sup>29</sup> Civil Aviation Safety Authority (CASA), 2013a, p. 57.

Section 145.1053(b) ...[will]... allow the FAA to certify a repair station outside the US based on a certification from an authority acceptable to the FAA. This change would allow the FAA to make the finding based on a recommendation from a national aviation authority, EASA, or any other EASA-like entity that may be created in the future.<sup>30</sup>

Yet there are signs that the attempt to reduce oversight duplication through BASAs and mutual recognition agreements has run into trouble. A recent report by the US Office of Inspector General (OIG) has criticised FAA for not subjecting certain European MROs to a sufficiently rigorous degree of auditing before granting recognition of their host countries' NAAs' abilities to perform adequate safety oversight.<sup>31</sup>

#### 7.4 Pushing the limits in both directions: the US experience

In this context it is instructive to look at the US as a case study of a nation which, despite being internationally known as a fervent advocate of deregulation, itself chose ultimately to move in the opposite direction to the global tide of liberalisation when it came to the safety oversight of offshored maintenance. The US case indicates the latitude which still exists within the ICAO framework for a country with sufficient resources and market power to impose its will on the globalisation process for maintenance, to the point where it at least temporarily brought the whole process of offshoring from that country to a sudden halt.

Two significant differences exist in this context between Australia and America, one of them obvious, the other perhaps less commonly recognised. The obvious one is America's enormous power in all areas of the global aviation market, both as a seller and as a purchaser. The less commonly known difference is that the FAA is subject to much more rigorous oversight by the political process than is Australia's CASA. It is continuously accountable to three overseeing agencies: the Government Accountability Office (GAO), a body whose remit of reviewing the effectiveness of all government agencies is broadly comparable to the Efficiency Audit function of the Australian National Audit Office; the Office of the Inspector-General (OIG) within the Transportation Department; and the National Transportation Safety Bureau (NTSB), which sits above the regulator rather than alongside it as the Australian Transport Safety bureau (ATSB) does in Australia. Resting over and above these public service agencies, the House of Representatives has a standing Subcommittee on Aviation. Together these have the effect of leaving the FAA far more closely scrutinised, and far more often in the public eye, than CASA which has to report only to Estimates Committees, the Auditor-General, the very occasional parliamentary committee inquiry, and portfolio Ministers who in recent years (with the possible exception of the current one) have been largely content to leave it to its own devices.<sup>32</sup>

A third characteristic which distinguishes America is that as the first mover among industrialised nations in large-scale outsourcing and offshoring of maintenance, it had an early and painful experience of the consequences of laissez-faire which later adopters like Australia have largely been able to avoid. The most recent trend toward tighter regulation can be seen as a belated reaction to some highly visible disasters with loss of life in which maintenance was a factor, and which have figured prominently in the media. Over that period there has been a degree of political mobilisation against offshoring, not only because of the "exporting jobs" argument, but

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<sup>30</sup> Federal Aviation Administration - United States (FAA), 2012a.

<sup>31</sup> *Aviation Daily*, 2015. Interestingly, one of the main reasons for OIG's concern was the insufficiently high level of inspector training in the European countries.

<sup>32</sup> Australian Government, 2014, pp. 52-56.

because of the safety and regulatory issues. The most striking demonstration of this growing public concern was the emergence of an improbable cross-class *Coalition to Legislate Aircraft Maintenance Outsourcing Reform* (CLAMOR), in which businesspeople with an interest in safely arriving at their destination joined forces with unions seeking to save their members' jobs.

During the 1990s, an explosive growth took place in heavy aircraft maintenance offshoring from the US, and this arguably exceeded the capacities of the regulatory regime, because so much US maintenance had previously been taking place in locations where the FAA had deployed fewer resources, or in "uncertificated" shops that largely escaped scrutiny by the FAA. The sheer multiplicity of small shops also stretched regulatory and inspection resources. Where once airlines may have maintained a limited number of large centralised repair facilities, the FAA now had to deal with a myriad of repair stations involved in complex and ever-shifting webs of contracting and subcontracting with different airlines. Thus scrutiny of offshore MROs became more logistically challenging.

A particular problem that arose as a consequence of the overstretched regulatory apparatus was offshoring to uncertificated shops, of which there were as many as 1400 in 2005 according to a report by the OIG.<sup>33</sup> Unlike certified repair stations, non-certified repairers were not required to implement quality control systems, designated supervisors and inspectors, or training. There were no restrictions on the scope of work they could perform, and they were not subject to regular inspection. Six of the ten non-certificated facilities reviewed had not been inspected by the FAA, nor had 104 foreign non-certificated repairers identified as performing maintenance for three carriers in 2003-4. In effect, non-certificated repairers largely escaped regulatory oversight.

Over the decades since deregulation, the FAA accumulated a long history of critical reviews from its three overseeing agencies, relating to issues such as regulation of airlines' use of ageing aircraft, high rates of safety incidents in the first years of new low cost carriers (LCC) airlines, failure to properly implement risk analysis procedures, and misallocation of its inspectorate resources which in any case had been overwhelmed by the growth in numbers of workstations, low-cost and regional carriers, and uncertificated shops. In 2008, the OIG released another audit, *Air Carriers' Outsourcing of Aircraft Maintenance*, which noted that nine major carriers were outsourcing over 70% of jetliner overhauls (25% going to foreign repair shops).<sup>34</sup> The FAA was found to lack comprehensive data on the extent and location of outsourced maintenance, and the definition of "substantial maintenance" did not include all critical component repairs. Neither did the FAA have a policy scheduling inspectors' visits to maintenance providers. The audit found oversight failures at all levels – the regulator, the operator and the repairer – leading to the use of untrained mechanics, lack of required tools, and unsafe storage of aircraft parts.

Throughout this period of growing public and governmental concern, the FAA's inclination was to leave the responsibility with the carriers. Indeed, this reaction was highly understandable given the minimal likelihood of its ever receiving sufficient resources to carry out the inspection load required to satisfy all the legitimate complaints. What forced change was the political reaction to the 9/11 atrocity and the fears it fuelled of terrorist infiltration in offshore maintenance facilities. In response, Congress legislated to tighten up the regulatory and supervisory practices of both the FAA and the increasingly influential Transportation Safety Administration (TSA), which is responsible for aviation security. Starting with the *9/11 Commission Act* of 2007, Congress effectively prevented the FAA from granting new

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<sup>33</sup> Office of the Inspector General - United States (OIG), 2005, p.6.

<sup>34</sup> Office of Inspector General - United States (OIG), 2008.

certifications. New rules mandated by the *FAA Modernization and Reform Act 2012* required it to regulate for all “covered” maintenance work to be performed by certified repair stations by 2015, establish a safety assessment system for all part 145 stations, and inspect them annually. Subsequently, the FAA announced new rules requiring all airlines to develop policies and procedures for contract maintenance acceptable to the FAA, include them in their maintenance manuals, provide the FAA with a list of all persons contracted to undertake maintenance, and maintain surveillance of contract maintenance providers to ensure they complied with the carrier’s maintenance program.<sup>35</sup>

The result was a massive burden both on the airlines and on the FAA, particularly as there does not appear to have been any corresponding willingness on the part of Congress to fund the necessary increase in its inspection and auditing capacity. Thus, whether or not this had been the intention, the US went overnight from one extreme of the regulatory spectrum to the other – from virtual open slather to a regulatory net so tightly stretched that it brought all new offshoring to a sudden halt. It was not until the beginning of 2014 that the first new certification was granted to an overseas shop, and the few accounts which have come into the public domain suggest that very little progress has been made, or is likely to be, in making up the backlog.

On the positive side, the sudden change of policy did achieve a useful industry policy outcome, even though this does not appear to have been a major concern of Congress. As early as March 2013, a survey by the Oliver Wyman consulting group found that over 30% of respondents who currently outsourced their maintenance would be willing to bring it back to the US even if it entailed a cost penalty of 6-15%.<sup>36</sup> In the event, that sacrifice appears to have proved unnecessary, as the devastation of manufacturing employment which followed the global financial crisis (GFC) in America has driven wages down so far that the labour costs of carrying out heavy maintenance at home are now possibly as low as, or even lower than, what it costs in the most popular offshore maintenance destination countries. As a result, an apparently vigorous new maintenance and associated sector is growing up, particularly in the southern States which were hit especially hard by the GFC, where \$46,000 a year is considered a good wage for a fully qualified Airframe and Powerplant (roughly the American equivalent of a licensed aircraft maintenance engineer (LAME)) licence holder.<sup>37</sup> Simultaneously, the shortage of skills which had begun to emerge in the main source countries increased the attractiveness of the large pool of suitably skilled labour which was either seeking work or on its way up through the training system in America. While the ICAO had judged in 2010 that North America was the only region in the world training a substantial excess of maintenance personnel,<sup>38</sup> by the time of the 2013 survey many respondents were indicating that their main reason for not bringing more maintenance back on shore was a lack of skilled labour.<sup>39</sup> Just as tellingly, the major Hong Kong provider of contract maintenance to the global market found it necessary to buy up one of the large American MROs in 2014 as the only available means of getting the capacity to handle the growing world demand.<sup>40</sup>

It is understandable that Australians should look wistfully at this unintended success story of old-fashioned protectionism. However, realism suggests that the result would be much less likely to

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<sup>35</sup> Quinlan, Hampson Gregson, 2013.

<sup>36</sup> Spafford and Rose, 2013, p.11.

<sup>37</sup> Chandler, 2014.

<sup>38</sup> ICAO, 2010b, p.46

<sup>39</sup> Spafford and Rose, 2013, p.11.

<sup>40</sup> AviationPros, 2013.

have come about without a degree of wage compression which few Australians likely to be in line for such work would willingly countenance — or indeed, without the patriotism factor which motivated so many American customers to contemplate paying a premium for local work, and which Australian airlines are unlikely to share (though one must remember that this willingness was probably also due to considerations like supply chain security and the ability to form closer working relationships with providers). What is more questionable is whether the American approach would be effective or even feasible in its primary function of safety regulation in Australia. Even the FAA with its comparatively enormous budget, strong support from higher levels in the bureaucracy for taking an activist approach, and culture of willingness to take on and proceed against non-compliant airlines, was unable to keep pace with the need for new inspections. It seems likely to remain so even if the legislation remains in place unchanged.

In fact, the recent mid-term elections which saw Republican majorities elected in both houses of Congress have been followed by moves to rescind or seriously water down the 2012 legislation. Perhaps surprisingly, some of the most intense lobbying is coming from the Aeronautical Repair Stations Association (ARSA), which might have been expected to support their continuation as working to the benefit of its members. Significantly, one reason it has given for supporting repeal is that the strict control on offshore MROs has put the BASA with Europe at risk and thereby hindered EASA approval of its members.<sup>41</sup>

The US reform program has not been in operation for long enough, and its survival is not sufficiently guaranteed, for any clear lessons to be drawn from it. Certainly the impression in the short term is that rather than leading to a sustained scheme of adequate regulatory oversight, the sudden introduction of the new requirements simply closed the door on any new offshore MRO providers who were not already tied in by contracts with US airlines, while the requirement to discontinue the use of uncertificated shops by 2015 would probably have required the cancellation of many existing ones. That alone casts some doubt on the commercial or political feasibility of the scheme beyond the end of 2015. At the same time, the degree of public and Congressional enthusiasm for remedying the current situation of effective *laissez-faire* was not enough to guarantee the FAA the funding which would have been needed to implement the remedy effectively. One proposal which was aired was that the full costs of increased inspection be borne by the outsourcing airlines,<sup>42</sup> something which would certainly have altered the economics of offshoring by eliminating much of its (albeit diminishing) price advantage. However, there is no indication that the authorities were ever willing to take up this suggestion. In Australia, however, the much lower level of offshore contracting would make the task of inspection a lot more manageable and perhaps affordable for Australia, particularly if the airlines were forced to cover the full costs of increased inspection, which would exceed those of CASA's current cost-recovery program.

In 2015, there were 38 offshore MROs included on the CASA website as having been certified by under CASR Part 145. There were 13 airline subsidiaries, 7 OEMs and 18 MROs. Of the latter, there was a mix of line, aircraft on the ground (AOG) and heavy maintenance providers, working across aircraft sizes, on- and off-wing, performing A to D checks, engines, engineering and modifications. 11 were linked to each other or to original equipment manufacturers (OEM) or airlines via joint ventures, or in subsidiary or sub-contract relations. The three main groupings, with some inter-connections were SIA/HAESL, HAECO and ST/SASCO/STARCO. The websites of several identified a range of further subsidiaries in various parts of Asia and the US. Most had EASA certification, and presumably they would therefore also have had FAA recognition under

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<sup>41</sup> This is the argument of Daniel Fisher, Vice President Legislative Affairs, ARSA. Fisher, 2014.

<sup>42</sup> Transport Workers Union (TWU), 2012.

BASAs with the US, although the US has recently had cause to re-examine some of its recent mutual recognition arrangements. In 2014 one had surrendered its EASA licence.

Some aspects of the 2012 regulations appear to lend themselves to adoption in Australia within the present regulatory framework and directions, and would produce benefits in terms of transparency and possibly consumer confidence, besides facilitating the enforcement of current regulatory requirements. We refer in particular to the requirement for carriers to provide the regulator with details of the MROs with which they have signed contracts for maintenance, and possibly for other types of outsourced work, and also with details of the work performed offshore. Some of this information is already public knowledge, the reports could be generated easily from existing internal records, and so long as the reporting was not required to go into too much detail, it is hard to see any reasonable argument for keeping it out of the public domain on grounds of commercial confidentiality. Similarly, it would seem reasonable and not especially onerous to require carriers to document the safeguards they apply to contract maintenance, incorporate them into their manuals, and include this documentation as part of their safety management system (SMS) accreditation, even if the details do not pass wholly into the public domain. Certainly it can and should be a requirement for approval of an SMS that it make adequate provision for safety management of the supply chain, something which is foreshadowed in the draft IOSA standard for SMS currently under development. It will probably be worth monitoring the US experience with such requirements to see whether any problems arise.

### 7.5 Is there a solution?

Now that carriers are faced with a choice between an increasingly large range of new businesses competing for different aspects of their maintenance work, it is important that they have accurate means of distinguishing the good providers from the bad ones. Provided this can be done, the market in many cases will exercise the most effective sanction on careless or unscrupulous providers, and where market incentives fail, public disclosure will often achieve the same effect.

CASR Part 42 is designed to ensure that the air operator certificate (AOC) holder, who must be the registered operator of the aircraft, cannot avoid or delegate responsibility for its airworthiness. Approval as a continuing airworthiness management organisation (CAMO) requires demonstration of management structures and employee qualification standards that will safeguard airworthiness standards. Shifting responsibility to the aircraft operator is thus not the pass-the-parcel exercise it might appear, providing the regulator is prepared to act decisively and prosecute when breaches occur. Even though the culpability for a safety breach of the offshore MRO might be transparent, legal redress is generally more assured and less subject to the vagaries of international litigation if there is someone in the same jurisdiction to proceed against.

Equally, a logical justification for the growing presence of OEMs in the world MRO market is the need to minimise their liability and to control any damage to their reputation by keeping control of the airworthiness of their products beyond the point of sale. There is no question that an oligopsonistic global corporation can be a much more effective regulator (albeit not necessarily a fairer one) than any one government's instrumentalities. That very reputational element exerts pressure on the OEMs to be more careful in the choice and supervision of their suppliers and subcontractors. Hence the emergence of Nadcap as an industry-managed approach to applying industry and government technical expertise in setting, applying and auditing accreditation

standards for components along the tiers of the aerospace manufacturing supply chain.<sup>43</sup> The logical extension is the growing move of OEMs, into the tight control over maintenance of their products, through the careful choice of contractors for tied afterservice.

Despite these real incentives to behave responsibly, there is still a need for some kind of definitive sanction against the most unsatisfactory providers and against the carriers who knowingly continue to use their services. This will become especially important if (as we forecast in Chapter 9) worldwide capacity shortages make it difficult for carriers to be as discriminating in their choice of provider as they ought to be. This is where regulatory powers, as opposed to simple information exchange and disclosure, have their part to play.

The difficulties we have outlined with the regulation of offshore maintenance mainly affect the practicality and legality of directly monitoring practice in the source countries. Since the opportunity to intervene on that level is restricted under international law and in many cases has already been traded away in bilateral agreements, it is logical to seek opportunities for more effective regulation at the international level. However, as things stand, this is not really practical either, for reasons set out below.

Other possibilities exist for a non-governmental auditing process which could provide a margin of reassurance over and above the ICAO SARPs, which are acknowledged in Article 33 to be minimum standards. Only recently the Executive Director of ARSA claimed that

Corporate flight departments often institute much higher standards than those required by parts 43 (maintenance), 91 (general operating), and 145 (repair stations). Ensuring continued airworthiness for businesses and executives cannot be based on minimum standards; there is too much at risk.<sup>44</sup>

Demands such as these for a premium standard could create the opportunity for an independent, apparently unbiased standards-setting process to complement or eventually to challenge the current ICAO-based regime. Such accreditation could equally serve the needs of airlines seeking a new MRO, or of ordinary non-executive consumers and consumer organisations, if the ICAO regime becomes less effective for the reasons canvassed in this chapter. The International Standards Organisation (ISO) is the obvious model for such a process, and ideally these consumer-focused bodies would be looking for compliance with an ISO standard.<sup>45</sup>

Indeed a suite of aviation and aerospace-specific standards have already been developed out of ISO9001. Of particular relevance is Aerospace Standard S9110A, setting out a Quality Management System for aviation management organisations (the US MROs), specifically for Part 145 organisations. Organisations certified to AS9110A are also certified to ISO 9001. The purpose is to assist in demonstrating consistent capacity to meet both customer requirements and statutory and regulatory standards through a program of continual improvement in quality management systems with a focus on safety, training, and the use of approved parts. Whilst voluntary, AS9110A certification is already a selling-point on the websites of some MROs, both in Australia and offshore. The use of such providers by AOC holders could serve as a selling point on their websites. More strongly, it could weigh strongly with the regulator during the audit process as one indicator of a compliant quality safety management system.

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<sup>43</sup> Performance Review Institute (PRI), 2015).

<sup>44</sup> Macleod, 2014.

<sup>45</sup> As discussed below, the ASRR found several violations of the ISO standards around MRO inspection in Australia, and until the training of CASA inspectors is improved, it is likely these would replicate themselves in an international environment.



## 7.6 Domestic regulatory options

Australia is passing through something of a crisis of direction with regard to domestic enforcement, which limits international oversight options, and predisposes towards BASAs. The focus of regulation globally is shifting from the monitoring and enforcement of individual rules and processes to the assessment and accreditation of safety management systems (SMS), and if Australia's capacity to keep up with the changes in its domestic sphere is in doubt, more so is its capacity to conduct proper inspections of overseas facilities. The ASRR describes the transition:

...aviation regulation globally is moving towards a performance-based model, and away from a compliance-based and procedural approach ...

New methods of safety oversight are being introduced for high-risk sectors. Regulators are having to step back from prescriptive hands-on inspection processes and apply systems approaches to safety oversight.<sup>46</sup>

In principle, a systems approach to safety regulation is logically compelling and should lead over time to a reduction in the regulatory burden. By definition, a system is made up of a configuration of beliefs, values, rules, procedures, expectations and conventions which are mutually reinforcing, and consequently should adapt to changing circumstances and self-correct except when severely disrupted. Once the system is in place and operating, it should be able to look after itself, and its beneficiaries, for extended periods without the need for close monitoring.

However, assessing and accrediting a safety system is a considerably more complicated and skill-intensive job than simply verifying a set of rules and processes on the assumption that compliance will occur. It is necessary to make an informed judgement about something that amounts to a living entity, and making predictions about its future behaviour in a dynamic environment. Above all, the system that matters is the system which actually operates, rather than the system described on paper. In a systems context it is more important than ever to be aware of Argyris and Schön's<sup>47</sup> distinction between the espoused theory and the theory-in-use.

What this means is that it is more inappropriate than ever to evaluate such a system on the basis of the paperwork alone. What is needed is for someone with a good knowledge of organisational behaviour to be on the ground for extended periods and observe patiently how the system works in practice. Unfortunately, it seems to be commonly assumed that SMS-based regulation saves time because it is possible to go through the paperwork once, at the beginning, sign off on it and work thereafter on the assumption that things will look after themselves. We have noted the problems already caused by paper-based auditing of offshore MROs, and any systems-focused approach is bound to fail if the same precedent continues to be followed.

The bad news for CASA is that the SMS concept is going to make its job even harder than it already is. To quote the ASRR once more:

Performance-based rules and the application of SMS, along with risk-based surveillance concepts, require a change in how safety agencies work. These changes bring challenges, placing more responsibility on regulated organisations and changing how regulators conduct oversight.<sup>48</sup>

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<sup>46</sup> Australian Government, 2014, pp. 28, 58.

<sup>47</sup> Argyris and Schön, 1996, p.13.

<sup>48</sup> Australian Government, 2014, p. 57.

In other words, a system approach is going to involve considerably more discretion and considerably more fine, context-based judgement, which needs to be supported by a deep knowledge of organisational science and a diverse range of experience in actual organisations, other than just the public service. Such an approach faces problems of implementation on its own soil. The ASRR found that the existing relation between CASA and the industry is adversarial, and not appropriate to an advanced nation like Australia, and it argued that CASA and the industry therefore need to build a “collaborative” relationship. The ASRR endorsed numerous representations from the industry to the effect that CASA’s approach to enforcement had been high-handed and peremptory, and not in accord with relevant ISO standards. The Government in its response supported some form of customer-focus training and better arrangements for consultation and early warning.<sup>49</sup>

Like many Commonwealth agencies in recent years, CASA has suffered a skills drain with little or no replenishment. As the ASRR pointed out:

... over the past 20 years, the availability of military expertise has diminished as governments reduced armed forces and changed retirement policies. Many GA schools closed due to increasing costs of GA flying. The result is global concern about the diminishing availability of trained, capable and experienced pilots and engineers. The shortage of expertise, along with a growing air transport sector, is leading to challenges in filling critical safety oversight positions.<sup>50</sup>

As a result of that skills drain, it now finds itself short of critical auditing skills, a point picked up by the 2008 USOAP audit as one of the major failings in the Australian National Safety System. The ASRR echoed this finding, noting that:

... some inspectors lack adequate knowledge and understanding of the sector they are regulating to ensure correct and consistent regulatory decisions. Interviews with industry representatives and CASA staff indicated that adequate audit training is not provided.<sup>51</sup>

The experience and knowledge of auditors was found to need upgrading through CASA’s internal training. In this, the Aviation Safety Regulation Review echoed findings of the ICAO 2008 USOAP – that Australia needed to upgrade its ability to retain technical expertise within CASA.<sup>52</sup>

If CASA has a skills problem already, then moving to a system approach will show up those deficiencies far more starkly. Put otherwise, making this approach work will require a large investment, both in attracting and recruiting the right people, and in giving them a rigorous training in relevant auditing skills.

Such a lack of specialised expertise, and the lack of self-confidence it engenders, could go some way towards explaining the agency’s hard-line and adversarial approach to its regulatory responsibilities in some contexts, as well as its apparent diffidence when it comes to dealing with safety issues that arise in the major airlines. Moreover, the appropriate approach to regulating the relatively sophisticated aviation industry in Australia may not be the same one

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<sup>49</sup> Australian Government, 2014, p.77. This would be in accord with ISO19011 which specifically suggests that, when a fault is found, the inspecting officer can exercise “discretion” (p. 69) and if it is not too severe, can issue a “requests for corrective action” before “graduating” to a “non-conformance” notice.

<sup>50</sup> Ibid., p. 55.

<sup>51</sup> Ibid, p. 57, 79.

<sup>52</sup> ICAO, 2008b, p. 13.

which is needed when dealing with some of the less well developed safety cultures in nations where several of the offshore MROs are located. In the words of the ASRR:

A firm, hard-line regulatory stance may be the most effective approach in countries where the aviation industry is relatively new and has a degree of immaturity. In these countries the rules must be more prescriptive and the regulator must provide tighter oversight and be more diligent in ensuring rules are followed. Aviation in Australia is advanced and the safety record is good. The aviation community is generally at the forefront of new advancements and safety thinking.<sup>53</sup>

The other problem which should be more or less self-evident is that this kind of auditing is feasible if carried out on a small number of entities in one's own country, but a great deal more difficult when it comes to companies with networks of sub-contractors, located in different continents, speaking different languages and with disparate national cultures. In practice, a general move to system-based regulation will leave Australia more dependent than before on the conscientiousness and quality of assessment applied by overseas regulators. It seems reasonable to assume that in countries where regulation has hitherto been lax, system-based regulation will quickly degenerate into even more of a formality. The only thing which might mitigate this risk is the development of detailed protocols for system accreditation, and a determination to enforce them.

Hence we can only conclude that where offshore maintenance is concerned, the existing Part 145 approval process has lost much of its effectiveness in protecting the travelling public against poor practices, and can no longer be expected to bear the main burden of guaranteeing crew and passenger safety. Failing an effective regulatory shield, informed choice – market forces based on good information – may be the only effective substitute.<sup>54</sup>

To say that the international regulatory apparatus casts doubt, rightly or wrongly, over the safety of any given maintenance operation performed outside Australia is not the same thing as saying it is unsafe. There is no question that many offshore MROs are world-class, producing a very fine product. However, we also know that some have in the past displayed some very poor practices indeed.

It can only be presumed that the airlines do some due diligence before letting out a maintenance contract. In any event, the travelling public does not have access to the information that lies behind this due diligence (since it is treated as commercial-in-confidence), and there is no MRO rating agency or TripAdvisor to inform their choices about which airlines are safest to fly with. They would at least have the possibility of carrying out their own consumer research if only carriers were required by law to disclose where their maintenance is done, as is currently mandatory in the US. But no moves have yet been taken to impose such a requirement in Australia, and the ASRR did not consider the option.

A further approach is one based on international collaboration and consultation. Whilst the impact of such work is likely to be slow, and to depend on voluntary cooperation, its importance in diffusing agreed standards should not be underestimated. The Australian Government has in the past commissioned its relevant Industry Skills Council, Manufacturing Skills Australia, to undertake intergovernmental and industry level work in the Asia-Pacific region, in order to

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<sup>53</sup> Australian Government, 2014, p. 58.

develop comparable engineering and manufacturing skills standards and specify training needs. Such work is important and should continue to be undertaken with renewed energy by the new aviation Industry Reference Committee and its Skills Service Organisation, when they begin work in 2015.

Nevertheless, consultation is not a substitute for regulatory oversight, and until there is assurance of international comparability of standards and their enforcement, the best way for Australian regulators to confidently control the airworthiness of Australian aircraft is on Australian soil. This solution, however, will require rectification of some impacts of recent changes to the licensing scheme in this country, as we will explain in the next chapter.

## **RECOMMENDATIONS**

- **RECOMMENDATION 6:** That an urgent review be undertaken of Australia's safety oversight of offshored maintenance, having regard to the diminished effectiveness of the international regulatory system in detecting and discouraging unsatisfactory practices

*This review should examine the extent to which the current ICAO regulations provide clarity and certainty around the safety oversight of offshored maintenance, and should form the basis of recommendations for new quality assurance mechanisms that can be applied either within, or additional to, the current international scheme. The review should note the inconsistencies in ICAO regulation, the evident violations of good safety practice that have emerged in the course of this research, and the precedent set by the FAA in negotiating a "trust but verify" model of mutual recognition in its agreement with EASA.*

- **RECOMMENDATION 7:** That air operators increase their own safety oversight of offshored maintenance, with CASA playing a greater role in the inspection of offshored maintenance facilities to which it has issued part 145 approvals. The increase in inspection frequency and intensity should be funded by the offshoring air operators, on a full cost-recovery basis.
- **RECOMMENDATION 8:** That CASA be required and funded to build its capacities for inspection, specifically in terms of the number of inspectors and their training in the latest auditing techniques.

## Chapter 8 The New Suite of Maintenance Regulations: Issues of Safety Oversight

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### 8.1. Introduction

This chapter explores how the introduction of a new set of regulations around aircraft maintenance in Australia based on the European Air Safety Agency (EASA) system, implemented in Australia through the Civil Aviation Safety Regulations (CASRs), may affect the safety of aircraft maintenance within Australia. Together with Chapters 6 (on Australian and international safety regulation in an age of offshoring) and 9 (on the implications of the CASR licensing reforms for training), it maps out how the regulation of aircraft maintenance has changed through the ongoing Civil Aviation Safety Authority (CASA) Regulatory Reform Program (RRP), and some issues that have emerged during this process.

Contests over the conditions of “safety” and “airworthiness”, and the scope of “safety work”, have often taken the form of esoteric disputes over the terminology in regulatory documentation. Fertile ground for such a contest exists in the voluminous and highly complex regulatory instruments, ranging through the Manuals of Standards (MOS), Acceptable Means of Compliance, Guidance Material, Airworthiness Bulletins, Advisory Circulars and Aviation Advisory Circulars, where clarity and consistency is sometimes lacking. The recent Aviation Safety Regulation Review (ASRR) remarked on the complexity and opacity of Australian aviation safety regulation – as well as the potential penalties attached to non-compliance, even if unintentional.<sup>1</sup> The regulation of aircraft maintenance licensing is a particular case in point, although the ASRR barely mentioned it. The ASRR did, however, opine that the current RRP is “*having a negative effect on effective safety oversight*” (our emphasis).<sup>2</sup>

This chapter shows how the authority and autonomy of the licensed aircraft maintenance engineer (LAME), a crucial line of safety defence in the International Civil Aviation Organisation (ICAO) Annex One system, are put at risk of being eroded under the new arrangements. It points out how the new CASRs taken together appear to shift risk and liability from CASA to other players in the system – notably the training providers and employers, who now take on greater responsibility for, and therefore assume greater power over, the (assessment of the) competence of their employees. This, along with other changes we consider, may have the effect of obscuring clear lines of accountability. In this chapter we also examine key aspects of the LAME’s labour process, and examine the issue of small plane - general aviation (GA) licensing (now referred to as Small Aircraft Licensing, or SAL). This has been the subject of intense controversy, which at time of writing is still not resolved.

### 8.2. The role of the aircraft maintenance engineer licence holder

We begin with the international regulatory scheme’s lynchpin that protects passenger and aircrew safety by guaranteeing the quality of maintenance – the aircraft maintenance engineer license holder (the LAME) – or the “certifying employee”. The linguistic slippage between the

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<sup>1</sup> Australian Government, 2014, p. 96. The ASRR mentions cases “where a quite simple provision has transformed into a confusing statement, which imposes significant penalties on anyone who fails to comply” (p.96).

<sup>2</sup> Australian Government, 2014, p. 91.

terms “licence holder” and “certifying employee” exemplifies the contest over the powers invested in the licence that is at the centre of this chapter.

In the work of James Reason, and in the ICAO documentation in which Reason’s work figures prominently, the trained expert with technology and safety uppermost in his or her considerations should have the last say in whether or not a technical system can be deployed safely.<sup>3</sup> Expertise is testified by qualifications and (usually) by a licence issued by the State.

Accordingly, Annex One to the Chicago Convention, which governs personnel licensing, defines the role of the LAME:

The privileges of the holder of an aircraft maintenance licence shall be to certify the aircraft or parts of the aircraft as airworthy after an authorised repair, modification or installation of an engine, accessory, instrument, and/or item of equipment, and to sign a maintenance release following inspection, maintenance operations and/or routine servicing (Annex 1, 4.2.2.3)

ICAO distinguishes between certifying that a *stage* of maintenance has been correctly performed, and certifying for *release to service* (CRS) – also sometimes known as “maintenance release” – i.e. certifying that the plane is “airworthy”.<sup>4</sup> “Maintenance” is defined as any work on an aircraft that affects its airworthiness. Although most signatories to the Chicago Convention, including Australia, have legislated that the ICAO Annex One LAME, as an agent of the state, is responsible for ensuring that after maintenance planes are “safe”, the recent regulatory changes have begun to erode the LAME’s role. Terminological shifts seem to allow certain aspects of the certification work of the LAME to be transferred to “certifying employees”, “specialist maintainers”, or (most recently) “competent persons”, opening the way to extending such privileges to people with lesser qualifications, in breach of treaty obligations.

ICAO regulation itself can appear not entirely consistent on the privileges of the LAME, in that Annex One (4.2.2.4) also permits the option of a scheme without licences, but *only so long as the certifying personnel are trained to the same level as a licence holder*. Annex One also makes this clear:

When a Contracting State authorises an approved maintenance organisation to appoint non-licensed personnel to exercise the privileges of 4.2.2, the person appointed shall meet the requirements specified in 4.2.1. (Annex One, 4.2.2.4).

This paragraph specifies that the only difference between a person who can certify for maintenance as an Annex One (4.2.2.3) licensed person, and an Annex One (4.2.2.4) unlicensed but “approved” or “authorized” person, is the possession of the licence – which in this interpretation functions purely as a permit. The “approved” but unlicensed person would have the same knowledge, skills and experience as a LAME, but just would not hold the licence. This crucial point is sometimes overlooked or obscured, and the sub-paragraph has since opened the way to dilute the licence-based framework. This point is crucial because, as we will argue below, in combination with other aspects of the CASA RRP (CASR Part 145) employers would determine

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<sup>3</sup> Reason, 1997, p. 195ff; Reason and Hobbs, 2003; ICAO 2008

<sup>4</sup> There is some confusion among key terms like “CRS”, “maintenance release”, “maintenance certification”, and “airworthiness review”. In some interpretations, the CRS may not necessarily indicate that the plane is “airworthy”, since it could be taken to mean releasing the plane to the operator noting that there are a number of defects that need attention. These are technical points, which we cannot solve here but which would be surfaced by plain language rewriting. Here, the “simple” meaning above is adequate. Correspondence from Partner Organisation, 22 June 2015.

whether the “certifying employee” meets the requirements of Annex 4.2.1. This change would shift the balance of power in the relation between the employer and the LAME, potentially impeding the latter’s ability to perform their socially protective function.

The LAME’s role itself embodies an inbuilt contradiction. S/he must on the one hand function as an inspector operating under delegation from the State, and at the same time work as an employee of the business whose work s/he is certifying. That is, in addition to performing a *socially protective*<sup>5</sup> role, s/he is also an employee, entrenched in conflicts over wages and conditions, and in many cases a member of a union or professional association with its own strategic interests. Sometimes, “safety” overlaps with the industrial interests of the LAME and her/his union or professional association. At other times, industrial conflict can involve opportunistic use of the protective function to “press the safety button”. Airworthiness is thus intimately tied up with the industrial and regulatory protection of, or constraints on, the individual who is at the centre of what Reason<sup>6</sup> calls the conflict between protection and production – between safety and profits – in this case the LAME.

It is important for this person to feel assured of support from both the regulator and industrial relations law in the difficult “conversation” that can occur between a manager wanting to get the plane back into service and the LAME concerned that something is not quite right. Below we give examples of such “conversations” from our interviews, without being able to assess how typical these comments are. Nevertheless, but among the 708 responses to our 2012/2013 survey of maintenance workers, 384 respondents answered a final open-ended question, and 167 of them expressed concerns about the implications of training and licensing changes. Additionally, concerns were expressed during interviews<sup>7</sup> and the following quotations from interviews are relevant here:

*The corrosion in the engine bearer was so bad I could push my screwdriver through it. ...the boss actually told me sometimes you’ve got to compromise safety for the sake of operations. I said: but ten people could die, and he said: well, we’ll just have to risk it. I said no, we don’t ....*<sup>8</sup>

*I know that I have never compromised my standards, but I had the union to support me but I also had the fact that the department supported me... But now I feel sorry for these guys, you know, because they don’t have much legislation to support them.*<sup>9</sup>

It will be noted already that these “conversations” were not only high-stakes from the point of view of the LAME concerned – not to mention the passengers – but were conducted in a way which was not conducive to a logical or consensual resolution. Other examples from the project’s interview database include the following, which highlight the intensity of the industrial relations issues around safety, as well as the crucial role of collective organisation in the protection of passenger safety.

*Australian LAMEs typically also would tell the boss to go and get stuffed if the individual thought there was a safety issue and the company said look, push it on, it’ll be fine. The Australian LAMEs would say go and get stuffed, it’s staying.*

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<sup>5</sup> Polanyi, 1944.

<sup>6</sup> Reason, 1997.

<sup>7</sup> See Appendix 1, Methodology, for details of the survey and interviews.

<sup>8</sup> Interview, CASA Inspector, 2013.

<sup>9</sup> Ibid.

*It's going to stay on the ground until I fix it, and he'd take on the world. That's still basically the case.*<sup>10</sup>

*[The employer] will rebuke the LAME association for having this, they call it a belligerent attitude. But I still think this is what keeps Australian safety so good, is that this so-called belligerent attitude that [the employer] might say that we have, is exactly the thing, the character of an Australian LAME that means the Australian public may have that slight element of safety that you may not get in more subservient societies .....*<sup>11</sup>

LAMEs' ability to stand firm against pressures to prioritize "production" over "efficiency" depends on the extent of protection by law and/or the conventions in industrial relations systems. Unfortunately this protection appears not to be guaranteed under present Australian laws, as the 2012 *Sunstate* case demonstrated. In this case, the Court found that certain provisions of the *Civil Aviation Regulations* 1988 – namely the obligation to report a defect<sup>12</sup> – were not workplace rights as defined in the *Fair Work Act* 2009. LAMEs at the Qantas subsidiary Sunstate Airlines had found that entry to the cockpit of a plane could be gained by use of identity cards or paddle-pop sticks, and reported this as a defect. The company argued that this was not a "safety" issue but a "security" one and not LAMEs' business. The Australian Licensed Aircraft Engineers Association (ALAEA) took industrial action, which it justified on the grounds that the cockpit security affected airworthiness. The employer eventually stood them down. The Court found that the obligation under the CASRs to report a defect did not constitute a "workplace right".<sup>13</sup> Perceived implications are that potentially, an employer can issue directives overriding professional and socially protective obligations even if those are based in regulation. How important this precedent will be remains to be seen.

The role of the LAME combines a statutory responsibility to act independently with a responsibility under employment law to comply with directions of the employer, and instances will often arise where the two are in tension. This tension was undoubtedly easier to manage in the days when a good safety record was a source of competitive advantage to an airline, and good aircraft engineers were regarded as a valuable corporate asset. In more recent years, the long-term decline in accident rates appears to have increasingly encouraged an attitude of complacency, especially towards those aspects of safety that are less visible for both airline operators and their customers. Conversely, competitive pressures have created a new urgency both to contain the costs of safety-related maintenance and to put planes back into the air as quickly as possible after a malfunction or scheduled check. In this new environment, the role of the LAME has become a focal point of both industrial and regulatory conflict, with potentially serious safety consequences.

In some parts of the world, however, the model of the licensee enjoying statutory independence either never applied, or gave way as far back as the 1950s to an alternative arrangement, which Haas<sup>14</sup> calls the *company model*. In this model the responsibility for ensuring airworthiness after maintenance has been completed lies with the employing company rather than the certifying person, who operates solely as an agent of the company. Since the conflict between the two

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<sup>10</sup> Interview, LAME, 2009.

<sup>11</sup> Ibid.

<sup>12</sup> Civil Aviation Safety Regulations CASR 1998 (CASR 1998), Part 42.355, "Reporting Defects".

<sup>13</sup> Federal Court of Australia, 2012, especially pp. 140-141.

<sup>14</sup> Haas, 2010.



models was central to the way the EASA scheme developed, it is worth looking in some detail at the practical differences between the two, starting with Haas's account:

*One factor that the two systems have in common is that the company names the certifying staff.* In a licensing system, it is the state (the national aviation authority) that satisfies itself that the candidate possesses the necessary competence... [A] licence is issued that serves as both a proof of basic competence and a permit. Under a system of company training, by contrast, the competence assurance is delegated to officially accredited maintenance companies. The role of the supervisory authority is restricted to approving and making spot checks of the internal organisation at the firm... Unlike in the licensing system, the company does not require approval to authorise a person. A career in an accredited training system of the company is sufficient as proof of competence. There is no licence in this regime of internal training and job markets.<sup>15</sup>

As Haas notes, the company model has significant practical attractions for many of the parties involved, especially employers:

The supervisory authority has the advantage of passing on monitoring costs to the companies (testing, traceability of work histories, record keeping and release authorisation checks). And... the companies have more leeway: company-specific instead of standardised skills profiles, allowances in assigning release authorisation, and moderation in wage level.<sup>16</sup>

Partly on the strength of these perceived advantages, there has been pressure from some quarters to move away from the licensing system since at least as far back as 1958, when the ICAO actually canvassed a system along the lines of company licensing. At the time, it was rejected by a majority of member countries, specifically including Australia, but others including Afghanistan, Ethiopia, France and the US were firm in their continuing allegiance to their established company models.<sup>17</sup>

When the European Economic Community (as it then was) began work on coordinating the training and qualification requirements for aircraft maintenance across Europe, France and Belgium were the only two among the then 27 member nations to operate outside the licensing framework. France in particular exerted considerable effort to achieve a system which would give equal standing to the licensing and company models and allow a free choice between them. Although the initiative was strongly opposed by the remaining members, the European Union (EU) Commission eventually forced a compromise because the size of the French maintenance repair operations industry would have made it absurd to exclude France from the common European framework. This compromise involved the development of a shared model for recognising equivalence of qualifications, but left the issue of whether to adopt a licensing system as such open to the discretion of individual member nations.<sup>18</sup>

Importantly, this discretion survived in linguistic ambiguities in the EASA regulations, which went further than the strictly circumscribed latitude within Annex One, as described above. EASA used such terms as "certifying staff" and "support staff" which could refer at once to B level LAMs,

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<sup>15</sup> *ibid.*, pp. 603-4 (emphasis added).

<sup>16</sup> *ibid.*, p. 604.

<sup>17</sup> *ibid.*, p.603.

<sup>18</sup> Haas, 2010, pp. 604-611.

and to non-licensed personnel approved by Part 145 approved maintenance organisations (AMOs) (see below). Base maintenance could be performed by “qualified” people – leaving it open to employers to determine the type of “qualification” – which (in Europe) could be from a very large range, some of them potentially unrelated to the task.<sup>19</sup> These and other ambiguities have found their way into the CASR and related documentation, which CASA resolved to introduce in Australia from 2006, and which we trace below.

Many of the uncertainties and risks involved in CASA’s approach could fairly be attributed to their origins in the internal politics of the EU. In the event, however, contradictions are appearing as the new Australian licensing system emerges, which pose risks to its integrity and international alignment, and the remainder of this chapter describes how this is starting to occur.

### **8.3. Reforming the maintenance suite of regulations**

#### **8.3.1 Part 66: Moving to EASA harmonisation**

After preparing for some years to move Australian airworthiness legislation closer to the United States (US) Federal Aviation Regulations (FAR) system, CASA abruptly switched course around 2000<sup>20</sup> and began developing a new set of additions to the 1998 Civil Aviation Safety Regulations (CASRs) based on the EASA system. Full implementation did not begin until 2007, and the process took some time to show results. The new regulatory structure came into force on 27 June 2011, with a four-year transition period, taking the timeline for final implementation to June 2015. However, the timeline has been extended to 2019 for certain components of the former system, notably to do with exclusion removal and licensing in the small aircraft maintenance sector.

CASA issued a Regulatory Impact Statement (RIS) in 2010<sup>21</sup> which provided arguments in favour of the implementation of the EASA-based suite of maintenance regulations. The proposed new system, it argued, would allow increased international labour transfer between Australia and the various jurisdictions of Europe, as well as other international EASA-approved MROs, through mutual recognition of skills, qualifications and licences. It would, the RIS argued, also aid in attracting MRO work to Australia, and in bolstering the local industry’s competitiveness.<sup>22</sup> It would improve the labour “flexibility” considered necessary to meet the technical demands of modern aircraft maintenance by overcoming work demarcations with their roots in obsolete licence categories. The training and learning required to gain licence privileges would be less expensive than under the previous regime. These claims in effect provide a partial checklist against which the licensing reforms can be judged, and we briefly digress to foreshadow how they have fared in hindsight.

First, the expectation that harmonisation between Australian and European regulations would improve transferability collided with reality when, following the transition in June 2011, Australian LAMEs were reportedly unable to gain work in Europe with their new CASR Part 66

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<sup>19</sup> Interviews, Robert Alway, President, Air Engineers International, Ola Blomqvist, Vice President, Air Engineers International, 39<sup>th</sup> Congress of Air Engineers International, Istanbul, 4-9 October, 2011.

<sup>20</sup> The exact point in time at which the decision to introduce the EASA system into Australia was made, as well as the underlying decision processes, merit historical investigation, as there are multiple and conflicting accounts in the industry – some of them quite contentious. To our knowledge, there has been no comprehensive explanation of the shift.

<sup>21</sup> Civil Aviation Safety Authority (CASA), 2010d, pp.8-10.

<sup>22</sup> Ibid., p.3.

licences. The example given in the RIS text was of Europeans transferring to Australia, not the other way around.<sup>23</sup> The ASRR<sup>24</sup> commented that for international transferability of skills, qualifications and licences resulting from harmonisation would require intergovernmental agreement.

Second, the RIS argued that more efficient deployment of labour would result from the regulatory reforms. It provided the example of servicing a hydraulic system, part of which was an electric pump, which in Australia (so it was claimed) required three licensed engineers, but in Europe required only one.<sup>25</sup> However, the Australian Licensed Aircraft Engineers Association (ALAEA) response<sup>26</sup> to the CASA RIS pointed out that this example confused the concepts of licence *holders* with licence *categories* – in Australia, while the example chosen did indeed cross licence categories, it was possible for one licensee to hold endorsements in all three categories and in that case only one appropriately licensed engineer would be required, not three. Further, CASA itself had previously endorsed the practice of LAMEs being called upon to work outside their endorsed licence categories – in particular licence holders endorsed for engines and mechanical categories might perform and sign for electrical work.<sup>27</sup>

A third point was the cost of training. Briefly the new EASA B licences require Diploma level qualifications, whereas Australian training funding extended only to Certificate IV, leaving a large training gap to the Diploma. First, the RIS put this training gap at 550 hours on average,<sup>28</sup> whereas it is in fact in the order of 1,000 - 1,500 hours (see Chapter 9). Second, the CASA RIS indicated the cost of this training would be borne by government, yet state training authorities have almost uniformly refused to fund it. Third, the CASA RIS claimed the cost of gaining a licence endorsement through the previous route of self-study and the CASA Basics exams (see below) exceeded the cost of the new pathway. This is implausible.<sup>29</sup> The new “full” licence structure also requires ratings in categories that some Civil Aviation Regulation (CAR) 31 LAMEs would not necessarily have. We return to these issues below and in Chapter 9.

At this point, we set out explain key differences between the former and reformed licensing systems. The suite of maintenance regulations consists of CASR Part 42 (continuing airworthiness), Part 145 (Approved Maintenance Organisations), Part 147 (Approved Training Organisations (ATO) and Part 66 (licensing structure and privileges). We discuss Part 66 first, as it covers personnel licensing.

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<sup>23</sup> Civil Aviation Safety Authority (CASA), 2010d, p.8.

<sup>24</sup> Australian Government, 2014. According to the ASRR, “... many mistakenly expect that if Australia harmonises its regulatory suite with an overseas jurisdiction, then CASA-issued approvals or certificates will automatically be accepted in that foreign jurisdiction” (p.97). It would have been helpful had this point been clarified at the time.

<sup>25</sup> Civil Aviation Safety Authority (CASA), 2010d, p. 3.

<sup>26</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2010.

<sup>27</sup> Civil Aviation Safety Authority (CASA) 2002, p. 15 states: “In many instances, a licensed engineer can carry out and sign for maintenance in areas not normally associated with the area their licence covers – for example, an airframe LAME can do some (restricted) work on electrical systems, instrument systems and radios”.

<sup>28</sup> Civil Aviation Safety Authority (CASA), 2010d, p.7.

<sup>29</sup> Anyone wishing to follow the calculations is referred to Civil Aviation Safety Authority (CASA), 2010d, pp. 6-7; and Australian Licensed Aircraft Engineers Association (ALAEA), 2010, pp. 3-4.

**Part 66** defines new (to Australia) licence categories based on the EASA system, with higher-level qualifications indicating higher theoretical knowledge attached to the main licences.<sup>30</sup>

Significantly, however, the new licensing system also proposes some new and most controversial forms of licence, one at sub-trade level.

### **8.3.2 Background – The CAR 31 licensing system**

To understand the changes, it is necessary to know how the former licensing system, regulated under CAR 31 that had developed in Australia, differed from the new EASA/CASR system. The former system's building blocks were *categories* and (group and type) *ratings*. There were five categories: airframe, engines, electrical, instrument and radio. The concept of *groups* referred to aircraft and systems with strong similarities, while *types* refers to systems and structures that are sufficiently different from each other, as well as sufficiently complex, to warrant focussed training and their own licence rating. As pointed out in the next chapter, these categories corresponded neatly to aircraft maintenance trades, but were rationalised in the early 1990s.

These concepts of categories and types are usefully portrayed on a grid (see Table 8.1), with the main division being by weight [8,000 kg as specified by CASA (after the 2011 reforms 5,700 kg)] – groups 1-3 registering planes and systems with strong similarities to each other, and higher-level groups devoted to specific aircraft and system types. A person might be trained, qualified and licensed in Group 1 engines (allowing them to work on, and certify maintenance for piston engines in light planes). A mix of Group 1 airframe and engine was most common in GA.<sup>31</sup> Group 21 in the category “Engines” covered engines that might be found on a large passenger plane, and required specific knowledge and experience about one particular large complex engine. These were seen as sufficiently unique and different to each other to warrant a separate licence type.

One common career path would start by working on broad groups in GA and then become qualified and endorsed to sign for work on larger more complex types in the RPT sector. The latter work is generally better paid, with pay increments linked to licence types. Thus an orderly career path existed from GA to RPT. As the licence contained many more separate categories than the later EASA licences, it was possible to acquire them piecemeal and in a targeted fashion throughout a working life, rather than requiring a large dose of front-end theory training, with the experience and “type” training requirements added later. This allowed more flexibility and specialisation in the acquisition of licence endorsements as well as more flexibility in studying to attain them. Aspiring licence holders would need to demonstrate knowledge and experience for each of the ratings they sought, by sitting the so-called “Basics” examinations, administered by CASA. CASA would also assess the applicant's “Schedule of Experience” (SOE) — in order determine whether the applicant had sufficient experience to be awarded the licence endorsement sought for work on a particular aircraft component or system.

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<sup>30</sup> Civil Aviation Safety (CASA), 2015f.

<sup>31</sup> In addition, a semi-formal dispensation existed by which CASA allowed holders of airframe and engine categories to certify for some electrical work. See Civil Aviation Safety Authority (CASA), 2002, p. 15, which states, “In many instances, a licensed engineer can carry out and sign for maintenance in areas not normally associated with the area their licence covers – for example, an airframe LAME can do some (restricted) work on electrical systems, instrument systems and radios.”

**Table 8.1 Licence groups under the CAR 31 system**

| Groups | Airframes  | Engine  | Electrical  | Instrument                                    | Radio                          |
|--------|--|---|---|---|--------------------------------|
| 1      | Aeroplanes not covered in Groups 2-20  | Piston engines in aeroplanes and airships                 | Single generator power systems  | All general instruments not in Groups 3 or 20 | VHF and HR other than Group 20 |
| 2      | Helicopters not with hydraulic flight control  | Piston engines in Helicopters                             | Multi generator systems except Group 20   | Autopilots (except Group 20)                  | Audio and cockpit recorders    |
| 3      | Wooden Airframe  | Supercharging and turbo charging systems                  |   | Auto pilots (except Group 20)                 |                                |
| 20     | Aeroplanes, with (jets) and heavier than 8,000 kg as specified by CASA (after 2011 reforms now 5,700 kg) |   | Electrical systems in aeroplanes above 8,000 kg (after 2011 reforms now 5,700 kg) |   | Radios in RPT sector           |
| 21     |  | Piston and gas turbine engines in aeroplanes and airships |   |   |                                |
| 22     |  | Piston and gas turbine engines in Helicopters             |   |   |                                |

Source: Adapted from CASA, 2007b, pp. 19-20 and CASA, 2002, pp. 16-18

### 8.3.3 The EASA/CASR reforms to the licensing system

The CASR reforms incorporate the five categories of licence into the two EASA classifications of B1 (Mechanical) – composed of the former categories of airframe, engine, electrical; and B2 (Avionics) – composed of the former categories of electrical, instrument and radio. A B1 licence holder signs for airframe, engine and electrical work; the B2 signs for avionic work. When supplemented by appropriate type training, B licences confer privileges over multiple types of aircraft and systems. The underlying theoretical knowledge is correspondingly broad and comprehensive, justifying a Diploma qualification. The EASA Part 66 regulations<sup>32</sup> specify around 2,400 training hours to qualify for a B licence (depending on the precise category), in addition to a period of industrial experience, the length of which varies according to when the trainee commenced training. A person seeking a B licence requires five years of industrial experience if they have no relevant technical background, and 2 years' experience following completion of a relevant course of study at Diploma level or an apprenticeship.

<sup>32</sup> The CASR Part 66 MOS did not, at the time of writing, specify numbers of hours for "category" licence training.

Crucially, the EASA regulations and the CASRs provide for two new licence categories of “release to service” engineers, category C and A, confined to base and line maintenance respectively. Category C licence holders issue CRS (Certificates of Release to Service) based on maintenance certifications issued by “support staff” – B licence holders – in base maintenance.<sup>33</sup> However Category C licence holders cannot themselves perform maintenance certification (for a stage of maintenance).

Category A licence holders can sign for and perform work listed in the Part 145 Manual of Standards,<sup>34</sup> including the replacement of wheel assemblies, brake units, emergency equipment, ovens, boilers, beverage makers, lights, seats, harnesses and aircraft batteries. But the scope of the Category A licence can also be extended to the replacement of any other component *if the task is one that CASA approves as a simple task* (emphasis added). Category A licence holders can also perform “simple defect rectification”. Significantly, Category A licence holders can sign for their own work (but not supervise the work of others) and can issue a CRS,<sup>35</sup> but only following line maintenance and then only for specific and limited maintenance activities.

Under the Australian CASRs, the Category A licence can be awarded after Certificate II level training (680-800 hours) and two years’ work experience, although it can also be attained by Certificate IV qualified AMEs after appropriate bridging training. A range of interview and survey respondents expressed concerns that the Certificate II path does not provide sufficient training and experience, and that a Certificate II/Category A licence holder will as a result lack sufficient experience and “maturity” to release a plane to service safely – particularly in light of the pressures that the job may entail, as described above.

CASA’s prerogative to “approve any task as a simple task” (described above) offers possibilities for broadening the scope of the A licence. Consider “phased maintenance” which involves rolling some elements of what was previously base maintenance (B and C checks) into A checks, traditionally considered part of line maintenance. This could potentially bring some maintenance operations previously certified only by a full CAR 31 LAME within the purview of the Category A licensee, whose training and experience are well below the level that would have been needed to qualify for any kind of licence under the old system. Many interviewees argued this was a serious breach in safety defences. Others disagreed. Much depends on the level of training associated with the licence.

In Europe, the Category A licence is underpinned by varying qualification and training structures. In some countries, notably Sweden, it is not used at all (at time of writing). In others it is used extensively, but entails higher levels of qualification. In Germany, the Category A is generally grafted into a three-year apprenticeship, (although admittedly variation does occur).<sup>36</sup> In Britain, a young person who starts as an apprentice mechanic or fitter can gain apprenticeship qualifications after three years of training and can gain a Category A basic licence after a total of four years of training or a Category B after five.<sup>37</sup> Australia, however, has set the Category A and its associated qualification at the bottom of the range, following EASA regulations that set the number of training hours for a Category A licence at 620-800 (plus two years’ experience).<sup>38</sup>

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<sup>33</sup> Civil Aviation Safety (CASA), 2011a, p. 3.

<sup>34</sup> Civil Aviation Safety (CASA); 2011c.

<sup>35</sup> Civil Aviation Safety (CASA), 2011a, p. 5.

<sup>36</sup> Interviews at AEI Conference, Turkey, 2011; Alway, Blomqvist (see Footnote 14).

<sup>37</sup> Lewis, 2012, p.16.

<sup>38</sup> See Chapter 9 which gives required hours from the Victorian Purchasing Guide for the MEA11 Training Package.

The CASR Part 66 MOS appears based on the assumption that an ICAO Annex One licence is equivalent to a Part 66 licence. Yet the Part 66 Category A licence allows important sign-off privileges, including CRS, although it is based on a sub-trade (Certificate II) level of training. An important issue requiring further exploration is the question of whether the Category A licence, when based on a Certificate II level of training, is in fact ICAO compliant.

## 8.4 CASR reforms to continuing airworthiness

### 8.4.1 CAMOs – Continuing airworthiness management organisations

**CASR Part 42** outlines a new approach to continuing airworthiness based on separating the responsibility for continuing airworthiness *management*, now to be performed in continuing airworthiness management organisations (CAMOs), from the *performance* of maintenance itself, carried out in Part 145 approved maintenance organisations (AMOs).<sup>39</sup> CAMOs administer aircraft maintenance programs, records and schedules, and these are communicated to air operator certificate (AOC) holders and AMOs. The CAMO could be a separate organisation, or could exist within an AOC-holding organisation, but if the latter it must maintain internal organisational separation of function.<sup>40</sup>

The purpose is to ensure that responsibility for airworthiness and safety rests ultimately with AOC holders and cannot be delegated. Part 42 emphasises the separation between certifying for the *completion of a stage of maintenance* on aircraft or aeronautical products, which is the responsibility of the AMO, and certifying for *release to service (CRS)*, for which the CAMO (of course employing a LAME) is responsible.<sup>41</sup>

Whilst endorsing the principle upon which the separation of function is based, experts are divided on the merits of how the division between management and performance of maintenance is playing out in practice. This is because the CAMO, with formal responsibility, is ultimately reliant on the technical expertise of the LAME in determining that an aircraft or component can be released to service. One expert interview participant believed the organisational separation of functions could create opportunities for miscommunication and disarticulation, particularly if the regulations are unclear and/or poorly understood. Potential geographic separation adds another safety concern, as one former CASA inspector and maintenance manager opined:

*We've created three certificates issued by CASA; three independent bodies responsible for this one aeroplane. You've got the operator here that's going to fly it. You've got the CAMO that's going to manage the airworthiness and the documentation to it. Then you've got the maintenance org over here that's going to be contracted to do work on it. So you've got three silos now. When you've got silos and you've got to have things work between them, that's when the problems can arise.*<sup>42</sup>

Another maintenance manager saw an advantage for safety in separating the planning from the execution of maintenance, echoing a LAME's concerns about being overridden by over-zealous managers:

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<sup>39</sup> Civil Aviation Safety Authority (CASA), 2011a; 2011b.

<sup>40</sup> Civil Aviation Safety Authority (CASA), 2011b.p .4.

<sup>41</sup> Civil Aviation Safety Authority (CASA), 2011a, p.3.

<sup>42</sup> Interview, CASA Inspector, 2013.

*...they could ask for something to be done which is against the intent of the regulations. But if they're also in the line of command then they could put undue influence on the engineer to do the maintenance that they specify, not the maintenance in accordance with the regulations.*

*If they're in the same chain of command then it's very difficult to separate what is a request versus what is a directive for the engineer on the floor.*<sup>43</sup>

Other issues requiring further clarification within the new regulations include the concepts of an “airworthiness review” i.e. that an aircraft has conformed to pre-set maintenance schedules and airworthiness directives – and an *overall judgement* of airworthiness such as is implied in signing the certificate of release to service.<sup>44</sup>

The stated intent of the new role separation is to ensure that the AOC holder is accountable for safety. Nevertheless, research interviews revealed quite widespread concerns about the potential risk of breaches to a key airworthiness safeguard: the requirement that a person who signs off on the performance of safety-critical maintenance actually has witnessed or supervised its performance to standard, before the plane can be released to service. In Europe, although the practice is illegal, it is reported that un-licensed people within CAMOs have signed certificates of release to service completed by licence holders, on receipt of certification from Part 145 AMOs that an “airworthiness review” has been conducted.<sup>45</sup> Though we cannot independently verify these claims, their existence counsels caution. It is important to ensure that Australia implements CASR Part 42 in a way that is fully internationally compliant and that also that airworthiness sign-off be conducted only by licensed personnel who have supervised the performance of safety-critical work to standard

On the other hand, particularly with the emergence of independent MROs, the separation – provided it is well managed – may also be an appropriate organisational form for consolidation of maintenance capacity across a number of smaller MROs. For example, one organisation could keep and update maintenance schedules for a number of different planes, and these records and maintenance manuals could be accessible from a number of small shops — provided the scope of Part 145 is extended below aircraft of 5,700 kg maximum takeoff weight (MTOW). It could also provide new career paths from L/AME into management.

The conclusion must be that CAMOs have advantages and disadvantages, and that some further clarification is required, even among experts, of their merits, role and powers. So far, it is mainly airlines and a handful of independent MROs that are listed as CAMOs on the CASA website. There is justification for ongoing and enhanced monitoring of how CAMOs work in practice, and analysis of how, in any future restructuring of the industry, their organisational flexibility be exploited to the best advantage.

#### **8.4.2 AMOs - Approved maintenance organisations**

**Part 145** regulates organisations that provide maintenance, known as approved maintenance organisations (AMOs). The CASR Part 145 Manual of Standards requires that an AMO develop a “maintenance exposition”,<sup>46</sup> which is a document setting out the following: clearly defined roles for an Accountable Manager, a Responsible Manager, a Quality Manager and a Safety Manager.

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<sup>43</sup> Interview, Senior Maintenance Manager, major Airline, 2014.

<sup>44</sup> See footnote 4 above.

<sup>45</sup> Reported at 39<sup>th</sup> AEI congress, Istanbul; 4-9 October, 2013; 41<sup>st</sup> Congress, Melbourne, 29 November, 2013.

<sup>46</sup> Civil Aviation Safety Authority (CASA), 2011c; 2015d, 2015e.



The AMO must implement Safety Management Systems (SMS), including drug and alcohol testing, and must ensure that Human Factors training has been completed. Importantly, it must now describe the processes by which it (the AMO) will formally authorise and approve licence and qualification holders to carry out and certify for maintenance.<sup>47</sup> It must ensure that a certifying employee has an adequate understanding of the aircraft and/or aeronautical products referred to in their certification authorisation, and of the AMO's procedures and of the maintenance exposition itself.<sup>48</sup>

Importantly, the AMO is now held responsible for approving its employees' competence to perform maintenance tasks including certifying for maintenance.

An AMO must specify standards (*including, but not limited to, qualifications and experience*) in its exposition for the competence of individuals involved in any maintenance, management or quality audit task and must ensure these individuals meet the standards for a task that they are authorised to perform.<sup>49</sup>

This could be read as a shift towards the "company approval model" outlined earlier. Questions have arisen, and have been frequently voiced by our interviewees, over how this responsibility is intended to interact with the qualification and licence. A senior maintenance manager explained the significance of the change as well as acknowledging its subtlety:

*... what comes on top of just having a licence is things like induction training, training on your procedures and your documentation, training on the differences because each airline orders their aircraft in a different specification, different mod status to just about everyone else, so you'd need differences on what's changed.*<sup>50</sup>

From one point of view, requiring a company to take responsibility for the competence of its employees is simply formalising something that is part and parcel of an employment relationship. When an employer employs a licence holder, and allocates work to them, s/he is in effect "approving" the person to do work for which they are qualified and licensed. From another point of view the new system may place too powerful an industrial relations lever in employers' hands, swinging the balance between production and protection back to the former.

*So that means you can't just leave and go to another place if you've got a lousy job. So then you're compromising safety by blokes knowing they're going to lose their job and not be back on that pay level for a long time. Your licence is not portable in that regard whereas before you could leave from TAA one day and be assigned that aircraft at Ansett the next. So they've - basically they've castrated LAMES' independence*<sup>51</sup>

*Well they've got to show they're competent and that they've been trained on it but they don't need anything like the experience that we used to require. Or, it's left to the employer to decide that. Well that's a bit too flexible I think.*<sup>52</sup>

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<sup>47</sup> Civil Aviation Safety Authority (CASA), 2011c; 2015e.

<sup>48</sup> *ibid.*

<sup>49</sup> Civil Aviation Safety Authority (CASA 2011c), 145 A 30 d, p. 4.

<sup>50</sup> Interview, Senior Maintenance Manager, major Airline, 2014.

<sup>51</sup> Interview, CASA Inspector, 2013.

<sup>52</sup> Interview, LAME, 2011.

Since the determination of competency has such strong consequences for both industrial relations and safety, there is a strong case for requiring that the company approval process should be open to participation - for example, a committee with employee representation could make the determination. Exactly how different companies are using these approval powers and their consequences remains a matter for further research.

Company approvals may build another layer of defence into the system, which may be important if there are deficiencies in the training, qualifications and licensing systems. Employers' approvals could also play a positive role in the assessment of current competence, since the VET qualifications framework is not designed to support periodic reassessments of a qualification holder's competence over time.<sup>53</sup>

On the other hand, in the event of a maintenance issue caused by faulty training (the person not knowing what they were doing) it is unclear where liability would lie. The poorly trained employee might defend himself/herself by insisting that he/she had been trained and assessed in an organisation approved by both CASA and the VET regulator, as well as having been approved by the employer. The employer might say the approval depended largely on the qualifications and licence endorsements, performed by the training provider and CASA. The training provider might insist the person was competent at the time they were assessed, although their skills had decayed and theoretical knowledge had been forgotten. CASA might say the employer is now responsible for the employee's competence, no matter what their qualifications and licence endorsements are. There is no way of knowing how such accountability would be resolved in a legal case. Such responsibility however needs to be resolved, particularly in the context of the emergence of independent MROs. Support needs to be provided to safeguard and enhance the supply of well-trained and currently-licensed engineers, as part of the overall duty of care owed by a government to its citizens, which has effectively been delegated to CASA.

#### **8.4.3 The "Specialist Maintenance" controversy**

Confusing and sometimes contradictory documentation around the licence opens the way for the responsibility to certify for certain maintenance tasks to shift beyond the holder of an Annex One/Part 66 licence to "certifying staff" who, may or may not hold licences, whose qualifications may or may not be appropriate, and whose knowledge of aircraft systems may or may not be up to the task. The CASR Part 145 MOS on the one hand affirms the role of LAMEs in performing maintenance certification and issuing CRS:

An AMO may only authorise an individual to perform maintenance certification and issue certificates of release to service for aircraft maintenance under the following circumstances:

- the person is the holder of an Australian Part 66 Aircraft Engineer Licence for the aircraft/engine combination or rating in the licence category applicable to the authorisation (the applicable aircraft/engine combination or rating);<sup>54</sup>

However, the MOS also contains subtle conceptual slippages between the concepts of "holders of Part 66 licences" and "certifying employees" who may or may not be licensed.<sup>55</sup> This opens the way for a conscious or unconscious normalisation of the migration of work from the former to the latter.

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<sup>53</sup> Australian National Training Authority (ANTA), 2002.

<sup>54</sup> Civil Aviation Safety Authority (CASA), 2011c, p. 5.

<sup>55</sup> E.g. *ibid.*, p. 7.

An apposite case is that of the “specialist maintainer”, usually a contractor, for example a skilled welder, who is employed to perform specific tasks, and to sign for their work. The term used to denote the latter process – “maintenance certification” – is ambiguous, and could equally refer to contractors taking responsibility for their own work, or to the contractors’ certification that their work has not affected the “airworthiness” of the aircraft – a judgment they are not qualified or licensed to make. The latter is a higher order of certification, preserved by ICAO Annex One to the licence holder or equivalent. Tasks the CASR 2011 Part 145 MOS allows specialist maintainers to perform and sign for include non-destructive testing, welding, borescope inspections, composite repairs, repairing in-flight entertainment equipment, and “other maintenance as approved by CASA as specialist maintenance”.<sup>56</sup>

In the October 2014 Amendments to the CASR Part 145 MOS,<sup>57</sup> CASA used the terminology of “Specialist Maintenance Certifying Employees” to refer to the people approved to perform specialist “maintenance certification”, and foreshadowed extending this list of tasks.

CASA intends to approve Part 145 Organisations for specialist maintenance “D” Ratings for Non Destructive Testing (D1) or Welding (D2) or for other specialist maintenance fields such as composite repair and aircraft surface finishing (including painting & plating) under a “D3” Rating. CASA may also approve IFE software, on-wing engine maintenance, borescope inspections and interior furnishing (seats) as specialist maintenance for organisations for specialist maintenance under their “A”, “B” or “C” rating. The list of specialist maintenance fields for which CASA would issue approval at paragraph 145.A.30 (f) requires updating. Appendix I may require updating to reflect regulatory intent.<sup>58</sup>

The ALAEA opposed extending the scope of specialist maintenance work on two grounds: first, because it entailed the possibility of losing its own work coverage (although it insisted its opposition was not industrially motivated), and second, because it violated longstanding Australian regulation of the safety certification system based on Australia’s obligations under the Chicago convention. Since the regulatory changes were, in fact, delegated legislation under the Civil Aviation Act (1988), they had to be approved by the Senate – normally an unproblematic process. The ALAEA therefore lobbied Senators to oppose the changes. This was a formidable task of persuasion, since the issues are not easily explainable. They enlisted a senior QC, Mr Brett Walker, whose subsequent opinion<sup>59</sup> laid out the issues.

The Walker Opinion accepted that Australia’s obligations under the Chicago convention required CASA to accept the ICAO Annex One interpretation of the role of a licensed aircraft maintenance engineer. Further, following ICAO Annex One, Walker argued that there were two forms of certification – the certification of stages of maintenance, and the certification of airworthiness and the release to service (CRS) (p. 4). Airworthiness “relates to the whole aircraft, and thus to all of its many systems and materials” – it has a “holistic aspect” (p. 6). Thus, by expanding the list of tasks that CASA intends permitting AMOs to approve non-licensed contractors or employees to perform, the amended MOS contradicted the provisions of ICAO Annex One (which reserve signing off on work that affects airworthiness for licence holders).

Further, CASA had contradicted its own Guidance material. The latter states that

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<sup>56</sup> Civil Aviation Safety Authority (CASA), 2011c, 145.A 30 (f), p.4

<sup>57</sup> Civil Aviation Safety Authority (CASA), 2014a; 2014e, Part 145.A.30(f).

<sup>58</sup> *ibid.*

<sup>59</sup> Walker, 2014.

Specialist Maintenance personnel are trained and qualified in the specialist field and may not have a holistic understanding of the interrelationship of an aircraft's systems, or airworthiness implications, such that a Maintenance Certification Licence holder should have. For this reason the Maintenance Certification for Specialist Maintenance work will only be for the scope of the specialist maintenance and is not intended to cover work normally performed and certified for by a Part 66 Maintenance Certification Licence holder who is a Certification Authorisation holder. Additionally the AMO may not authorise an employee to issue a CRS predicated on the Specialist Maintenance qualification.<sup>60</sup>

Walker accepts that it is "a real possibility that CASA did not intend, as a matter of policy, to remove LAMEs from important aspects and stages of airworthiness evaluation, by making the amended MOS" (p. 3). In the event, the Senate voted to disallow CASA's proposed changes. However, the ambiguities in the EASA-based regulations ensure this will be an ongoing issue. This case would seem to affirm the wisdom of the ASRR in suggesting that Australian regulations be re-written in a "third tier" of plain language regulation.<sup>61</sup> Such a move would force existing ambiguities to the surface where they could be debated, rather than be fought out in dense dense thickets of regulation which actually obscure the crucial issues involved. Meanwhile issues relating to the regulation of specialist independent MROs require resolution, particularly in the non-regular public transport (RPT) space.

## **8.5 Implementation issues**

While it is fair to say that the EASA system has bedded down to an extent, and now enjoys a higher degree of acceptance than when first introduced, a number of implementation issues emerged early and while some of them have abated, others continue to cause problems.

### **8.5.1. Clarity**

A number of interviewees reported how when the new-system licences were first issued, some LAMEs were left unsure about the scope of their privileges – that is, what they were entitled to sign for, and what not – and some even report having lost privileges in the transfer. Even more alarmingly, some LAMEs claimed to have been issued with privileges they did not formerly have! In some cases, the new licences came with thirty pages of text, replacing one or two pages that clearly described their privileges. This could present a serious safety issue, which could be compounded in the event of a disagreement with an employer about the scope of an employee's licence. In addition, they found CASA's style of writing regulations confusing (a point also made by the expert Aviation Safety Regulation Review) while "strict liability" made transgression costly and, presumably, anxiety-provoking.<sup>62</sup>

### **8.5.2 Restrictions, exclusions, privilege gaps and training gaps**

Interview and survey participants reported a common perception that recipients of the new B licences found their former licences had been degraded in status, because they were no longer "full" licences but were explicitly "restricted", in that the licence holder was not permitted to exercise privileges across the full range of categories to which the new B licence applied. The new B licences not only required a higher level of theoretical knowledge, but also that the latter

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<sup>60</sup> Civil Aviation Safety Authority (CASA), 2014e, GM 145.A.30 (f) p. 27.

<sup>61</sup> Australian Government, 2014.

<sup>62</sup> Australian Government, 2014, pp. 95-6, 104.

be spread across a broader scope of licence categories – in the case of the B1 licence, across airframe, engine, and electrical categories. Where the former CAR 31 licence holder's privileges did not cover a particular category, s/he was "excluded" from exercising them. This was noted on the licence, and in some cases these exclusions were voluminous. Although Manufacturing Skills Australia (MSA) quickly developed "skill sets" – or competency standards which went to most of the common exclusions, and against which a licence holder could undergo recognition of prior learning (RPL) or "gap training" – such gap training and RPL had to be delivered by a Part 147 MTO and was therefore expensive. Some LAMEs reportedly decided not to undergo the "gap" training, and their licences were therefore "degraded" (in terms of their previous status as "full") and did not command the same premium on the external labour market as previously, especially in comparison with overseas "full" EASA licence holders. It also correspondingly decreased the availability of appropriately licensed LAMEs in some categories.

This project has allowed an estimate of the size of the training gap across the labour force in at least the most significant categories. The project survey was conducted as the new regulations were implemented (in 2012/13), and we received 579 useful responses to our questions about what categories of licence respondents held. The discussion here is confined to the case of B1 licences. From Table 8.2, it can be seen that 346 of 579 LAMEs (57.8%) held privileges in the engine and airframe categories – but did not have endorsements in the electrical category. Their B1 licences were issued as partial – "restricted", with exclusions to be removed by gap training and/or RPL assessment. To the extent that the responses were representative, this suggests that a significant training gap has emerged across the occupation, in the course of implementing the new CASR licensing regulations.

**Table 8.2 Frequency of licence combinations, survey of AMEs and LAMEs, Australia, 2012–2013 (n=708)**

| Licence Type                                | N          |
|---|------------|
| Engine & Airframe only                      | 346        |
| EIR only                                    | 133        |
| Airframe only                               | 25         |
| Electrical & Instrument + Engine & Airframe | 18         |
| EIR + Engine & Airframe                     | 15         |
| Electrical & Instrument                     | 13         |
| EIR + Airframe only                         | 1          |
| Engine only                                 | 10         |
| Radio only                                  | 8          |
| Electrical + Airframe & Engine              | 4          |
| Electrical only                             | 3          |
| EIR + Engine only                           | 2          |
| Electrical & Radio                          | 1          |
| <b>Total</b>                                | <b>579</b> |

Source: Project Survey of Aircraft Maintenance Engineers, 2012-13

A remedy cannot be found simply by removing all exclusions from a former CAR31 licence, as this would not provide the full theoretical background implied by the possession of a B licence that requires a Diploma level qualification – there is a corresponding gap in terms of training hours between CIV and Diploma of some 1,000 training hours (see next chapter). As explained in the following quotation from an experienced training manager:

*We're now in a position where you'll find that people that have gone through, done their apprenticeship - or currently doing apprenticeships - haven't even started basics. It's like we've got a generation of AMEs that aren't even suitable to become LAMEs - not without a great deal of effort... There is a generation of them that haven't kicked off - they have to go back to TAFE and undergo an RPL process in which case they then have to probably redo their examinations in a number of cases.*<sup>63</sup>

### **8.5.3 Overseas recognition**

New Australian licences were not automatically recognised in Europe and in some other jurisdictions. As the ALAEA notes<sup>64</sup>

Despite both Australia and the EU having maintenance engineer licences based on the same ICAO standards (and the professional standards of the licences being equal) the EU will not recognise the qualifications of the Australian engineers and requires them to recomplete their entire professional training if EU accreditation is sought.

Australia, on the other hand, fully recognises the EU licence qualification and, subject to a minor legislation/difference exam, issues EU licence holders with an equivalent Australian Part 66 licence.

Two points can be made about this. First, the ASRR argued that it had always been unrealistic to expect the new licences to be automatically recognised, in Europe or elsewhere, without appropriate intergovernmental negotiations.<sup>65</sup> Despite the apparent assurance of mutual recognition in Article 33 of the ICAO Convention, such recognition generally does not occur today except through specific undertakings made in bilateral or multilateral agreements. This is presumably because of the “equal to or above the minimum standards” requirement that appears later in the same Article, and given what we have learned about the widely varying standards of training and certification across the world, we would certainly not recommend that national aviation authorities (NAAs) relinquish the right to make that judgement for themselves. However, given that CASA would have been well aware of this requirement at the time it issued its RIS (2010), it might have been reasonably expected to make or at any rate recommend provision for negotiating such mutual recognition agreements, where they did not currently exist, before citing international transferability of the licences and qualifications as a selling point for the maintenance reforms.

More importantly, the Australian training system struggles to incorporate the EASA training requirements that underpin the new licences – particularly the theory modules, and the higher numbers of training hours required for a diploma level qualification. Moreover, taking a CAR31 licence, and removing any exclusions through competence-based assessment, still does not supply the essential theoretical background. Thus the question of “equivalence” of current Australian training with EASA training remains to be addressed. While Australian licences and training were equivalent to world’s best practice some years ago, Australian training now appears to be falling below that standard. Thus there is no reason why recognition would be a reasonable expectation.

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<sup>63</sup> Interview, Training Manager, MRO, 2011.

<sup>64</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2014c, p. 8.

- <sup>65</sup> Australian Government, 2014.

**Timeliness:** The National Aviation Policy of 2009 *Flight Path to the Future* envisaged that “the suites of regulations relating to licensing, aircraft maintenance and flight operations standards” would be finalised by the end of 2010.<sup>66</sup> Yet at time of writing (June 2015), the reform program was far from finalised, with the licence structure for GA still under consultation, though reportedly much closer to resolution.<sup>67</sup>

## 8.6 General aviation and small aircraft licensing (SAL)

Small plane licensing, in the GA sector, has proven to be difficult for the CASA RRP and a final resolution has been deferred to 2019. Until then, the old route of gaining licence privileges – self-study, CASA Basics exams and demonstrated experience – is still open for exclusion removal and for small plane licensing.

The fundamental issue is whether the aircraft maintenance licensing system should continue to cover both large and small planes, allowing for career progression and labour mobility between GA and RPT, or whether there will be in effect two licensing systems, with different qualifications, that apply to what may become increasingly separate labour markets. This report argues that there is a strong case for retaining a single licensing system, underpinned by high-quality training and qualifications, and generating multiple career path possibilities, including upward progression, as well as movement into the new job roles that have been generated by the EASA system. In the short term, the challenge is that, for much of the GA sector, the skills required in GA maintenance today are significantly different from those of RPT.

An AME in GA will have to work across a greater range of aircraft, and a LAME will be licensed to sign off on essentially similar tasks on a greater number of aircraft. In some parts of GA the most common aircraft types and models use piston engines and traditional technology – metal or (with decreasing frequency) wooden airframes, direct mechanically actuated controls, and discrete instruments, no longer common outside the sector. In addition, documentation is less comprehensive, placing a greater premium on self-reliance and experience to guide practice. Thus a person starting a career in GA today requires a range of skills, with the additional capability to extrapolate and think by analogy across a wide range of aircraft, sorting out problems, sometimes by trial and error, but mostly on the basis of their acquired knowledge of how aircraft and components worked. A number of GA employers interviewed for the project lamented the absence of such hands-on abilities in apprentices who had come out of more recent, airline-oriented formal training. This is one reason why some advocates, including Aviation Maintenance Repair and overhaul Business Association (AMROBA),<sup>68</sup> favour a separate GA licence following the old CAR 31 or possibly resembling the licence systems in other countries, like the Federal Aviation Administration’s (FAA) airframe and powerplant (A&P) model, or the New Zealand (NZ) model.

However, there are several arguments to encourage a single licensing scheme. First, the distinction between the two sets of skills cannot be captured simply by the size-based definition (up to 5,700 kg MTOW used to separate GA out from commercial aviation, since many larger planes still in service require the old skills to keep them airworthy, while there are an increasing number of planes below the 5,700 kg dividing point which have composite airframes, glass

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<sup>66</sup> Australia, Minister for Transport and Regional Services, 2009, pp. 104-105.

<sup>67</sup> Civil Aviation Safety Authority (CASA), 2012a.

<sup>68</sup> Aviation Maintenance Repair and Overhaul Business Association (AMROBA), 2014b.

cockpits and other up-to-the-minute technology.<sup>69</sup> Moreover, problems arise at the margins, since the weight demarcation has shifted from 8,000 kg, meaning that a number of planes that were formerly maintained under the group system of licensing, now require type ratings and special licence privileges.

Second, in the future there will be a need for much greater specialisation across the industry, and much more agility at the level of individual businesses and individual workers to move across the different segments as demand changes. This would seem to imply a multiplicity of specialised licence types operating in distinct career silos; and an integrated licensing system with a common qualification base which provides a basis for such mobility without the need to retrain from scratch. This implies an approach to continuing training which allows LAMEs to upgrade their qualifications and license ratings rapidly, in a modular fashion, as the composition of the fleet changes.

The EASA system may be better suited to these developments than the CAR 31 system it replaced, in that the large dose of theory acquired at the front end of a person's working life, reflected in broad licence categories, can be tailored through modular "type" training across a large number of specialised complex aircraft and systems. Yet challenges exist at the division between "large" and "small" aircraft, as explained above due to the mistaken assumption that automatically equates size with complexity, and these remain a challenge even for EASA itself.

EASA has gone some way towards developing a separate licensing system for GA, including a B3 licence that applied to aircraft between 2,000 kg and 5,700 kg MTOW. This was approved by EASA, and legislated by the European parliament. It is not clear how widely the B3 has been taken up within Europe, but the issue is obviously still a vexing one for EASA, which has announced in its "GA Road Map" and a new Notice of Proposed Amendment (NPA) about the possibility of adapting the B2 licence for small less complex planes.<sup>70</sup> GA was the central theme of EASA's 2014 Annual Safety Conference.<sup>71</sup> Australia should keep a close eye on these developments, and should make sure its licensing structures and the underlying training do not stray too far from any template emerging in Europe – if only to ensure that its training products become more widely marketable internationally, and its engineers globally employable.

It is disappointing that CASA appears to be moving in the opposite direction. In 2006 CASA issued a Notice of Proposed Rule Making (NPRM 0604MS), which introduced maintenance regulations based (in some aspects, loosely) on the EASA system, and foreshadowed further work on "a small aircraft licence structure to mesh with and supplement the A/ B1/B2/C licence structures".<sup>72</sup> Options examined included retaining the CAR31 structure for small aircraft, applying the B1/2 structure to small aircraft, adopting the EASA B3 licence, and permitting GA licence endorsements to be granted by approved AMOs.<sup>73</sup> From May 2007 to March 2008 a B3 licence proposal was generated and circulated among key stakeholders for comment, but the

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<sup>69</sup> Nevertheless, as Table 3.3 indicates, over half of Australia's 8,192 CASA-registered helicopters in 1992 were under 5,700 kg MTOW and built after 2000: while mostly small, simple and piston-engined, many have new design features such as hydraulic flight controls, composite construction, or advanced avionics, a(Airliners.net.au, 2015). There are also 564 turboprops and jets up to 5,700 kg MTOW on the CASA register, 201 of them built after 2000. In addition, there were 1,289 small planes less than 10 years in age, and presumably employing new technology.

<sup>70</sup> European Aviation Safety Agency (EASA), 2015.

<sup>71</sup> European Aviation Safety Agency (EASA), 2012; 2014b.

<sup>72</sup> Civil Aviation Safety Authority (CASA), 2009.

<sup>73</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2009, 2013.



initiative was terminated as the process apparently became too complex and difficult. Interestingly, the proposed structure of a B3 (Mechanical) and B4 (Avionics) licence bore little resemblance to the EASA B3 and B4 categories.

CASA restarted the process in December 2012,<sup>74</sup> with a new discussion paper apparently in response to a new ICAO policy encouraging competency-based training and modularised licences.<sup>75</sup> The Discussion Paper rejected the terminology and structure of B3 and B4 but retained the B1/2 licence with specified groups which seemed to ingeniously combine the CAR 31 and CASR Part 66 licence structures. But it added the possibility of a small plane licence which would require the candidate to acquire a licence, with full CRS endorsements, across all three B1 categories, in two years. In a more recent NPRM (1310SS, September 2014)<sup>76</sup> it advocates a small plane licence which would be available to graduates of the Certificate IV in Aeroskills (Mechatronics) after two years of study and experience. The proposal also provides for the equivalent of a Category A licence for Small Planes – that is, to perform and certify for limited tasks known as “elementary maintenance”. The structure would replicate the RPT B categories, but with a Small Plane endorsement – for example, B1.1 SAL. It would also contain the modules of the CAR 31 Group structure.<sup>77</sup>

The ALAEA in its response,<sup>78</sup> argued that the “small aircraft licence” should be included on an existing B licence as an endorsement or rating, not a separate licence. The base qualification for a licence should allow the possibility of acquiring the necessary theoretical knowledge in “chunks”, which would articulate towards the Diploma,<sup>79</sup> (not Cert IV) and with additional category training to ensure that all three categories (airframe, engine, electrical) are adequately covered. Subject to these and other qualifications, ALAEA has broadly endorsed the new CASA NPRM. By contrast, AMROBA has canvassed, alternately, a version of the FAA A&P mechanic and Inspection Authorisation, or failing that a complete reversion to the CAR31 licences and group ratings, or even drawing on the NZ system. AMROBA has in addition produced several discussion papers, including specifications for a future aircraft maintenance training system, which will be partially evaluated in the next chapter.<sup>80</sup> Sensibly, it proposes that the increased training load imposed on the system should be met by rejecting CASA’s prohibitions on self-study and its commensurate requirement that people seeking a diploma must undertake category training through a Part 147 organisation. This would move Australia back into line with EASA itself in this respect, raising the question of why the option of self-study was ever deleted?

## **8.7 Discussion and conclusions**

The introduction of the EASA-based licensing scheme disrupted the system of work organisation and skill development around which the industry and the training sector had consolidated. The

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<sup>74</sup> Civil Aviation Safety Authority (CASA), 2012a.

<sup>75</sup> Subject to significant differences between what international agencies mean by CBT, and what is meant in Australia (see Chapter 9).

<sup>76</sup> Civil Aviation Safety Authority (CASA), 2014d.

<sup>77</sup> Civil Aviation Safety Authority (CASA), 2014d, p. 15.

<sup>78</sup> Australian Licensed Aircraft Engineers Association (ALAEA), 2014c.

<sup>79</sup> It has emerged that, according to some trainees who are caught by the change in arrangements, that the new MEA15 training package does not contain diploma level piston engine (B1.1 and B1.4) competencies, so it is clearly being anticipated that the Diploma level qualification covering both GA and RPT will not proceed. We define this controversy as beyond the bounds of this project, noting simply that the controversy proceeds.

<sup>80</sup> Aviation Maintenance Repair and Overhaul Business Association (AMROBA), 2014a, 2014b, 2014c.

reasons for doing so appear in hindsight to be fundamentally sound, in that Australia was always going to have to align itself with one or other of the major regulatory blocs, although the reasons for preferring EASA over FAR remain controversial, and the handling of the process left much to be desired.

As the chapter has argued, the processes have opened the way to slippage of certification work from licensed to unlicensed personnel, something which has its roots in the industrial politics of Europe at a time when EASA itself did not yet exist, and also in the industrial relations of Australia's airline industry. The emerging consequences have implications for Australia's compliance with ICAO Annex One, (as the recent Walker Opinion found), and has implications for the organisation of aircraft maintenance work and safety. It is important that any questions about the proper mechanism for ensuring the quality of aircraft maintenance be resolved by full and open public discussion, not by regulatory slack and confusion. This is why the ASRR's proposal for plain language re-writing of safety regulations, in a "third tier",<sup>81</sup> is so important, and why this project makes a similar recommendation with respect to the CASA RRP components we have examined – Parts 42, 66, 145 and 147.

It is in this respect that the implementation of the EASA-based system in Australia has so far proved less than satisfactory. Part of the problem undoubtedly lies in the sheer difficulty of adapting the skills identified in the CAR 31 licence categories to fit the different structure of the EASA B licences and the new underlying qualifications. Even acknowledging this constraint, however, it is hard to defend the absence of practical support for the transition between systems. We have not been able to quantify precisely how many workers licensed under the old system found themselves prevented from exercising their full potential productivity (or in some cases, from working at all) in the immediate post-transition period, but the fact that any found themselves in this position is an indictment of the process, as is the way so many appear to have been thrown back on their own resources and on the mercies of the training market to make up for the gaps between their existing skill base and the requirements of either new licence category. And though it appears that many of the teething problems with the system itself have now been resolved, the serious problem of the transferability of Australian licences and qualifications to other international jurisdictions remains.

Notwithstanding the claimed virtues of the previous CAR 31 system (which, incidentally, not all policymakers agree) there is considerable merit in pursuing harmonisation. Greater systems integration in new aircraft increases the premium attached to a greater scope and level of theoretical knowledge. Moreover, once again apart from certain difficulties in implementation, the merging of 5 trade streams into 3 (and ultimately 2) makes sense – and indeed was foreshadowed by developments in qualifications that predate the EASA reforms. The intersection of the Part 147 reforms with the aircraft maintenance training system are the subject of the next chapter, but we note that the manner in which responsibility for assuring that necessary theoretical knowledge was appropriately built into the qualifications that underpin licences was cavalier, to say the least, in view of the known quality problems in the Australian VET system and the evident inability of the current regulatory scheme to control them.

Another problem which has not been resolved by the EASA system even in the continent of origin, is the issue of small plane licensing. Ferment around this issue continues. We have defined it as beyond the bounds of the present project to attempt to suggest a comprehensive solution. We have, however, made several general points. First, that a new licence structure

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<sup>81</sup> Australian Government, 2014, pp. 2, 104.

should allow a person to move from one sector to another – it should support orderly career progression as far as possible, with flexible qualifications underpinning any new licence structure. Second, any new licence structure and associated qualifications should as far as possible harmonise with EASA. It is no longer possible or desirable for Australia to have its own system, separate from the rest of the world if, as we will argue in Chapter 10, a looming skills shortfall provides opportunities for Australia to market training products. Third, the new GA licence must be capable of considerable flexibility at the margins, allowing for the creative use of both “group” and targeted type ratings below the sub-5,700 kg MTOW dividing line.

For now, therefore, and probably for at least the next ten years, the licensing system must be able to accommodate conflicting requirements. On the one hand, it must be future-compatible to the extent that it allows new entrants to the workforce a feasible and affordable path to reputable and functionally adequate licences – based in turn on high quality qualifications – which will enable them to step into the places of the current generation. On the other, it must be capable of ensuring that the huge base of expertise embodied in the existing LAME workforce remains available to MROs and aircraft operators, and that this workforce has accessible, affordable paths to developing its knowledge in line with developing technology and changing practices, together with an occupational structure that provides adequate recognition and incentives to justify the time and effort involved in doing so.

## RECOMMENDATIONS

- **RECOMMENDATION 9:** That Australia reaffirm its commitment to state-based licensing as the most effective mechanism for ensuring independence and quality in aircraft maintenance certification, and remedy any loopholes in the existing regulation which permit its substitution by a company authorisation scheme.
- **RECOMMENDATION 10:** That the interactions between the *Fair Work Act* and the *Civil Aviation Act* be examined with a view to resolving the conflict revealed by the *Sunstate* decision in a way that safeguards the statutory independence of the licence holder.
- **RECOMMENDATION 11:** That the issue of international transferability and mutual recognition of qualifications and licences be explored and resolved at both the national and the intergovernmental level, including urgent action to ensure that Australian licences are genuinely equivalent in their knowledge content to those issued by EASA and other jurisdictions which have adopted the same model, and negotiation of bilateral recognition arrangements (with appropriate safeguards) where these do not currently exist.
- **RECOMMENDATION 12:** That the parts of the CASRs relevant to maintenance licensing be rewritten in plain language as recommended by the Aviation Safety Regulation Review, with a view to resolving ambiguities in key terms which are a potential source of confusion and/or conflict between interest groups.
- **RECOMMENDATION 13:** That the minimum qualification requirement for an A licence be set at the same minimum level as required by best-practice EASA members (i.e. Certificate III), and that this licence become part of an articulated progression of licence categories built around a common training framework and qualification structure.
- **RECOMMENDATION 14:** That the arrangements for a new small aircraft licence be finalised as quickly as possible in order to permit GA operators and MROs to recommence recruiting for LAME vacancies, but in a way that allows a seamless pathway between small aircraft and RPT aircraft, while making provision for licensees to train in and be endorsed for new small aircraft technology as it comes into wider use.

*This should include provisions for smooth transition from Certificate IV to Diploma, group category endorsements which could be added either to a Diploma-based B licence or to a Certificate IV-based SAL, type ratings for selected small planes, and an exercise to rate all small planes (including retrofitted ones) for licensing purposes in terms of their technical characteristics and associated maintenance skill sets.*

# Chapter 9 Training and Licensing Reform: Implications for Workforce Capability Development

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## 9.1 Introduction

Building workforce capability will be crucial if Australia is to meet the challenges posed by the future global shortage of skilled licensed/ aircraft maintenance engineers (L/AMEs), to be outlined in Chapter 10. The numbers of annual training graduates, and the quality of training, both need to be addressed if Australia is to meet its own needs and help build aircraft maintenance and maintenance training as significant components of its export industry. If this is to happen, we must move quickly to resolve training issues generated in part by the efforts at European Aviation Safety Agency (EASA) harmonisation identified in Chapter 8.

Domestically, the escalating world shortage of skilled maintenance personnel will leave Australia increasingly reliant on its own internal resources to cover its requirements for maintenance skills. With the loss of existing skill likely to occur as a combined result of workforce ageing, headcount reductions and some experienced workers leaving the industry in search of more rewarding and less stressful work, the capacity of the training system to produce a quality replacement workforce will become increasingly critical as fewer experienced workers remain to guide new graduates. Additionally, in a world of looming skills shortages, aircraft maintenance training has the potential to become a very large and lucrative export industry for Australia, as well as providing employment paths making full use of the skills and knowledge of those L/AMEs who are currently suffering interrupted careers.

This chapter seeks to analyse the impasse into which Australian aircraft maintenance training appears at the moment to have fallen. In particular, we argue, Australian aircraft maintenance training has fallen well below the level of activity required to maintain a skilled labour force even at its present level, and it is increasingly apparent that it may not be fully compliant with international standards. The licensing reforms have increased the knowledge content and raised the level of the qualifications which underpin the main Australian aircraft maintenance licences. But capacity to meet these requirements has been hampered by disconnects between licensing requirements and key components of the current Australian vocational education and training (VET) framework for delivering training and for assessing the skills and knowledge needed to guarantee safe and competent maintenance performance.

Training Package development, within a tightly-prescribed competency-based format, has had to grapple with three issues. These are:

- The need to “patch” the LAME privilege gaps created by the transition from Civil Aviation Regulation (CAR) 31 to Civil Aviation Safety Regulation (CASR) Part 66;
- The delayed finalisation of the general aviation (GA) licensing requirements; and
- The transfer of category licence knowledge training and assessment from the Civil Aviation Safety Agency “CASA Basics” system to VET providers operating within a training market.

Standards and assessment criteria, specified in terms of competencies, are set by industry skills councils, but responsibility for developing curriculum and delivering training and assessment falls to training providers. There is some concern as to who is responsible for safeguarding the depth to which underpinning theoretical concepts are being taught, and as to whether the training market, which may tend to conflate concepts of “cost” and “value”, is conducive to the fostering of either in-depth theoretical knowledge or highly developed hand-skills. Meanwhile, new apprentice intakes have sharply declined, as transition problems have been exacerbated by

the failure of maintenance repair organisation (MRO) employers, State training authorities and the Commonwealth to provide support for the additional up-front training required by the new licensing requirements.

## **9.2 A decline in training capacity**

The primary concern is that the capacity of the training system has fallen well below even the replacement need for new qualified entrants, leaving aside for the moment any questions of their quality (Figure 9.1). Admittedly the number of apprenticeship completions more than doubled between 2007 and 2013. However, this increase reflects a large spike in commencements in 2008 that has since been working its way through the system, with its effect now practically exhausted. Completions peaked in 2013 and were running almost 30% below that peak a year later. If we look at commencements instead, we see a steady fall over the last six years, with the total for 2013 less than half that recorded five years earlier, although numbers recovered slightly over 2014.

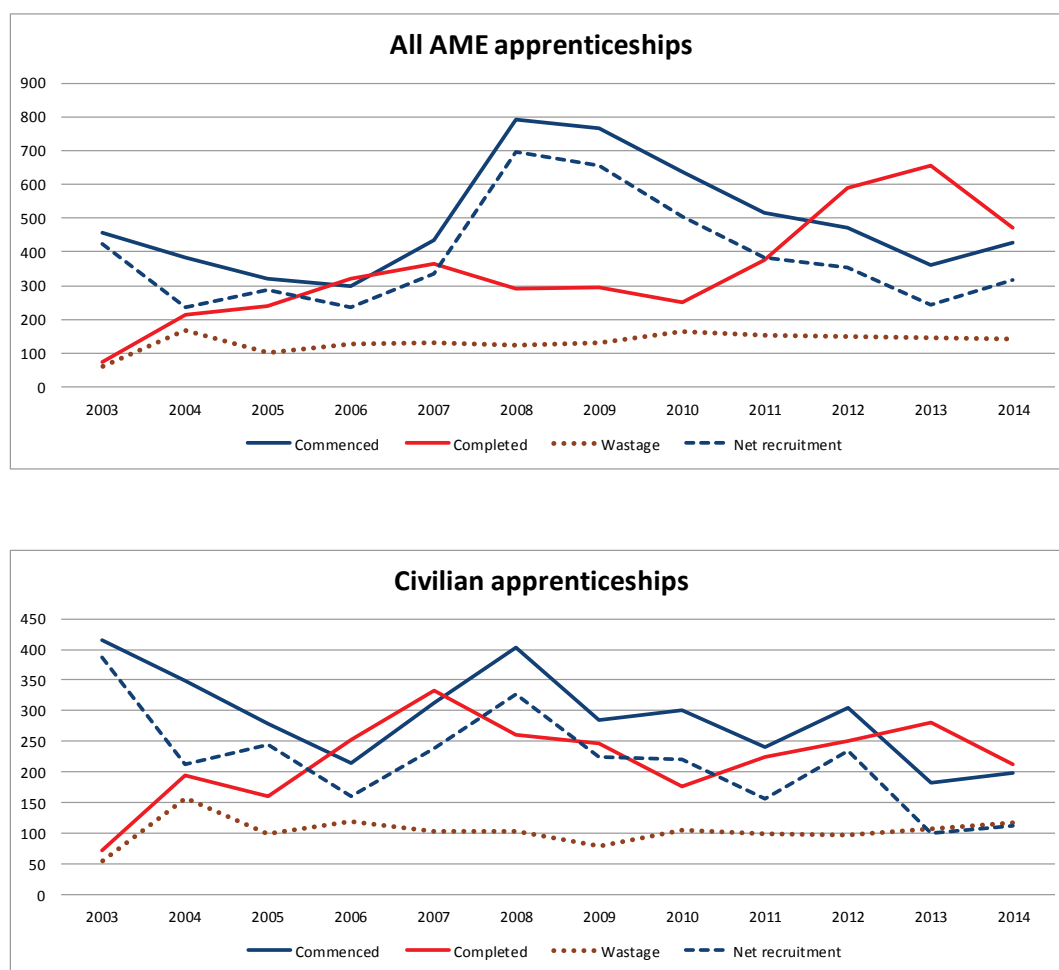
Comparing the two graphs in Figure 9.1, three differences become obvious once the contribution of Defence is excluded. First, the curve for completions peaks far earlier, and though a second, lower peak appears in 2014, the marked surge in aggregate completions after 2010 is due largely to a big increase in Defence activity.<sup>1</sup> Figure 9.2 illustrates this pattern more clearly by tracking the overall numbers in training, in the process showing that the combined civilian and Defence training systems had the capacity as recently as 2012 to handle over 2,000 apprentices a year, most of them studying at the Certificate IV level.

Second, the drop in civilian commencements since 2008 is both less even and less pronounced, but the figures for 2013 and 2014 still stand out as the lowest since statistics have been available at this level of disaggregation. The slight upturn in 2014 cannot yet be taken as evidence of a sustained recovery in activity, and none of the qualitative evidence from industry sources suggests that such a thing is likely in the near future.

The third difference concerns the trend in wastage (the combined impact of apprenticeship cancellations, withdrawals, suspensions and expiry). Once outside the Defence environment, where apprenticeship is generally more tightly managed, more closely linked to a post-completion job, and conducted in a more disciplined culture, wastage emerges as a growing concern. While its rise since 2007 has been relatively gentle and its 2014 level is by no means the highest on record, it has grown steadily instead of falling in line with the numbers in training as might have been expected. In each of the last two years, the number of civilian apprentices lost through wastage was equivalent to nearly 60% of the number who joined the system through commencements in the same year. As a proportion of all civilian apprentices in training at all points of the cycle (Figure 9.3), it had reached nearly 20% in 2014.

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<sup>1</sup> The initially mystifying fluctuations in Defence apprenticeship activity appear to be due to specific circumstances in that sector. In the first place, a high proportion of the maintenance which had traditionally been carried out in-house by uniformed personnel began to be outsourced to civilian contractors from the late 1990s on. This led to a sharp drop in the requirement for recruitment to uniformed maintenance areas, particularly apparent in the early 2000s when apprenticeship intakes declined virtually to nothing. Later in the decade, a large number of senior NCOs in the remaining uniformed workforce retired or left the services, creating a demand for more training to replace them. As this gap in the workforce was filled, apprenticeship commencements declined sharply again to meet the lower long-term intake requirements, currently around 200 a year. (Source: personal communication from MSA)

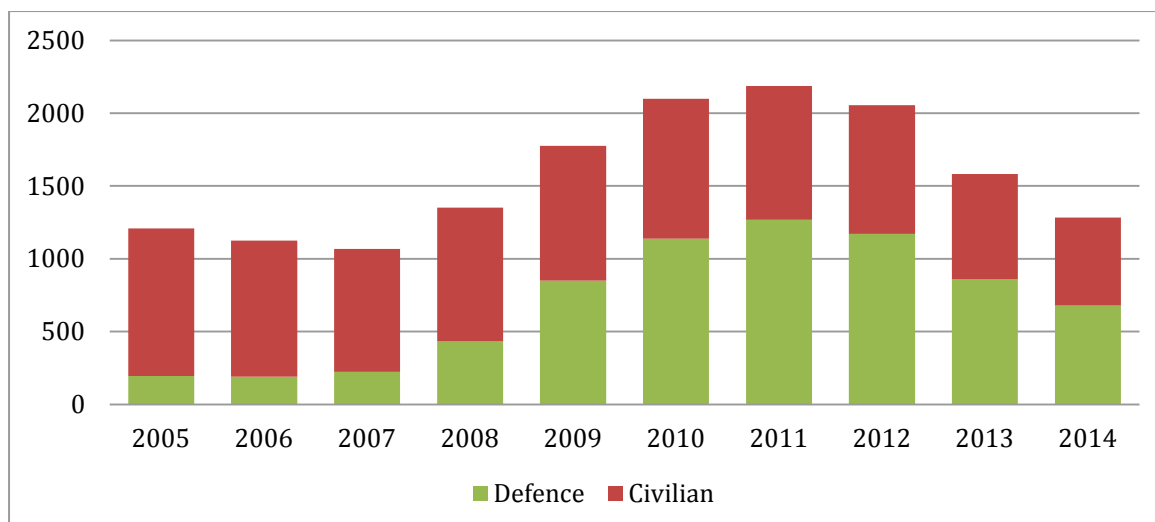


Source: NCVER Apprentices and Trainees 2

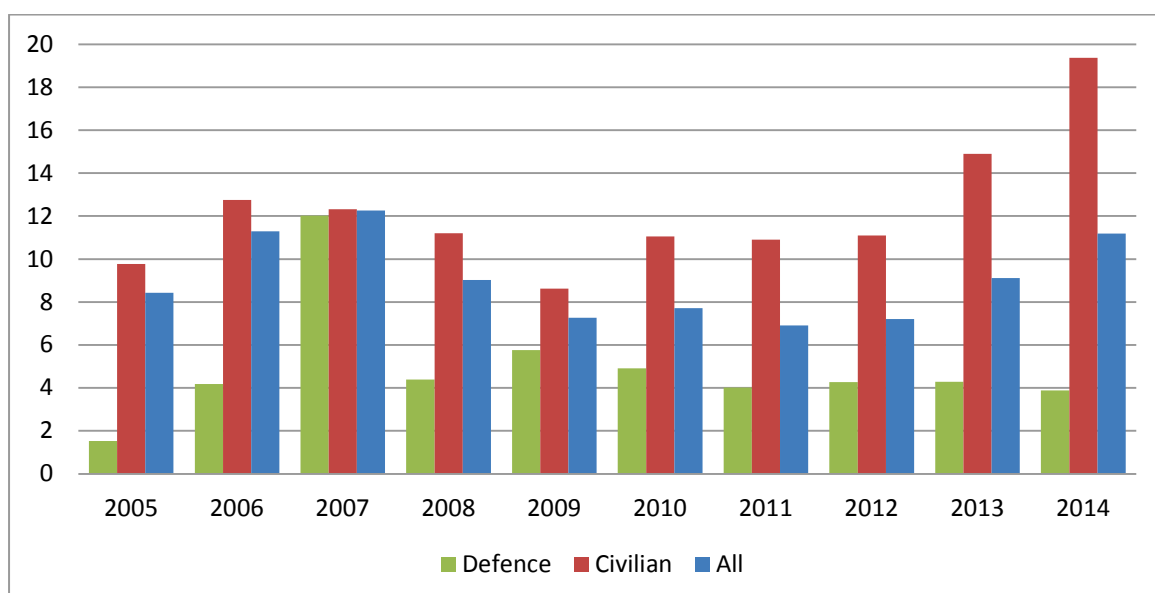
**Figure 9.1 AME apprenticeships by status, 12 years to December 2014**

The reasons for this high relative level of wastage cannot be determined from the statistical sources, as the relevant NCVER (National Centre for Vocational Education Research) figures are issued only irregularly and are not available at this level of disaggregation. It would seem reasonable to speculate that they could result from one or more of declining job prospects, a decline in the quality of candidates, or a decline in the perceived effectiveness of the training itself. The last of these is our concern in the remainder of this chapter, though it cannot be linked directly to the rise in dropouts from the evidence currently available.

<sup>2</sup> Data from this source, though highly regarded and used by most other labour market analysts, show quality problems (specifically, apparent errors in coding) which mean there is a risk that the raw statistics may significantly either understate or overstate the actual number of apprentices in this occupation in any given year. These errors limit the confidence with which we can present findings based on this series, a qualification which should be borne in mind both in this chapter and in Chapter 10.



**Figure 9.2 Apprentices in training by sector, average over full calendar year, 10 years to December 2014**



**Figure 9.3 Loss through cancellations/withdrawals, expiry and suspension as a proportion of number in training, by sector, 10 years to December 2014**

There appears so far to be limited support for reducing the recruitment deficit. The crisis within the formal training system – exemplified by the collapse of activity in leading-edge Technical and Further Education (TAFE) institutions such as Kangan-Batman TAFE which once set national standards in the training of aircraft maintenance personnel – combines with the decline in activity at the industry level to compromise Australia's capacity to bring its output of skilled labour back up to acceptable standards. With many of the most active maintenance workshops now closed, the opportunity to provide workplace experience is becoming scarcer.

At the same time, the continuing reduction in the experienced workforce in the industry is leading towards the decay of a resource of practical knowledge which in better times would have been available to contribute to the practical learning of a new generation of apprentices. An impressive body of such knowledge still remains in the active Australian workforce, but it needs to be brought up to date with the requirements of a future global workforce. Aside from line maintenance, the heavy maintenance on newer, more sophisticated types like the A380



appears to have been scheduled to go offshore before a significant number of Australian aircraft engineers have acquired the relevant knowledge, whereas the models and types on which Australians have gained most of their experience will be well into the aging process by the end of this decade. With reduced numbers of experienced workers to provide mentoring, or opportunities for workplace experience in Australia, on the new generation of commercial aircraft designs, it will be even more difficult for Australia to generate a future-compatible maintenance workforce.

Further evidence about skills shortages has emerged from the survey of MRO business owners described in Chapter 3 and Appendix 1. Of 73 respondents, mainly from the GA sector, 30, or 42%, had had a skilled vacancy in the past year (2012-2013), and of those who had a vacancy, 53% had found it hard to fill. The main reasons cited for difficulty in filling vacancies were lack of applicants with specific skills relevant to the aircraft/component types (19 responses) and not enough applicants with current licenses, certifications or licence privileges required for the job (18 responses).

A further statistic is also of great concern. As was noted in Chapter 8, the base qualification required for a B licence is now a Diploma. However, in the four years to September 2014, only 90 apprentices commenced study for a Diploma (83 of them in the year to September 2012), and of these only 39 had completed the qualification, with another 37 still in training. More alarmingly, there had been no new commencements at this level since June the previous year, and 30 had withdrawn or cancelled in the June quarter 2014 alone. Of all apprentices still in training at September 2014, a full 97.6% were studying at the Certificate IV level.

As indicated in Chapter 3, Table 3.9, by 2015 there were only four CASA-approved maintenance training organisations (MTOs) providing category licence training in Australia. The statistics suggest a viability issue for the institutions to whom CASA has delegated approval for administering licence assessments. There are thus question marks over the sustainability of the system for generating an ongoing supply of LAMEs in Australia.

Thus on present indications (i.e. assuming completion within four years of commencement), barely a dozen of all the AMEs who complete their apprenticeships on or after June 30 this year are likely to have the minimum qualification which will be mandatory by then for a full licence to certify work on large commercial aircraft, and the situation is unlikely to improve for at least another three years unless a substantial investment is made over that period in bridging courses to cover the gap. Since a Diploma is the mandatory requirement under the EASA scheme as well, they will also find great difficulty having their qualifications accepted for employment in any other country which follows the EASA system.

### **9.3 Training reform in Australia — implications for aircraft maintenance**

On top of this very significant decline in throughput have come increasing concerns about the quality of those graduates who still emerge from the system. The following sentiments, drawn variously from structured interviews with employers and maintenance managers and unprompted comments in the free-response section of our 2012 survey of AMEs and LAMEs (described in Chapter 2),<sup>3</sup> are typical:

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<sup>3</sup> See section 2.5.2. The survey had 708 respondents, of whom 57.2% were LAMEs and 12.5% were aviation managers, operational managers or professionals.

*We are now licensing people by having them put through a private enterprise training organisation which has a vested interest in the result. A result financially, not a result technically.<sup>4</sup>*

*The skills level seen lately has dropped, and if the rate and type of maintenance memos is anything to go by, we are making basic mistakes, things that were taught at apprentice levels.<sup>5</sup>*

*We have an AME who started his Basic exams. He failed the most basic Basic three times. He sent his TAFE qualifications to an approved training organisation for RPL and it came back with only a few modules to pass to become a B2. The module he had failed three times wasn't one of them.<sup>6</sup>*

*The apprentices are more concerned about filling in their journals than actually learning anything on the job. Overall, their hand skills, knowledge and ability to work under supervision is the equivalent generally of a first-year apprentice under the previous system.<sup>7</sup>*

*I'm seriously concerned at degradation of the training ... if you give them money you get a certificate. I think it's very much the same with this maintenance training, you know, [name redacted] ... does this training and it's such a hoax. A lot of companies won't employ people out of there.<sup>8</sup>*

*The other major problem I can see, costs of skilling, enormous, absolutely enormous. These lads, our apprentices will do so much, but... they've got to do all the skilling up to a complex aircraft from what I can basically see, which they're not getting... covered by their local state government or TAFE.<sup>9</sup>*

*It is my opinion that the quality of graduates from schools such as [name redacted] are on the decline, and under the new licensing system it worries me that these new guys will be certifying for aircraft systems that they do not understand. Studying for the CASA Basics was a tough process. Studying at [name redacted] is an almost guaranteed pass and their bar is set too low and the quality of applicants for apprenticeships these days is lacking.<sup>10</sup>*

*I feel the training received by today's apprentices is lacking. They are taught a lower basic skills and are generally taught to pass exams. They lack practical experience too. Employers focus on people's licences, not experience.<sup>11</sup>*

*That base skill shortage... the GA people saying that what they're getting out of the TAFE sector they're not happy with. That's pretty much across the board*

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<sup>4</sup> Australian Licensed Aeronautical Engineers Association (ALAEA) Focus Group, 2009.

<sup>5</sup> Survey Respondent, 10489.

<sup>6</sup> Survey Respondent, 10025.

<sup>7</sup> Survey Respondent, 10680.

<sup>8</sup> Interview, CASA Inspector, 2013.

<sup>9</sup> Focus Group, GA Employers, 2011.

<sup>10</sup> Survey Respondent, 10401.

<sup>11</sup> Survey Respondent, 10117.

*but I think it's a - it's now a generational thing where we no longer have that basic hand skills training in the high schools.<sup>12</sup>*

Most of these issues are not simply the result of specific training processes applied in the aircraft maintenance occupations, but can be traced back to increasingly visible structural deficiencies in the model of VET provision which Australia has followed since the early 1990s. We argue below that the CASA RRP (Regulatory Reform Program) has exposed Australian aircraft maintenance training to these systemic failures.

### 9.3.1 General background

The VET reforms that began in the 1980s were a response to the emerging need for a genuinely national qualifications structure to support national markets for skilled labour. Australia's federal system of government has historically allocated most power over training and education to the States and Territories. Each state has had its own Technical and Further Education (TAFE) system, and its own State Training Authorities, which traditionally issued their own credentials. Their sometimes very different approaches to training policy have posed problems for the development of nationally portable qualifications. As will be discussed further in the next section of this chapter, this was complicated by the need for the same training system to cater for the needs of Defence maintenance personnel.

Up to the 1980s, most Australian training was built around the trades apprenticeship model, in which young, usually male, apprentices served their time, received workplace training, and attended technical colleges. Unions and the industrial relations system restricted trade entry and helped regulate the quality and content of training and assessment. Awards preserved industrial demarcations often along skill-based lines, defining the skill content of work and reserving it for holders of certain qualifications.

1994 saw the introduction of a Training Market, in which State TAFE systems competed for federal funding with private registered training organisations (RTOs), that were authorised to provide both training and assessment as well as to award qualifications. The States agreed to mutual recognition of qualifications, while the Federal government jointly set up the Australian National Training Authority (ANTA), which administered a new phase of national regulation from 1994 until its abolition under a Coalition government in 2004.

Under current legislation, only RTOs can issue nationally recognised qualifications, but they do so under conditions where, to a large degree, they effectively exercise quality control over their own output. This makes the system highly reliant on the integrity and expertise of the individual participants. As early as 2000, the market-based system experienced reports of rorting by some private RTOs, including the issuance of false qualifications, highlighted in a Senate inquiry.<sup>13</sup> The Federal government in 2001 responded by creating an Australian Quality Training Framework (AQTF) and by introducing new quality assurance standards for RTOs. Initially the standards were administered and enforced by State Training Authorities with varying approaches, until reforms of 2009 created a national regulator, the Australian Skills Quality Authority (ASQA).

Assessment has been identified as one of the key issues on which the quality of the system as a whole depends. In 2008, the Organisation for Economic Co-operation and Development (OECD) Review of Australian training commented on "the lack of standardised national assessments [which] means that there is no standard to ensure that a particular set of skills has in fact been

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<sup>12</sup> Interview, Training Manager, 2011

<sup>13</sup> Australia, Senate Employment, Workplace Relations, Small Business and Education Reference Committee (SEWRSBERC), 2000.

acquired”.<sup>14</sup> It is important to consider whether this comment applies to training in aircraft maintenance — an area where tight regulation is important on safety grounds.

To gain and to maintain registration, RTOs need to meet certain standards issued by the appropriate Minister. These are expressed primarily in terms of the qualifications required of individual trainers and assessors. The first iteration of the AQTF in 2001 required that trainers and assessors, in addition to being competent in the area of work they are assessing, be qualified to Certificate IV level, modified in 2011 to “necessary training and assessment competencies as determined by the National Quality Council or its successors” (p. 16, Standard 15.4). Anecdotal evidence suggests that learning time in training and assessor courses can be quite varied, and may have diminished overall over time. In addition, a loosely worded clause allowing qualified assessors, if they lacked the competencies they were assessing, to “work with” people who had those competencies during the assessment process, led to assessors assessing outside their area of competence. Assessment practice itself probably varies greatly, although we know of no large-scale research on assessment practice in Australia.

We therefore examine evidence as to whether these general concerns apply to the training and assessment practices required in aircraft maintenance, in particular to the development and assessment of the higher level skills necessary for diagnostic and rectification work on complex aircraft systems.

### **9.3.2 Aircraft maintenance training and assessment**

In addition to the VET quality assurance framework just outlined, the training of aircraft maintenance engineers, being safety-critical, is also regulated by CASA under CASR Part 147. There are controls, governing specialised type training, and also governing the more comprehensive category training that underpins it.

At present, it is of some concern that the CASA website lists only four organisations as having transitioned to approval for category training — Aviation Australia and Aerospace Training Services (both category and type), Kangan Batman, and Padstow TAFE (South West Sydney Institute (SWSI)). Information suggests that this information may not be current in the case of Kangan Batman, and that Padstow, who has been working closely with Tamworth TAFE, has suffered from the Sydney decline in Qantas apprentices. We understand that Parafield TAFE has Part 147 approval, although at the time of writing it was not listed on the CASA website as a Part 147 an approved category training provider. These small numbers are in themselves of concern for the future supply of Australian AMEs and LAMEs. A further 12 Australian and 20 overseas organisations (a mix of training providers, airlines and original equipment manufacturers (OEMs) have type training Part 147 approval. On the other hand, there are 36 Part 147 organisations providing type training, and, as Chapter 3 outlined, 11 of these are international OEMs.

The CASA Manual of Standards (MOS)<sup>15</sup> governing maintenance training stipulates that any organisation seeking Part 147 approval to carry out category training must also be a registered training organisation (RTO), although an MTO that seeks approval only to conduct type training does not need to be a RTO.

Thus the Part 147 approved MTOs providing category training are subject to regulation by CASA as well as ASQA — the VET regulator. In category training, the requirements for assessment are more closely aligned with the VET regulations. Ideally, a person performing assessments should have the relevant assessment competencies specified in the Australian Qualifications

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<sup>14</sup> Hoeckel et al., 2008, cited in Guthrie, 2009, p.13.

<sup>15</sup> Civil Aviation Safety Authority (CASA), 2011d; 2015g.

Framework, as well as the competencies being assessed. That is, they should be competent in what they are assessing, as well as in assessment itself. However, the CASA regulations allow that an MTO may appoint two persons to perform assessment, as long as one has the assessor competencies, and the other has the competencies being assessed.<sup>16</sup> It is worth noting that allowing this separation has been seen as a weak point in the AQTF assessment regime.

Things are significantly different for type training, where the organisations providing it, although regulated under Part 147, are not subject to the same VET regulations standards under the AQF. There, an assessor is subject only to the rules of the MTO's exposition, but must have the vocational knowledge and skills, again as set out in the MTO's exposition, that are being assessed.<sup>17</sup> In other words, there can be no separation between assessment competencies and competencies being assessed – the system appears stronger in this respect.

Other requirements for category training include: provision of workshop access and quiet under-cover facilities for theory training in classes of no more than 28, as well as the setting out of staff/student ratios in the exposition. The MTO must provide secure office space for storing records and assessments and a library containing relevant, accessible and up to date reference material, including examples of maintenance documentation and technical information. An accountable and responsible manager must have the designated role of overseeing resources and compliance and must appoint a sufficient number of suitably qualified teaching staff to carry out maintenance training and assessment in accordance with the MTO's exposition, although it may use another organisation to provide practical training and assessments if it has procedures in its exposition detailing how this will occur. Teaching staff must undertake a professional development course at least once every 2 years, covering current technology, practical skills, human factors and training techniques.

In addition, for type training, records about instructors and assessors must be kept. The MTO must include in its exposition a control procedure for the production, updating and distribution of all maintenance training materials and provide to CASA on request: course plans with specified content, assessment and recognition of prior learning (RPL) methods, as well as being able to produce student records for five years. The MTO must establish in its exposition a quality management system, including provision for an annual audit and remediation plan. An assessment pass mark of 75% is required for each unit of competency in category training, or for each element of aircraft type training. Results must be reported to CASA within 4 weeks, and may include information on English language proficiency and understanding of airworthiness management role. An MTO may assess a foreign licence or a Defence Force aircraft authorisation for RPL, but must provide CASA with a statement of how the requirements match.<sup>18</sup>

The questions to be determined are whether these requirements, particularly the audit provisions, are sufficient safeguards of training and assessment quality, for both AMEs and LAMEs, and why the rate of transition to Part 147 category training has apparently been so apparently been so slow.

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<sup>16</sup> Civil Aviation Safety Authority (CASA), 2011d; 2015g, 147 A.106 (a) (b).

<sup>17</sup> *ibid.*, 147 A.106 (c).

<sup>18</sup> Civil Aviation Safety Authority (CASA), 2015c.

## 9.4 Competency-based training (CBT) in aircraft maintenance

Competency-based training (CBT) was found to have strong advocates and detractors at all levels of the aircraft maintenance training policy network. To some extent, controversy derived from people talking past each other, as the term has acquired a multitude of nuanced, conflated and even confused meanings since its implementation in the training systems of the UK and of Australia. CBT has attracted a voluminous academic literature, much of it critiquing an earlier “behaviourist” version, as it was known in Britain and Australia, that many trainers and training administrators have actually abandoned, although these theoretical models often survive in outdated regulatory, policy and other literature.

This “version” of CBT tends to prioritise demonstrated performance over theoretical knowledge. Its critics have argued that the more the capabilities that CBT is called upon to develop and assess, approximate those of professional work, the less appropriate the competency model is.<sup>19</sup> As Wheelahan and Moody have recently argued, skilled workers may need to be able to exercise complex judgements, including performing diagnostic and analytical roles, and not merely perform workplace tasks and roles that have been defined for them or are based on existing or past practices.<sup>20</sup> Echoing earlier calls to abandon the CBT approach<sup>21</sup> they argue for a new concept of “capability” to replace “competence”. This may be something to consider for the future. But for now a version of CBT is being applied in the MEA Training Package and its qualifications, for assessing not only theoretical knowledge but also diagnostic and rectification work performed at Diploma level by a LAME. This recognises that there are multiple versions of CBT – or, which is much the same point, the term “CBT” is applied to radically different approaches to training, including some currently being deployed in the international sphere. We will return to these below.

Some VET professionals in the aircraft maintenance field argue that we are now in a “mature, competence-based system”<sup>22</sup> that allows precisely this holistic assessment, while others disagree. Critics see CBT as behaviourist, and argue that it fragments the assessment of overall capability into a large number of independently administered assessments of individual competencies. Yet the ability to do a complex job depends as much on the ability to select and coordinate individual competences from a repertory, and apply them together in a work environment, as it does on the worker’s skill at each element of the job. In recognition of this problem, Manufacturing Skills Australia (MSA) has developed units of competence to address coordination and diagnostics requirements of aircraft maintenance,<sup>23</sup> although the extent to which they guide the training and assessment practices in RTOs/MTOs must remain moot.<sup>24</sup>

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<sup>19</sup> Ashworth and Saxton, 1990; Jackson, 1993; Wolf, 1995.

<sup>20</sup> Wheelahan and Moody, 2013:2.

<sup>21</sup> The High Level Review of Training Packages (Australian National Training Authority (ANTA), 2004) also questioned how well CBT could register “hard to codify” skills. Despite strong arguments for a shift “beyond” CBT, the authors noted that such a change had few supporters in the Australian training community.

<sup>22</sup> Interview, Part 147 Training Provider, 2013.

<sup>23</sup> For example, MSA argues that “In the diplomas leading to licence there are two units of competency (MEA235 and 323) that aim to develop competency in fault diagnosis where progression from first principles is necessary. This is beyond the CASA basics or the EASA syllabus requirements.” The following example was provided: “[O]ne of the examples against unit MEA323 required knowledge of the aircraft refuel and fuel dump systems, the use of system simulator training boards to formulate a theory, aerodynamic knowledge relating to wing tip vortices, followed by construction of a small rig that would prove the theory and lead to the conclusion that the fault was a design problem and to the development

Where “demonstration of competence to the standard expected in employment”<sup>25</sup> is the touchstone of “competency”, it can be argued that how a person learned or acquired competence, or how long it took them to do so, is unimportant. Some people are quick learners, after all, and some teachers (and training providers) are more efficient than others. Risks arise out of the principle that qualifications should not be granted on the basis of time served, i.e. a specified number of training hours or years in apprenticeship.

However, under a funding model which provides strong incentives for the provider to put each intake of trainees through the course as fast as possible, certify them, collect their subsidy and move on to the next intake, there is a risk that the flexibilities inherent in this approach will be exploited to push trainees out into the labour market before they are fully ready to practise the occupation in a workplace. Some constraints remain when the training is government-supported, since State funding rules still specify the number of training hours which may be funded towards the achievement of a given qualification – a point examined in more detail below. An alternative concept of CBT has emerged in an international movement to transform aviation training in general, including aircraft maintenance training. This movement, discussed further below combines the concept of CBT with the “instructional systems design” approach to training, which is more prescriptive about the choice of training methods, in an attempt to increase training efficiencies.

## **9.5 The changing face of aircraft maintenance training**

Australia’s training system needs to accommodate the requirements of AMEs of the Defence forces alongside those in the civilian sector. The former operate under a somewhat different regulatory system outside the provisions of the Chicago Convention (which explicitly excludes state aircraft) and which features a hierarchical structure of supervisors and inspectors reflecting military rankings. There is no Defence AME licence. Transfer from Defence to civilian work on any scale has, for many years, been limited by lack of commonality in the aircraft AMEs worked on, and the necessarily dissimilar experience gained. Yet there has been considerable outsourcing of aircraft maintenance from Defence to civilian contractors, and as the Defence forces shift from purpose-designed military transports, search and rescue aircraft, etc, to new types based on what are essentially current-generation civilian platforms, transfer between them will tend to become easier provided a common knowledge base, qualification structure, opportunities to gain experience, and transition arrangements reflecting civilian qualification requirements based in licensing requirements can be developed. The recent changes in the civilian licence structure, and, in particular, the requirement for a Diploma qualification to underpin a B licence constitutes a challenge.

Defence installations and civilian AMEs working on defence aircraft need to observe the requirements of the Defence Technical Airworthiness Framework, (sometimes, confusingly, alongside a requirement for a plane to be certified for return to service by a civilian LAME),

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of a modification to overcome the problem. There will be many examples that experienced maintainers could identify and their use depends on the training organisation being able to muster the manuals and data sources required for the scenarios.” Correspondence from Manufacturing Skills Australia, November 2015).

<sup>24</sup> In a sense, all behavioural assessment is based on the assumption that the behaviour will be replicated in practice, just as all written assessment is predicated on the assumption that understanding will be applied in practice. The more complex the task requirement, for example diagnostic work, the more risk is involved in these assumptions.

<sup>25</sup> Wolf, 1995; Ashworth and Saxton, 1990; NTB, 1991; Wheelahan and Moody, 2013.

outlined in the Defence document DEF9022.<sup>26</sup> These requirements predate the implementation of the EASA licensing system, and are in any case significantly different from the ICAO Annex One based model in that they do not reserve the role of sign off (for safety critical processes) to a LAME. Rather, and significantly, an AME qualified at Certificate IV level, with appropriate type training and experience, can perform this role provided they have not participated in the work process they are signing off, although releasing the plane to service is usually done by the Maintenance Manager. Our limited evidence suggests that in few cases are Defence AMEs qualified to what is colloquially called “Certificate V” level – that is, with electrical as well as mechanical qualifications – corresponding to the CASR B1 licence structure. This creates transfer difficulties for defence AMEs who have been performing as “independent inspectors”, effectively undertaking the certification work of ICAO Annex One LAMEs, and who are seeking “certification” work (that is under ICAO preserved for LAMEs) in the civilian sector. In turn this works against the interests of both efficiency and resilience, by failing to ensure that the civilian workforce can function as a reserve source of labour for Defence in times of shortage, and vice-versa.

Prior to the 1990s, the aircraft maintenance occupation, in both civilian and Defence sectors, was divided into five trades – airframes, engines, radio, instrument, and electrical – and these were reflected in the civilian licence structures. From 1989 to 1992, a National Aeroskills Project, with involvement of both civilian and Defence sectors, undertook a rationalization of the skill and knowledge deemed necessary for the qualifications, and while the structure (if not the content) of the trades and licences remained virtually the same, a major outcome of this project was the National Aeroskills Curriculum (NAC 95). This was a true curriculum document. It was derived from the aviation sector as a whole, and did not use competency-based training and methodology. NAC 95 rationalised the structure of the five trades into three – mechanical, structures, and avionics. It was adopted by Defence and became an ADF (Australian Defence Force) standard, but was rejected for civilian purposes by the then Australian National Training Authority (ANTA) in 1997 on the grounds that it was not competency-based. NAC 95 provided the knowledge base for the first MEA training package in 1997, although it was subsequently dropped from this role. By this time a national curriculum-based approach was no longer permissible because of the legislative separation between responsibilities for the definition of training outcomes and the design of curricula.

### **9.5.2 Training and licensing under CAR 31**

At the time of the 2011 Census, there were still 1,589 people giving their occupation as AME (11% of those employed in the occupation) whose qualifications were listed as “not applicable”, suggesting that they came to the job without *any* formal post-school qualifications. But the most common path in more recent years was first to gain a basic AME certificate through a four-year apprenticeship, originally to Certificate III (the normal trades level), but since the late 1980s to Certificate IV level, in recognition of the increased knowledge content. Under previous licensing arrangements, an AME licence could be gained via a number of paths, including from a non-aviation background, provided CASA’s theoretical knowledge and experience requirements were met.

The apprenticeship comprised classroom training at a recognised provider (TAFE) and work experience in an employment situation. Workplace experience was recorded in the Schedule of Experience (SOE), a record detailing the on-the-job experience a person had gained doing particular tasks. State government training authorities administered trades-based

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<sup>26</sup> Commonwealth of Australia, 2006.



apprenticeships, and typically funded around 1,300 classroom hours that included supervised practice in the TAFEs, but not workplace experience.

Once the AME qualification had been gained, the aspiring LAME sought experience and theoretical knowledge in the maintenance specialisations for which s/he sought licence privileges. CASA issued the licence after it had accepted the applicant's SOE and the applicant had passed an examination (known as the CASA Basics) which it set and administered to test whether the applicant had the necessary theoretical underpinning knowledge to justify granting the class of licence concerned. Importantly, licence seekers could acquire the necessary theoretical knowledge through self-study. Our interviewees have recounted how the examination process used to be predominantly essay-based, requiring the examinee to explain concepts and even to draw certain aircraft systems from memory to demonstrate a depth of understanding, though later it moved to a multiple-choice format. Older LAMEs report how the licensing ceremony was viewed both by the regulatory authority and by the new LAMEs themselves as a ritual of *enculturation*. To inculcate a professional ethic, it was common practice for the representative of CASA, or its predecessor organisations, to hand over the licence personally and give the new licensee a pep-talk about how the LAME was in the front line of passenger safety and bore a weighty responsibility in the event of an aircraft crash attributed to faulty maintenance – and that in the event of a disagreement with an employer over a safety issue, the regulator could be called in to provide support.

### 9.5.3 The impact of CASR Part 66

The new system, which superseded CAR 31 on 1 July 2015 (except for exclusion removal and small plane maintenance licensing, where the earlier provisions will now remain in force until 2019), is more dependent on structured learning at the entry level than its predecessor. B licences, when combined with appropriate type training and experience, confer privileges over multiple types of aircraft and systems, and hence are far more comprehensive in their scope than the individual licence categories issued under CAR 31. The underlying theoretical knowledge is correspondingly deep, broad and comprehensive, justifying a Diploma qualification, and is to be acquired at or near the beginning of a LAME's career. This closes off the option of building up a suite of licence categories and ratings progressively over a full career as experience is accumulated in the work process to complement the additional instalments of theory. It front-loads theoretical knowledge acquisition, but further increases its cost by commodifying it.

The EASA Part 66 regulations specify around 2,400 training hours to qualify for a B licence, together with a period of experience ranging from five years for those who start from scratch to two for those starting from an already completed apprenticeship (although recall that Australia's corresponding CASR Part 66 does not specify numbers of training hours). There is therefore a large training gap between the Certificate IV (previously the platform from which a license was sought) and the new Diploma. The original RIS (Regulatory Impact Statement) for the new Part 66 framework put this training gap at 550 hours on average (p. 7), but in reality it is between 1,000 and 1,500 hours (as we establish below, in consultation with the Victorian Purchasing Guide for MEA11),<sup>27</sup> depending on the exact qualification and licence sought.

While the CASA RIS indicated that the cost of this training would be borne by government, State training authorities have almost uniformly refused to fund it, and paying for it has been left to the individual or to generous employers, though since 2013 it has been possible to fund the extra training through a student loan known as VET Fee-Help. This has allowed costs to escalate.

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<sup>27</sup> State of Victoria (Department of Education and Early Childhood Development) 2013.

Further, once the transition is complete, it is intended that the option of self-study for the theoretical component will no longer be available for knowledge training, though several other nations operating under the general EASA framework, notably Singapore, still permit it. CASR Part 66 mandates that category training – including knowledge training – be delivered as well as assessed by Part 147 organisations. This requirement is no doubt good for the business models of these organisations, but, when combined with the escalating fee structure itself, presumably explains why such a small proportion of current apprentices are training for a qualification at the appropriate level. The Basics examination option will no longer be available after June 2015, except for exclusion removal and small plane licensing.

For those seeking to gain prior standing of Certificate II qualifications towards the Diploma, or even the Certificate IV, there are problems in that some of the competencies need to be taken at higher levels, with higher pass marks, thus perhaps requiring that they be studied twice – again at the trainee's expense.

#### **9.5.4 Shifting liability and challenges to quality: CASR Parts 145 and 147**

With the new suite of maintenance regulations, CASA delegates two of what were previously its central responsibilities for assuring the quality of training and assessment. In CASA's words under Part 147, the competency-based system "replaces the knowledge tests and experience schedule".<sup>28</sup> Thus the process of assessing an individual's knowledge and experience, in terms of their adequacy as a basis for exercising the responsibilities of *licensed* practice, has been folded into the process of assessment for the base qualification to work on aircraft.

First, except for the two remaining transitional cases, CASA will no longer administer the licence examinations or set the central bank of questions. This will allow a variety of examinations to proliferate, with questions derived from multiple sources. Previously the content of each test was standardised; under the new system RTOs will develop or purchase their own examinations. This means turning over the responsibility for the theoretical knowledge held by licensed engineers to a fragmented training sector with a track record of uneven quality. CASA will issue the licence on the recommendation of an approved Part 147 organisation, but will play no other part in the assessment of competence, theoretical knowledge, or experience. Quality assurance is now based on CASA's audits of Part 147 organisations, although these organisations are also audited under the training regulator, ASQA.

Second, nor will CASA scrutinise a prospective licensee's records of their experience, formerly known as the Schedule of Experience but now known as a Log of Industrial Experience, used for evidence of competency. This task too is ceded to Part 147 organisations. These key responsibilities for safeguarding the welfare of the clients of MROs have been transferred from the safety regulator to a training sector which was never previously expected to be accountable to this extent, is not required to do so under the broader conditions of registration as an RTO, and operates under a pattern of incentives which makes it unattractive if not impossible to give such considerations the priority they previously held. CASA retains some reserve of control over the process through its authority to approve and audit MTOs. However, and critically, its powers in this regard are constrained, in many cases to the point of becoming unenforceable, because of the broader requirements of the VET regulation scheme.

Several training organisations approved as RTOs but lacking MTO status are permitted under the broader training regulatory scheme to deliver and assess aircraft maintenance training to the level of Certificate IV, so long as their training activity does not extend to Diplomas linked to a B licence. However, the mutual recognition requirements of the VET legislation make it *obligatory*

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<sup>28</sup> Civil Aviation Safety Authority (CASA), 2007b, p. 15.

for approved Part 147 MTOs to recognise certificates of attainment issued by another RTO for purposes of credit or advanced standing even if that RTO does not itself have Part 147 approval.<sup>29</sup> This represents a loophole through which inadequate standards of training, and more importantly assessment, can “leak” into the process of qualifying for a licence. While category training is reserved for Part 147 organisations (and, according to the Part 66 MOS, the pass mark for modules must be 75%), “mutual recognition” requires RTOs/MTOs to grant prior standing to certificates of attainment from non Part 147 organisations (which can have a pass mark of 50%). This is a tension or contradiction between CASA and ASQA regulations. The result is incompatible incentives, unclear lines of accountability and confusion about what is required which is likely to be experienced by MTOs and apprentices trying to navigate the system. It is one of a number of quite technical difficulties faced by people in Part 147 organisations that, in the interests of not cluttering the text with detail, are not fully outlined here. It is especially a problem if AMEs with Certificate IV competencies gained in non Part 147 MTOs seek a licence, and even more so when trainees bearing the Certificate II in Line Maintenance seek prior standing.

In the absence of enforceable regulatory power, the responsibility for guaranteeing that maintenance employees are adequately trained is shared with Approved Maintenance Organisations (AMOs). The CASR Part 145 Manual of Standards (MOS) specifies that an AMO must develop a maintenance exposition,<sup>30</sup> a document describing *inter alia* the processes by which the AMO will formally authorise and approve licence and qualification holders to carry out and certify for maintenance.<sup>31</sup> The Part 145 MOS requires that

An AMO must specify standards (including, but not limited to, qualifications and experience) in its exposition for the competence of individuals involved in any maintenance, management or quality audit task and must ensure these individuals meet the standards for a task that they are authorised to perform.<sup>32</sup>

The AMO is now held responsible for its employees’ competence, and hence may be liable under civil law in the event of a maintenance issue caused by faulty training - as discussed in the previous chapter.

## 9.6 Australian aircraft maintenance training and international standards

### 9.6.1 Approach to making international comparisons

There are three principal respects in which Australian aircraft maintenance training appears to be falling short of international standards. First, the funded training hours allocated to particular units of competency are sometimes insufficient for teaching to international standards. Second, it has proved difficult to encapsulate theoretical content in the competency standards of training packages, and the standards therefore provide inadequate guidance to curriculum developers, who are thrown back on their own resources. Third, Australian formal experience requirements, although similar to those prescribed by EASA and the International Civil Aviation Organisation (ICAO), are no longer subject to CASA enforcement because the judgement on adequacy is now left to the discretion of VET providers and employers.

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<sup>29</sup> See Australian Skills Quality Authority (ASQA), nd.

<sup>30</sup> Civil Aviation Safety Authority (CASA), 2011c.

<sup>31</sup> *ibid.*

<sup>32</sup> *ibid.*, 145 A 30 d, p. 4.

The task of comparing Australian training against international benchmarks is a difficult one. Without undertaking this task comprehensively, it is nevertheless possible to assemble evidence demonstrating that Australia is not meeting EASA benchmarks in terms of numbers of funded training hours, as well as in the specification of training content. While EASA regulations are clear about the numbers of training hours required for the qualifications which underpin the licences, the CASR Part 66 MOS (which in other respects is a near mirror image of the EASA Annex III Part 66 regulations) does not specify numbers of training hours for category training. However, the Victorian Purchasing Guide<sup>33</sup> for the MEA11 Aeroskills Training Package, which sets a benchmark for the funding practices of other states, makes up to some extent for this deficiency by specifying how many *funded* hours the government will allocate training providers to deliver particular qualifications and units of competence.

International training standards are contained in ICAO Annex One, and its associated ICAO Training manual.<sup>34</sup> While there is some lack of clarity about the extent to which the ICAO Annex One training standards are intended to be mandatory, there is no doubt these are accepted international benchmarks. The standards emphasise the need for “a high degree of technical knowledge” and “diagnostic prowess”, [1-1]. Training, the manual argues, should equip trainees not just with theoretical and practical skills and technical knowledge, but with judgement, a sense of responsibility [1-5], and a high degree of confidence, competence, initiative, team spirit and self-reliance [1-1]. Leaving aside any other implications, this means that the ICAO standards go much more thoroughly into the “soft” aspects of competence which are notoriously hard to define and test under the definition of CBT followed in Australia. Such characteristics would be enhanced through “social learning” during workplace experience, the evaluation of which, as explained above, has been delegated by CASA to the VET provider who will usually have had no opportunity to observe candidates’ interactions with real colleagues.

ICAO identifies three phases of competence acquisition: *knowledge* (phase 1), *practical skills* and *attitudinal training* (phase 2) and *experience* (phase 3). Despite the sequential specification of these phases, the Training Manual stipulates that they are meant to be completed as far as possible concurrently.

The ICAO and EASA standards complement one another in mapping out the scope of training and experience required internationally for full competence as a licensed or unlicensed AME. The comparison here has involved lengthy and intricate scrutiny of the documents that prescribe the details of training practice in each jurisdiction, generally using different conceptual frameworks to classify the elements. This detail is reproduced in Appendix 2 for the benefit of training specialists who need access to information at this level of specificity. The analysis that follows here summarises the key findings that emerge from the comparison.

First, a gap of some 1,000–1,500 (depending on the particular qualification and licence sought) training hours exists between the Australian Certificate IV (which, it will be recalled, is the level to which almost 98% of current apprentices are studying) and the EASA/CASR Diploma. This gap is not funded in almost all States, leaving the cost to be borne by the individual, even supposing that suitable bridging courses are offered at all. Moreover, in the specific case of theory training, the funding arrangements in Australia fall significantly short of those required to reach international standards.

Second, the theory content of the relative Australian training packages is underspecified by comparison with the overseas requirements. To quote only one example, two apparently

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<sup>33</sup> State of Victoria (Department of Education and Early Childhood Development, 2013).

<sup>34</sup> International Civil Aviation Organisation (ICAO), 2003.

practical competencies in the former MEA011 Training Package, “Remove aircraft electrical hardware” and “Install aircraft electrical hardware”, are deemed to “cover” three full modules in the EASA syllabus involving Mathematics, Physics and 18 other subjects of the EASA module “Electrical Fundamentals”, most of which appear to be wholly or primarily theoretical in content. In the new (2015) training package, the problem is partly ameliorated by the creation of a new competency standard – MEA 148, which specifies the theoretical content in more detail (see appendix 2). We stress that in itself, this does not prevent a conscientious Australian MTO from teaching to the full EASA syllabus, or to the ICAO Training Manual Standards. However, given that the individual MTO is left with considerable discretion to define, not only the content underlying each of the competences, but also what constitutes a satisfactory learning outcome and test for it, the scope for variation and more specifically corner-cutting appears wide, and the opportunities for regulatory oversight and quality assurance somewhat thin on the ground.

Third, while the ICAO Training Manual<sup>35</sup> distinguishes “practical maintenance skills training” (phase 2) from knowledge training (phase 1), the Australian practice regarding “practical maintenance experience” (phase 3) is uncertain. CASA’s position is that the task of mapping the experience attained by trainees is now the responsibility of the VET system, which, we have suggested, is imperfectly mapping it. In particular, it would appear that not all trainees are being encouraged to keep the log of industrial experience, which is intended to replace the former SOE. The overall picture is such as to suggest that Australian trainees are not getting the level or scope of experience that would compare favourably with international standards. Indeed, it is hard to see how they could, when so many of the workplaces that could have provided them with such training have now closed down or are struggling to offer apprenticeships.

### **9.6.2 Is our CBT their CBT?**

We turn here to the second set of reasons why Australian training may be falling behind international benchmarks for aviation training in general, and aircraft maintenance training in particular. The first of these derive from the limitations of the behavioural CBT model, which still plays a part in the Australian approach to the specification of competencies. The second is the legislatively-based institutional division between ISCs (Industry Skills Councils) (which at the time of writing develop training packages and qualifications) and the training market, composed of RTOs – which implements them. Yet to look at the current training initiatives from the International Air Transport Association (IATA) and the ICAO, it would appear that Australia is actually ahead of the field in adopting CBT, and the rest of the world is only now beginning to catch up. The question is whether CBT as understood in Australia actually has the same meaning as CBT in the language of ICAO and IATA, and if not, whether the Australian implementation of the concept needs updating to meet what are increasingly recognised as world standards.

In 2009 IATA proposed to counter the looming global shortage of qualified and licensed personnel through a new IATA Training and Qualification Initiative (ITQI), which proposed reducing training times and implementing CBT.<sup>36</sup> ICAO followed suit with its Next Generation of Aviation Professionals (NGAP) program sharing essentially the same objectives. NGAP in October 2014 conducted a symposium aimed at sharing conceptions of new training requirements and competencies, new training methods and to “highlight the need to coordinate more closely around these issues”, as well as ensuring “more equalized minimum implementation of civil

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<sup>35</sup> International Civil Aviation Organisation (ICAO), 2003

<sup>36</sup> International Air Transport Association (IATA), 2009, 2011.

aviation Standards and capabilities in all of its 191 Member States”.<sup>37</sup> These programs converged on the ICAO TRAINAIR *Plus* program, which

... embraces the principles of the ICAO competency-based approach and fosters the implementation of quality systems in civil aviation training institutions in line with the competency-based approach advocated by the Organization. The application of the updated methodology will considerably reduce the time of production of Standardized Training Packages (STPs), simplify the validation procedures, and decentralize decisions related to the approval of STP material by giving member centres more autonomy.<sup>38</sup>

TRAINAIR offers courses for training instructors and developers, so they can develop Standardised Training Packages (STPs) using competency standards and Instructional Systems Design (ISD) methodology. However, these are not “Training Packages” as the term is understood in Australia – in particular because they contain whole training courses, not just statements of training outcomes and qualifications. The TRAINAIR program also serves as a repository for a number of STPs (a quick website search revealed few related to aircraft maintenance). The TRAINAIR PLUS Training Development Guide (TDG) is intended as a tool to support international cooperation in the exchange of training courses, the TDG promotes a competency-based methodology for the development of high level training courses and programmes to ensure a mutual acceptance by training institutions.<sup>39</sup>

The ICAO NGAP and TRAINAIR both use CBT:

The development of competency-based training and assessment shall be based on a systematic approach whereby competencies and their standards are identified, training is based on the competencies identified, and assessments are developed to determine whether these competencies have been achieved.<sup>40</sup>

CBT according to these programs consists of

*The specification of the competency to be achieved, the evaluation of the students’ entry level, the selection of the appropriate training method and selection of training aids and the assessments of a student’s performance...*<sup>41</sup>  
(emphasis added)

This is different from the Australian concept of CBT in important respects. The Australian/UK concept is neutral about training methods – or the means by which competence is achieved. To repeat, the institutional separation between Skills Councils and the training market reinforces this – the former develop competency standards, encode them in qualifications, and then issue them into the training market, where RTOs develop curricula, making choices about training methods and assessment methodologies. Interestingly and significantly, ICAO’s Asian Regional Aviation Safety Group (RASG) argued in 2011 for a “CBT” approach, which included “the development of a curriculum based on adult learning principles and with a view to achieving an optimal path to the attainment of competencies”, while obliquely criticising Annex 1 as

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<sup>37</sup> International Civil Aviation Organisation (ICAO), 2014b.

<sup>38</sup> International Civil Aviation Organisation (ICAO), 2010e, 2.2.2; 2013d, p. 14.

<sup>39</sup> *ibid.*, 2011a, 2013d.

<sup>40</sup> *ibid.*, 2006, ch. 2.

<sup>41</sup> International Air Transport Association (IATA), 2009; 2011:7.

“essentially an inventory of knowledge, skill and experience requirements, without specific performance criteria”.<sup>42</sup>

The ICAO/IATA concept of CBT is embedded in an approach to training known as Instructional Systems Design (ISD), a staple of many training textbooks, with long roots in United States (US) military training.<sup>43</sup> Raymond Noe’s<sup>44</sup> *Employee Training and Development* combines the ISD approach with American human resource management-style “strategic training”, into a systematic approach to the identification of training needs, the definition of training objectives based on the needs, and the design of training programs around those needs. It links training methods to training objectives based on understandings of what approach to learning best suits different objectives, and these inform training delivery. The final evaluation stage links back to each step in the process. This approach is known in ISD as the ADDIE model – Analysis, Design, Development, Implementation and Evaluation.<sup>45</sup> The Australian system’s institutional separation between RTOs and ISCs cuts across the link between the evaluation stage, and the (re)definition of training needs and objectives.

ISD is informed by a taxonomy of learned outcomes – Verbal Information, Intellectual Skills, Cognitive Strategies, Attitudes and Motor Skills<sup>46</sup> – each of which entails a different approach to learning. In ISD, a particular theory of learning provides guidance for instructional events and in shaping the learning environment, again according to the desired learning objectives. For ISD, clear “events of instruction” map on to stages of learning through which learners move during a training session.<sup>47</sup> It follows that the “Standardised Training Packages” that emerge in the TRAINAIR programs are likely to be quite prescriptive about aspects of training itself, including the choice of training and assessment methods. This is a marked departure from the Australian approach, in which ISCs develop competency standards and qualifications, combining them in training packages, which are then released into the training market, where RTOs/MTOs make uncoordinated choices about training methods under market pressure.

The ISD approach appears to be becoming the global norm in global aviation. It is difficult to reconcile with the Australian institutional separation of qualifications and competency-based outcomes from the training strategies developed to achieve them, in the latter case under acute pressure from funding and resource constraints.

There will inevitably be argument over which of these approaches corresponds to “real” CBT. The ICAO and IATA have clearly been more incremental in their reform approach, drawing on long-established ISD principles, while Australia went early for a more extreme version – actually a British version from the 1980s, arguably owing more to economists than to training specialists.

If these international developments do lead to increased standardisation of aircraft maintenance training materials and practices, Australia will need to change its practices and policies and reshape its position on CBT – and indeed, on other aspects of its VET model – if it is to align with them. Staying the odd man out will not be an option once the market for MRO skills, not to mention the market for MRO services, becomes genuinely global and has shaken out to the point where it becomes appropriately segmented between high-value and low-cost providers. If

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<sup>42</sup> International Civil Aviation Organisation, Regional Aviation Safety Group (ICAO RASG), 2011, pp. 1-2.

<sup>43</sup> Gagne and Medsker, 1996.

<sup>44</sup> Noe, 2013.

<sup>45</sup> Noe, 2013, pp. 11-13.

<sup>46</sup> Gagne and Medsker, 1996.

<sup>47</sup> Noe, 2013, p.167.

Australia is to become a participant in either the international MRO market or the international MRO training market, it will need to ensure both that the qualifications it offers and the licences it issues are genuinely portable, and that its standards are seen to be keeping up with those of other advanced nations to which customers will increasingly be looking for their high-value maintenance requirements.

### **9.6.3 Is Australian training still ICAO-compliant?**

The question that inevitably arises from the above analysis is whether Australian MRO skills training is still compliant with Australia's obligations under the Chicago Convention. Certainly it could be argued that by devolving two of its key responsibilities to organisations which lie outside the safety regulation system, without retaining even reserve powers to ensure that maintenance training meets internationally accepted standards, CASA is at odds with the spirit of the international safety regulation framework. But here once more we return to the conundrum already discussed in the earlier chapters: that the framework set up under the Chicago Convention, while based on the quest for equivalent and transnational standards, is minimally coercive when it comes to regulating the actual behaviour of member states.

It must not be forgotten, either, that ICAO continues to regard Australia as one of its better performers when it comes to the implementation of Standards and Recommended Practices (SARPs), and there are plenty of states doing considerably worse. The point is that Australia does not just need to stay ahead of the worst performers. It needs to be seen to be up with the best if it is to compete at the high end of the global MRO market where its strengths are of greatest value and its comparative disadvantages least significant.

## **9.7 A reform agenda for aircraft maintenance training in Australia**

Research interview and survey responses suggested concern in the industry that licensing and training reforms implemented since 2007 did not work as intended. Employers mentioned inability to recruit appropriately skilled and licensed individuals, and trainees mentioned difficulty of gaining access to, as well as navigating, the new system. One of the most immediate problems has been the reluctance of state training authorities to fund beyond Certificate IV, contributing to the risk that Australia may not be capable of meeting the minimum requirements of the transition to the EASA system.

Leaving aside the significant problem of low numbers in training in 2015, this chapter has identified issues of training package content. One of these is the quite unusual degree to which safety rests on the adequacy of conceptual understanding and on the inculcation of professional standards. There have been questions about the extent to which theoretical underpinning can be specified and assessed adequately within a behaviourally based system of standard-setting and assessment.

Another issue is the question of an effective response to the common complaint that today's graduates lack "hand skills". This shortcoming justifies the insertion into the Training Package of a set of generic manual competencies, something which is either absent or inadequately specified in current packages, despite being explicitly addressed in the ICAO Training Manual. However, even were this to happen, it would still not ensure that trainees had adequate opportunities to practise hand skills in safe environments because Training Packages are not permitted to specify such matters of process. Some employers advocate that the foundation years of AME training, leading to a Certificate II, should be located in schools or VET colleges, but it is not certain that these are appropriately resourced for this to occur. Thus the solution to both these questions currently lies beyond the remit of the ISC, and remains not addressed.

An issue that is of greater importance in the MRO industry than in most others is the requirement to prepare the workforce for a global labour market. Thus harmonisation with EASA



standards and qualifications is of critical and more challenging importance than the more usual challenge for Commonwealth and State skills bodies of securing mutual recognition at a national level.

Two key structural features of the Australian VET model as it is currently in force are creating barriers to achieving globally-aligned standards and their recognition. The first is the institutional divide between the specification of training outcomes on the one hand, and on the other the design and delivery of training and assessment. The second is the devolution of assessment to the same parties who have undertaken the training in the first place, without adequate external quality checks. The 2014 Allen Consulting review of Australian VET quality acknowledged the first of these by voicing

a concern, that while ISCs are the bodies responsible for competency standard development they currently have minimal ability to ensure that registered training organisations (RTOs) consistently interpret, deliver and assess the requirements of the standards for all units and qualifications.<sup>48</sup>

One of the two discussion papers<sup>49</sup> produced to stimulate discussion of reform alternatives painted the process of training package review and development as remote, complex, time-consuming, bound in red tape, and not responsive to employer feedback. Yet the process of “streamlining” is false economy, if the result is flawed by lack of input into the specification process for each qualification by relevant industry voices, resulting in gaps which may affect the performance of qualification-holders in a real workplace environment. Ironically, recent issues of representativeness can be traced back to changes over the last thirty years, progressively excluding unions from the qualifications-setting process, thereby reducing the weight given in consultation to one of the most informed voices — that of the people who actually work in the occupation and understand the skills required to practise it in real workplaces. In the case of aircraft maintenance, the voice of industry is needed alongside that of CASA, because competency standards and qualifications must not only make reference to international standards, but reflect them in practice.

These shortcomings cannot be remedied by outsourcing the standard-setting process to a commercial organisation which would have little incentive or obligation to seek fully representative input to its deliberations. In July 2015, the Commonwealth and State ministers agreed on six objectives for a reformed national VET system. These were: clear governance roles for industry, the Commonwealth and the States and Territories; streamlined industry-defined qualifications responsive to major national and state priorities and emerging areas of skills need; a system of regulation and quality assurance based on risk management and consumer choice; appropriate valuation of apprenticeships as a career pathway; and the targeting of government funding to areas of jurisdictional inconsistency and “disruption to the fee-for-service market” failure.<sup>50</sup>

## **9.8 Conclusion**

Arguably, disruptions to the role of the market in allocating sufficient training places are signalled by the declining uptake of AME training and licensing, the declining numbers of apprentices and the resulting risks to the viability of RTOs with MRO approval for the provision of category training. A further market barrier lies in institutional fragmentation (airlines/GA;

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<sup>48</sup> Allen Consulting, 2013, p. vi.

<sup>49</sup> Department of Industry: Skills, 2014.

<sup>50</sup> Department of Education and Training (2015).

civilian/Defence) and geographical spread of the industry, resulting in a difficulty in ensuring off-the-job training access across the industry. As already argued, the creation of a LAME career pathway depends on opening up access to funded diploma-level qualifications. As well as market barriers, there are specific considerations, such as the very high risk to public safety posed by gaps in training, assessment and certification; the variety and national dispersion of the industry and the rate of technological change within it; the need for global alignment and the significant opportunities for creating a large new export education and training market. For all these reasons, education and training for aircraft maintenance trade and licence qualifications require special regulatory and funding attention during the process of VET reform. In Chapters 11 and 12, a range of options is canvassed, inside and outside the current VET system.

Aircraft maintenance skills training does not have time to wait for a drawn-out solution. The system is in crisis already, and drastic measures will be needed to revive it if Australia is to retain even the basic MRO capability it will need over the coming decade, but especially so if it is to tap into the enormous market for maintenance skills training which is already emerging across the world and Asia-Pacific in particular, before other nations pre-empt the option. It is apparent that if Australian aerskills training cannot recover in time while it remains embedded within the current model, and the best prospect of a resurgence lies in a rapid exploration of measures to turn around the problems identified in this chapter.

## RECOMMENDATIONS

- **RECOMMENDATION 15:** That appropriate funding be made available to support exclusion removal for those partial B licence holders who wish to recover their former potential productivity by regaining a full B licence
- **RECOMMENDATION 16:** That institutional and funding measures be put in place as a matter of urgency to ensure that the 98% of apprentices currently studying for a Certificate IV qualification have a readily accessible option on completion to upgrade to the Diploma required for a licence.
- **RECOMMENDATION 17:** That a National Aviation/Aerospace College (NAAC) be set up, drawing on the combined resources of the university and TAFE sectors, to take carriage of the training of Australia's aircraft maintenance engineers, to provide career paths to and from advanced aerospace manufacturing -and to provide a commercially attractive vehicle for an export industry in aircraft maintenance training and qualifications.

*That this College consist of nationally-networked local branches in each state and territory, including both civil and Defence aviation education and training providers, and gain recognition as Part 147 category Maintenance Training Organisation, a Registered Training Organisation and a nationally registered higher education provider. It will be necessary to ensure support from aerospace and aviation industry employers for a new model of shopfloor practical skills training and experience.*

- **RECOMMENDATION 18:** That the training structure for AMEs be redesigned to provide for:
  - a curriculum-based approach which is compatible with the international (EASA and NGAP) protocols and reflects the work already done in Australia on a common civilian/defence syllabus;
  - expert and independent oversight/moderation of the assessment process; and
  - closing the current loophole in the VET regulations that allows non-category training to provide prior standing for category training.

*Pending the establishment of the NAC, that the current constraints of the VET framework be relaxed for this occupation to the extent required to make these reforms possible, in recognition of the major public safety implications of having a properly qualified aircraft maintenance workforce.*

- **RECOMMENDATION 19:** That the training package be reviewed to create a broader base of capabilities (possibly based on a common first year) allowing trainees to specialise in either traditional MRO or the expanded industry, as well as providing avenues for early-career AMEs who find themselves temporarily surplus to requirements to move into related occupations (e.g. automotive mechanics or aluminium shipbuilding) with minimal retraining.



# Chapter 10 Australia and the Emerging World MRO Skills Crisis

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## 10.1 Introduction

Debates over the riskiness of offshoring are being increasingly overshadowed by a greater threat to aviation safety. This is the prospect that the whole world will find itself short of trained personnel to keep up current standards of maintenance. The certainty of this risk has been endorsed by two of the most credible institutions in the world aviation, the International Civil Aviation Organisation (ICAO) and the International Air Transport Association (IATA).

This chapter begins by summarising the forecasts from these and other authoritative international sources that most regions of the world face a growing shortfall of skilled aircraft maintenance engineers (AME) labour over the next twenty years, and evidence that it is already beginning to take effect. We then derive a range of credible estimates of the future demand for skilled labour in Australia and assess the current capacity of the Australian training system to meet that expected demand.

## 10.2 Estimates of future skill demand

Projections of future skill demand, especially in an industry experiencing the current levels of instability, are sensitive to a large number of factors which cannot confidently be predicted. Forecasting in this area will never be an exact science, hence the apparent precision of what follows should not be mistaken for accuracy; it is simply a matter of quantifying projections and converting them into visualisations for the sake of making it clear how large the challenges are.

At least four credible sources have made detailed projections of the world demand for new aircraft engineers (i.e. additional to the current workforce, and hence requiring to be trained up to professional entry level over the period in question). It is difficult to compare these estimates exactly, since they cover different time periods, each covers a different segment of the global fleet, and none makes full allowance for general aviation (GA). Some of their underlying assumptions may differ, such as the assumed rate of attrition in the existing workforce. Table 10.1 sets out the most important.

IATA developed its projections on the basis of a membership survey undertaken in 2009, while ICAO carried out a major research project in 2010 based on expert advice from its national authorities.<sup>1</sup> Both studies are reasonably well documented, though the public versions leave many gaps in our understanding of the underlying methodology or the assumptions that went into their projections. Boeing's methodology draws on its internal research, built largely around detailed projections of aircraft sales in each broad category over the next 20 years, but the published research reveals little of the detail behind its calculations. Airbus, while publishing its own annual forecasts of growth in activity and sales over the same period, does not offer any estimates of future labour requirements.<sup>2</sup>

It will be seen that the IATA and ICAO estimates fall within the same order of magnitude, once allowances are made for the differences in their coverage and the different time periods

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<sup>1</sup> International Air Transport Association (IATA), 2009; International Civil Aviation Organisation (ICAO) 2010d.

<sup>2</sup> Boeing, 2012, 2013, 2014b.

involved. Both sets show strong growth in demand in the period between now and the early 2030s. The Boeing figures are substantially lower (especially in terms of personnel per aircraft), and the surprising fluctuation between the three successive annual estimates provides a reminder – at least in the absence of information on how they were calculated – that they need to be treated with a degree of caution. Nevertheless, they are important because they are based on proprietary information not available to the other sources, and can be confidently treated as the lower boundary of the range of credible predictions.

**Table 10.1 Estimates of future world demand for qualified AME labour**

| Year | Source of estimate                                     | Estimated demand |
|------|--|------------------|
| 2010 | ICAO 2010  | 580,926          |
| 2015 | CAVOK 2015 <sup>3</sup> (commercial jet and turboprop) | 378,762          |
| 2015 | CAVOK 2015 (technicians only)                          | 278,073          |
| 2018 | IATA 2009 (main-route RPT only)                        | 405,000          |
| 2020 | CAVOK 2015 (derived)                                   | 469,752          |
| 2020 | CAVOK 2015 (technicians only)                          | 344,875          |
| 2025 | CAVOK 2015 (derived)                                   | 566,051          |
| 2025 | CAVOK 2015 (technicians only)                          | 415,574          |
| 2026 | IATA 2009  | 739,000          |
| 2030 | ICAO 2010  | 1,164,969        |
| 2031 | Boeing 2012 (jet airliners >30 seats only)             | 601,000          |
| 2032 | Boeing 2013 (as above)                                 | 556,000          |
| 2033 | Boeing 2014  | 584,000          |
| 2034 | Boeing 2015  | 609,000          |

Sources: IATA, 2009; ICAO, 2010d, CAVOK, 2015; Boeing, 2012, 2013, 2014b

The 2015 CAVOK report<sup>4</sup> offers a new set of estimates, considerably more up to date than those of ICAO and IATA, but again covering a different subset of the world fleet and using a different classification, both of which make direct comparisons problematical. Its estimates deserve respect above all for their currency, but also because of the reputation of these consultants for being well informed and cautious in their predictions (as evidenced by the fact that their projections run only ten years into the future). Their data are drawn directly from Federal Aviation Administration (FAA) repair station records, presumably compiled in the exercise of its responsibility to “certificate” repair stations outside as well as within the United States (US) (see Chapter 7). While CAVOK echo the other sources in disaggregating their statistics geographically

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<sup>3</sup> CAVOK, a global aviation services consulting firm, is a division of Oliver Wyman. For some years, this firm has published an annual maintenance repair organisation (MRO) survey under the Oliver Wyman imprint. These earlier surveys are referenced in this report under the names of the authors, Spafford and Rose. This 2015 study is a considerably more ambitious overview of the industry, carried out in conjunction with the Aeronautical Repair Stations Association (ARSA) and incorporating information previously collected and analysed by TeamSAI (now absorbed into CAVOK) for ARSA and published by that organisation.

<sup>4</sup> CAVOK, 2015.

only by the broadest ICAO/IATA regions, they are the only ones which do so by category of maintenance repair organisation (MRO). Whilst of limited usefulness for modelling specific demand in Australia, the CAVOK estimates thus potentially provide a basis for modelling scenarios to reflect different assumptions about the future structure of the Australian industry.

However, it is hard to compare the CAVOK forecasts with the others for two reasons. Firstly, the CAVOK estimates apply only to 2015, and labour demand as such is not modelled in the projections. Still, it is possible to do such modelling based on the predictions for growth in value which are provided for each segment, providing one accepts that the ratio of labour to other costs will not alter substantially over the 10-year period. This is the basis for deriving the estimates shown in Table 10.1, which do not appear in CAVOK's own publication. Secondly, the terminology which they use to describe different categories of labour is somewhat puzzling, and leaves it unclear whether the scope of their forecasts is the same as those from the other three sources.

Each of the other three sources uses a single term in its forecasts to cover all qualified personnel within scope. "Maintenance personnel" is used by the ICAO, "technicians" by IATA and Boeing. Since their estimates, at those points where they can be compared, fall within much the same order of magnitude, it is assumed here that all three terms refer to the same kind of labour, and that this in turn is the same covered by "aircraft maintenance engineers" in Australia. However, CAVOK classifies the workforce in three nested levels: "labour" in the generic sense, "technicians", and "certificated" technicians. The third term is virtually equivalent to licensed aircraft maintenance engineers (LAME) in Australian usage, meaning someone who is authorised (in this case, by the FAA) to sign off on the completion of maintenance.<sup>5</sup> There is a less clear dividing line between "technicians" and the rest of the labour that falls within scope, though it seems reasonable to understand the term in the same sense as "AME", i.e. someone who has completed an advanced middle-level training program, approved by the national aviation authority (NAA), to qualify them specifically to work on aircraft. Whether the remaining labour force is expected to be qualified at all, and if so to what level, is not made clear. The issue is further confused by the fact that the CAVOK study explicitly includes at least parts of the supply chain – indeed, specific subcategories are shown for on-aircraft line maintenance and the line maintenance supply chain.

The problem is more than one of terminology, as it directly affects the estimation of future needs for highly skilled labour. The CAVOK report supplies breakdowns not simply for the labour force as a whole, but for airframe, engine and component maintenance, though the proportions vary relatively little. Across all categories technicians represent 73% of all labour, while the proportion of "certificated" technicians in the workforce as a whole varies between 16% for all MRO (including line maintenance, for which no breakdown is given) and 19% for airframe maintenance. The ratio of certificated to other technicians ranges between 1:3 and 1:4, corresponding broadly to the ICAO benchmark for the same ratio. From this it seems reasonable to conclude that in CAVOK's assessment, the section of the aviation workforce modelled by the ICAO corresponds only to the technician category, and hence that the requirement for workers who have received intensive and specialised training of the kind required to qualify as an AME in Australia is 25-30% smaller than the other sources predict. It is open to interpretation that the remainder could be unskilled or semiskilled labour, or could include A licensees working on aircraft, and/or fully qualified tradespeople working elsewhere in the supply chain who are out of scope for the present study. Given that labour is of fairly peripheral interest to the CAVOK study, it seems inadvisable to accept its estimates as more authoritative than the ICAO or IATA

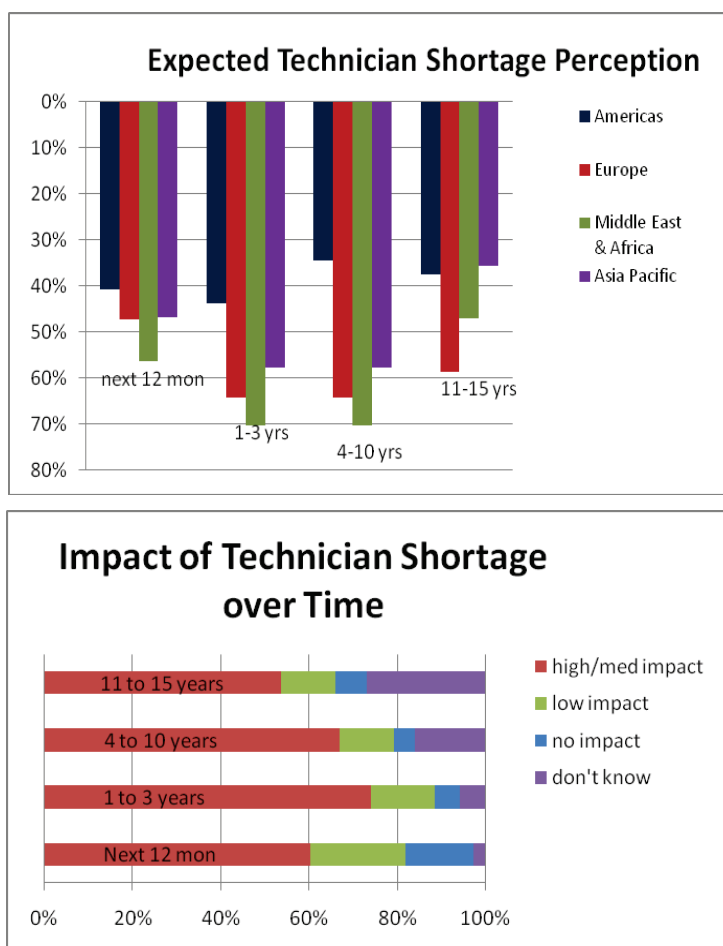
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<sup>5</sup> A definition can be found Federal Aviation Administration (FAA), 2001.

ones. Nonetheless, they do add to the range of credible forecasts, as well as providing a baseline figure for 2015 which is not available from any of the other sources.

The ICAO's regional breakdowns appear to be based on the notional premise that all aircraft registered within a jurisdiction will be maintained within the same jurisdiction, though they do assume some labour mobility, suggesting that persistent shortfalls in one nation's training effort could be compensated to some extent by increasing the output of other nations with a greater capacity. The remaining forecasts do not make it clear whether they allow for offshoring, but Boeing's projections for 2033 appear to be based on each broad region maintaining its own fleet: the ratio of AMEs per plane remains surprisingly consistent at between 12 and 14 across all regions except the Middle East (18.5) and Asia-Pacific (14.7), where the higher requirement may partly reflect the need for catch-up to compensate for present shortfalls of qualified labour.

The IATA research adds a further dimension to this information by attempting to map the pattern of growth. Its consultations with member airlines indicated that the strongest net growth in demand was expected to occur within the 4-year period from 2009, and remain strong over the full decade of the 2010s, tapering off after that point (Figure 10.1).



Source: International Air Transport Association (IATA) 2009, pp. 13, 14

Series labels on second diagram read, from bottom to top: Next 12 months, 1-3 years, 4-10 years, 11-15 years.

**Figure 10. 1 Survey responses on expected impact of maintenance labour shortage (Base year = 2008)**

While the report points out that this growth is likely to have been shifted back a few years because of the lull in demand growth following the global financial crisis (GFC), such a pattern



still appears credible in the light of the evidence, discussed in Chapter 3, that the number of current-generation planes in service will continue to grow strongly into the 2020s, and it will be well into the next decade before there are enough of the new generation in service to bring about a major decline in the maintenance requirement relative to the number of planes flying. Boeing in its 2014 projections states specifically that they are based on the expectation of a diminishing maintenance requirement over the next 20 years as a new generation of planes comes to dominate the fleet, but still maintains only that this will “moderate” that growth.<sup>6</sup> The CAVOK projections are explicitly linked to assumptions about the future composition of the fleet and the pace at which technological innovations will be implemented, and echo IATA, somewhat more explicitly, in predicting a change in the rate of growth in activity, in different directions depending on the segment, around 2020 as newer-technology designs come into more general use.

From these sources we can conclude that the world maintenance workforce in twenty years’ time will be around twice the number employed in the base year for each set of forecasts. Virtually all of this workforce — not just the net increase — will need to be recruited and trained from scratch over this period. However, the growth pattern is unlikely to be linear. Three out of the four sources suggest that we should reasonably expect demand to peak sometime in the early 2020s — about the time when a high proportion of the current Australian AME workforce will reach retirement age — and level off gradually over that decade to the point where new recruitment is needed only to compensate for attrition, though it is likely that further training activity will be required to update the skills base of the workforce in employment at any given time.

Both the ICAO and the IATA projections were made with declared intent of assessing the adequacy of the current training infrastructure to meet future demand. Both suggest the need for major upgrades of capacity in most parts of the world. Table 10.2 below contains specific estimates of the average requirement for newly trained personnel over the next 20 years and the likely shortfall in each year, assuming the potential output of each national training system remains at its current level.

**Table 10. 2 Estimated average annual training requirement and shortfall by region, 2011-2030**

| Region        | Total required by 2030 | Annual training need | Annual shortfall (surplus) | Training capacity (2010) as % annual need |
|---------------|------------------------|----------------------|----------------------------|---|
| Africa        | 58,635                 | 3,769                | 3,169                      | 15.9                                      |
| Asia-Pacific  | 289,510                | 190,10               | 14,745                     | 22.4                                      |
| Europe        | 330,522                | 22977                | 8,352                      | 63.7                                      |
| Latin America | 101,226                | 6,881                | 5,566                      | 19.1                                      |
| Middle East   | 59,905                 | 4,107                | 2,062                      | 49.8                                      |
| North America | 325,171                | 13,586               | (15,824)                   | 116.5                                     |
| World         | 1,164,969              | 70,331               | 18,071                     | 74.3                                      |

Source: International Civil Aviation Organisation (ICAO), 2009

The real significance of these figures is that the biggest shortfalls are expected to arise in precisely those parts of the world to which Australian carriers are increasingly turning to meet

<sup>6</sup> Boeing, 2014b, p.28.

their maintenance requirements. Already this development is showing up as something more than speculation. As noted in Chapters 6 and 7, the major Hong Kong MRO HAECO (which took over the heavy maintenance on Qantas's remaining 747s in 2013) has acquired one of the biggest US MROs with a view to accommodating some of its demand within the continental US, after experiencing a 21% drop in profits in the first half of 2013 due to problems in recruiting enough skilled labour. It is reportedly seeking government assistance to bring in more qualified personnel from overseas.<sup>7</sup>

According to industry expert Chris Spafford, China in particular is expecting a major curtailment of its ability to service foreign widebodies because the growth of its own fleet has completely outstripped the growth of its workforce.<sup>8</sup> Even the Gulf states, which only a few years ago were expected to have no problems recruiting maintenance labour because of the huge pool of trained labour available close to hand on the Indian subcontinent, are now expecting to undertake significant recruitment within the next five years, with none of the local training providers confident of being able to meet the full demand. In the words of a Lithuanian training provider, "... the deficiency of skilled professionals will definitely take its toll, as this is a global problem that cannot be solved by merely hiring people from other regions".<sup>9</sup>

More remarkably, even in North America – the one region expected by the ICAO in 2009 to be training well in excess of its needs for skilled labour – Spafford estimates that recruitment is falling 15-17% below the rate of natural attrition.<sup>10</sup> In a survey conducted by Spafford and Rose a year earlier for the Oliver Wyman consultancy, American operators cited lack of skilled labour as the main factor that prevented them from repatriating more of the maintenance currently done offshore.<sup>11</sup> This change is most likely related to the growth in American MRO businesses taking in foreign work since the ICAO produced its original estimates.

Growing shortages of skilled labour in these regions will necessarily affect both their capacity to take in work from countries like Australia, and the prices they will be able to charge in what will progressively become a seller's market. In the medium term, this is bound to mean a compression of the cost differential between performing maintenance in Australia and outsourcing it; eventually it could undermine much of the economic case for offshoring Australian work, as is already happening for the US.<sup>12</sup> In the longer run, the risk is that Australia could run out of opportunities to offshore some kinds of work, or at any rate that other buyers with greater market power will crowd Australian customers out, forcing them to use second-tier providers of uncertain quality. If this happens, Australia will face a genuine threat to the safety of its domestic aviation unless it is able to rebuild sufficient capacity to handle at least a reasonable proportion of the work which has been lost overseas. Even in the best case, Australian carriers could eventually find themselves paying more for offshore maintenance than they would have been paying had they maintained the capability within Australia.

In this context it makes sense to investigate how much could be achieved if Australia were to make the investment in repatriating a larger proportion of its maintenance currently performed offshore, and in particular whether the current training infrastructure and arrangements would be able to ensure an adequate supply of skilled labour to make this transfer feasible.

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<sup>7</sup> AviationPros, 2013.

<sup>8</sup> Cited in Chandler, 2014.

<sup>9</sup> AviationPros, 2014.

<sup>10</sup> Cited in Chandler, 2014.

<sup>11</sup> Spafford and Rose, 2013, p.11.

<sup>12</sup> Spafford and Rose, 2014, p.9.

### 10.3 Calculating Australia's future requirements

So far as we know, nobody has yet made any publicly accessible forecasts of the future demand for AME labour in Australia. The 2009 White Paper *Flight Path to the Future* made only a passing reference to the size of the workforce needing to double – a rule-of-thumb estimate commonly applied to growth in the workforce not only in aviation but in many areas of transport, globally as well as in Australia.<sup>13</sup> Even the ICAO and IATA do not disaggregate their estimates below the level of very broad regions (in our case, Asia-Pacific). Translating these regional estimates into forecasts for Australia is extremely difficult because Australia represents only an extremely small and atypical segment of the overall Asia/Pacific market, with a relatively stable and mature consumer market and industry structure in a region of the world characterised by massive growth in demand for air travel and a major explosion in both the number and size of competing firms.

Of the three sources, Boeing is the only one which publishes more informative disaggregations of the forecasts within each broad region, though labour requirements are not regularly included in these. A Boeing executive, in a 2013 newspaper interview,<sup>14</sup> predicted that Oceania (Australia, New Zealand (NZ), Niugini and all the Pacific islands as far east as Rapa Nui) would need around 15,000 qualified engineers by 2032. By the time the 2014 forecasts were released, however, the estimate had fallen to 14,000 by 2033.<sup>15</sup> Boeing does not quote base-year estimates for labour, and there has been no reliable way of estimating the present size of the Australian AME/LAME workforce at any time since the Census in July 2011.

Without proprietary information to which we have no access, we have had no option but to develop our own estimates derived with limited certainty from the CAVOK, Boeing, ICAO and IATA forecasts, the Census, and government research bulletins drawing on Australian Bureau of Statistics (ABS) Labour Force data.<sup>16</sup> On these bases we prepared two sets of forecasts, one linking labour demand to the size and composition of the Australian civil fleet, the other estimating the requirements if the active labour force in Australia grows in line with projected growth across the world industry.

The first analysis, based initially on the ICAO benchmarks, sets out to establish whether the Australian AME labour force in the base year (set at 2013 for the purposes of comparability with the Boeing projections) was adequate to the requirements of servicing the entire VH registered (Australian) commercial transport fleet. It models not only the growth required to keep pace with fleet growth, but the additional recruitment which would be needed to make up any shortfall in the base year. The second, derived from the CAVOK estimates of base-year employment and projected growth of activity in the sector, simply assumes the current (2015) level of employment as a baseline and calculates the number of trained recruits that would be required to keep this constant over the next ten years as a proportion of the world MRO labour force, without implying any judgement about the appropriateness of the current provision. Thus the two analyses serve different purposes, and their findings have different implications.

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<sup>13</sup> Australia, Minister for Transport and Regional Services, 2009.

<sup>14</sup> Cited by Creedy, 2013b.

<sup>15</sup> Boeing Corp, 2104 b

<sup>16</sup> Australian Bureau of Statistics (ABS), 2012; Department of Education, Employment and Workplace Relations (DEEWR), 2012a, 2012b.

The ICAO figures, which represent the starting point for the first analysis, are based on a set ratio of qualified workers to each plane:

- 20 engineers (five of them licensed) for each jet-powered passenger or cargo plane in service;
- three engineers (two licensed) for each plane in a category called “other” which consists of multi-engined turboprop and piston planes in commercial service, but excludes government and military aircraft, those used in non-commercial business aviation, aerial work, pleasure flying and instructional flying, and all helicopters.

No minimum or maximum takeoff weight (MTOW) is specified for either category.

These ratios are described as the “most likely scenario”, and are assumed to remain constant, as averages, over the period up to 2030 for which the projections are made. The ratios for each category were calculated on different bases. Those for passenger and cargo aircraft are an expert assessment made through a Delphi process in the light of “observed and reported industry practices” (presumably worldwide), while those for “other” aircraft were actual ratios taken from states which had only “other” aircraft on their registers. They are not intended as normative, but can be viewed as an indication of representative (rather than best) practice across the member nations, and consequently as benchmarks (rather than guidelines or quotas) for adequate resourcing. However, while we refer to them for convenience as “benchmarks” in the rest of this analysis, it must be understood that the ICAO itself does not refer to them by this term.

The ICAO ratios do not attempt to break down the estimates between line, base and engine maintenance. Moreover, it is clear from the remainder of the document that they are intended as fixed ratios of workforce size to fleet size, rather than simply as meaning that there should be a pool of 20 AMEs available to work on a given aircraft at the times when it needs maintenance, but free to work on others at other times.

Obviously these are very broad averages (suggesting, for example, that a 747 requires the same number of qualified workers to maintain it as an 80-seat regional jet), and the assumption that the desirable ratios will remain constant over a 20-year period seems highly schematic. For an exercise such as this, however, a broadly derived estimate is likely to be of more use, and even more reliable, than one which attempts to be highly accurate. Over such a long timeframe, where so many unknown factors could influence the eventual outcome, any attempt at precision is likely to work against accuracy. So while the figures that result from any such calculation are at best order-of-magnitude forecasts, they are probably the best anyone has to work from so far, and they are likely to prove no more inaccurate for Australia than for any other country.

Taking 2013 as a baseline, the Australian Aircraft Register was analysed to determine how many of the VH-registered fleet fell into the two categories covered by the ICAO estimates. The assessment was based partly on the category of airworthiness certificate, and partly from what we could ascertain about the identity and business of each registered operator. The estimated total, as of mid-2013, stood at 531 jet cargo/passenger planes and 836 “others”. (Boeing’s later estimate of 540 jets with over 30 seats for the whole of Oceania, as at January 2013, appears at least broadly consistent with this estimate.)<sup>17</sup> On this basis the current Australian requirement

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<sup>17</sup> An analysis of the Register as at 31 July 2015 (Table 2.1) shows 529 VH-registered multi-engine turbofan aircraft exceeding 7,500 kg MTOW, some of which may not hold a Transport CoA. No significance should be placed on such small movements in the size and composition of the Register over a period as short as two years, since fleet acquisitions and replacement tend to take place over a very uneven schedule.

would run out to 13,128 AMEs, of whom just over 4,000 would need to be licensed, assuming all the necessary work were to be carried out onshore.

We then took the number of people who gave their occupation as AME in the 2011 census. This is the only reliable way of determining the numbers employed in the occupation, as the other available estimates (notably the Australian Bureau of Statistics Labour Force figures) are based on a very small sample, and fluctuate wildly from quarter to quarter. From this we subtracted the number who gave their industry of employment as Defence, Public Order and Safety or Government (since the ICAO estimates exclude Defence or any other government-operated aircraft) to reach an estimate of the employed civilian workforce. From that estimate we subtracted 10% (probably an underestimate) to allow for attrition over the two years between Census night and the third quarter of 2013, and added the maximum possible estimate of top-up recruitment from Australian sources – i.e. the total number of apprenticeships at the relevant level that had been completed between July 2011 and June 2013.

Bearing in mind that the ICAO's benchmarks exclude a large part of GA, we applied a further notional adjustment of 10% to cover the part of the workforce employed in GA. This is a very conservative estimate,<sup>18</sup> but squares broadly with an analysis of the workplace locations listed in the Census, which showed that just over 11% of employed AMEs worked in a location not served by high-capacity regular public transport (RPT) or close to a defence base, and hence were probably engaged solely or primarily in GA maintenance.<sup>19</sup>

This left a current shortfall of just under 4,000 personnel (Table 10.3), though the available data do not permit an estimate of the shortfall (if any) of licensed personnel. This figure was converted into an adequacy ratio, expressing the estimated total number of AMEs available to work on the relevant sections of the fleet as a percentage of the ICAO benchmark figure for a fleet of this size and composition. The ratio we calculated for 2013 was around 70% - not especially creditable, but probably explained by the amount of work already offshored rather than just by under-resourcing within Australia.

A growth in the active workforce which kept pace with the ICAO benchmarks over the next 10 years would require a total of just under 20,000 workers in 2025 to match growth (a net increase of just under 6,000 on the starting figure in 2015), plus another 4,000 to catch up on the base-year deficiency (see Figure 10.5 below). Even this estimate is probably on the optimistic side, since it assumes a simple linear growth path through to 2030, whereas the IATA and CAVOK estimates both envisage a growth pattern in which the curve is steeper up to the early 2020s than in the latter half of the period. Although this figure of 24,000 refers to the size of the workforce at each point in time rather than the number of new trained recruits required over this period (to cover not only net growth but retirements and other forms of attrition in the existing workforce), the task still appears to exceed any foreseeable capacity of the Australian

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<sup>18</sup> ARSA estimates the business and general aviation component (which in their case includes turboshaft helicopters but no piston-engined aircraft) at 30% of the total world heavy maintenance bill (ARSA, 2013, p. 5). However, the US fleet includes a relatively large number of small corporate jets, which typically fly more hours and have more complex maintenance requirements than the broader GA fleet, but which are less strongly represented on the Australian register.

<sup>19</sup> Despite the removal of the occupation from the Skilled Occupations List in 2013, Manufacturing Skills Australia (MSA) in its submission to the review for 2015-16 noted a continuing shortage of suitably skilled GA maintenance engineers, concentrated in regional locations (MSA, 2014).

training system, even if supplemented by a high level of skilled migration - something that will prove increasingly difficult to achieve as the world market for specialist MRO labour grows tighter.

**Table 10. 3 Supply of qualified aircraft maintenance labour, Australia, relative to ICAO benchmarks**

|   |        |               |
|---|--------|---------------|
| <b>Estimated requirement for CASA-registered jet passenger/cargo and "other", excluding Defence (ICAO benchmark ratios)</b> |        | <b>13,128</b> |
| Employed persons at 31/7/2011 giving occupation as Aircraft Mechanical Engineer (ANZSCO 3231)                               |        | 14,489        |
| Less Defence and government   | -3,926 | 10,563        |
| Less 2 years attrition @ 5% (ICAO standard assumption)  | -1,052 | 9,507         |
| Add total apprenticeship completions Q3 2011 to Q2 2013 (incl. Defence)   | +872   | 10,379        |
| Less 10% assumed working in GA  | -1,038 | 9,341         |
| <b>Total estimated available workforce Q2 2013</b>  |        | <b>9,341</b>  |
| <b>Shortfall</b>  |        | <b>3,787</b>  |
| <b>Adequacy ratio</b>   |        | <b>71%</b>    |

Source: Australian Bureau of Statistics (ABS), 2012 Census 2011, adjusted to 30 June 2013

Given this constraint and the high discrepancy between ICAO and rival estimates of the demand 20 years out, it was appropriate to develop a second, less ambitious projection for forward demand, based on a compromise between the ICAO and Boeing forecasts. This meant calculating separate estimates, on different bases, for the jet passenger/freight and "other" components of the fleet. For the former, we use the 4.4% annual growth rate estimated by Boeing in its 2014 projections, which cover essentially the same portion of the overall fleet. Taking the average ratio for Oceania of 13.9 skilled employees per aircraft which is assumed by Boeing for 2033 (a figure broadly in line with its expectation for most other regions in the world), we work on the assumption that this will be the true average at the end of the 20-year period, while accepting the ICAO figure of 20 as the representative ratio at the beginning, and assume that the transition from one to the other will be incremental over the full period. This accommodates the common expectation within the industry that average maintenance labour requirements will decline progressively as the new generation of aircraft comes into service.

Where the "other" component is concerned, we have retained the 3.1% average annual growth rate predicted by ICAO in 2010. While falling below the most recent expectations of growth in overall aviation activity, this latter remains a credible figure in our estimation, given developments which can reasonably be expected in the overall composition of the Australian fleet. In the first place, many of the turboprops used by regional airlines for RPT and/or charter are likely to be progressively replaced by jets on the more thickly trafficked routes over the forecast period, given the higher traffic volumes expected, the likelihood of major population increases in many of the towns and cities along these routes, the wider availability of fuel-efficient smaller regional jets over the next 20 years, and the likelihood of increasing interoperability between the aircraft operating regional and interstate services if the domestic industry remains horizontally integrated along its present lines. This part of the fleet can therefore be expected to shift to the "jet passenger" category. Growth in the remaining "other" category should remain below the average for jets and broadly in line with earlier ICAO

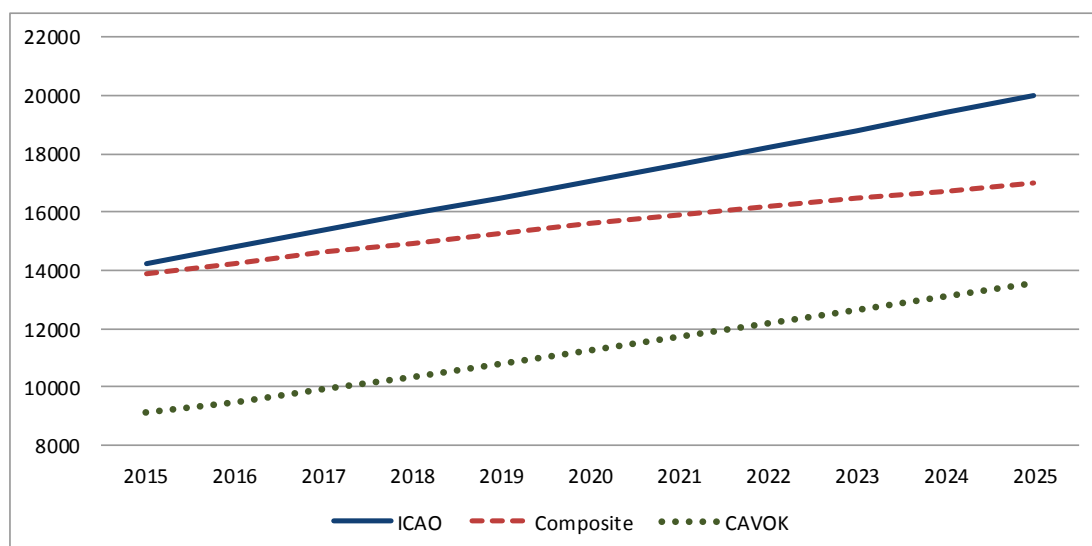
expectations, since we would expect most of the anticipated growth in the VH-registered GA fleet to occur in categories like aerial work and flight training, and above all rotorcraft, which lie outside the segments covered by the ICAO projections.

Adding the two figures, with their differential growth rates, produces a curve over the full period which shows some of the convexity that would be expected from the IATA projections. Compared against 2015 it would represent a net growth of a little under 3,000 – bearing in mind that this estimate too starts from the number required to match the ICAO benchmark ratios as at 2013, and further recruitment would be needed to catch up from the original shortfall. The projected total workforce in 2025 is estimated at slightly under 17,000.

For the second exercise, we work from CAVOK's 2015 estimates for "technicians" alone, on the assumption that everyone listed in Australia in the AME occupation would fall into this category. This conveniently bypasses the issue of whether the other projections include workers who are not qualified to that level, but leaves us with an assumed starting point considerably lower than the other two scenarios modelled here. If we take CAVOK's projections at their face value, it is reasonable to assume that in addition to the required growth in the supply of fully qualified AMEs, the training system would also need to support around a third of this number again, made up of people employed either in the supply chain or working on or around aircraft but not requiring qualifications under Part 147. Although this latter workforce lies strictly outside the scope of this study, it still needs to be borne in mind when calculating the overall requirement for aircraft-related qualifications.

Remembering that this second exercise involves no judgement about the adequacy of the present workforce, we take as our starting point the estimated population of AMEs in civilian employment (approximately 9,100 at the start of calendar 2015), and model workforce growth in line with CAVOK's forecast of the net cumulative annual growth rate (CAGR) in the value of world MRO output of 4.4% up to 2020, and 3.8% from 2021 to 2025. Once again this can only result in a very rough estimate, since it takes no account either of the degree to which technology will displace labour over the two periods, or of likely changes in the industry structure which would affect the balance between highly labour-intensive segments with relatively low growth potential (notably heavy airframe maintenance) and those which have very high growth potential but a relatively low component of labour inputs (in particular, engine maintenance). Nevertheless, it provides an order-of-magnitude figure which is no more subject to error than the ICAO-based modelling, and sets a convenient lower bound on the output which would be required of the training sector to fill the demand from within Australia. The resulting total workforce estimate for 2025 comes out to slightly over 13,600, though the low starting point means that the net growth from 2015 will still be in the neighbourhood of 4,500, this time not requiring any additional allowance for catch-up.

Since Figure 10.2 shows significant discrepancies among the three curves, it is important to remember the conceptual differences between the three sets of calculations. In particular, the CAVOK curve starts from a much lower point than the other two because it takes as its point of origin a real rather than a (presumed) optimal workforce size, and partly because it appears, so far as we understand CAVOK's terminology, to cover only persons requiring Part 147 qualifications. On their reckoning, it would be necessary to assume the need for an "associated" labour component working without the legal requirement for such qualifications, either on aircraft in an ancillary capacity, or in the MRO supply chain, which would add around another 30% to the total amount of labour required. It is unclear whether the forecasts on which the other two curves are based include any part of that "associated" workforce.



**Figure 10. 2 Alternative estimates of combined labour demand to 2033**

The lower starting point also accounts for the obviously steeper slope on the CAVOK curve than on the other two, since the latter are based on the optimal workforce required to accommodate fleet growth, and require additional labour input to compensate for the continuing shortfall in the workforce actually employed in Australia. For example, if the ICAO curve were to start at the actual number for 2015, the growth required in net population over the ten years would come out to more than 10,000. This comparison emphasises the fact that Australia starts in 2015 with a substantial handicap because of the collapse of recruitment to the occupation over the last four years in particular. This training deficit is important in assessing how realistic it would be for Australia to generate sufficient new MRO capacity within the next decade to recover the amount of work lost to offshore providers over the last decade.

## 10.4 Could Australia make up the gap?

How realistic is it to expect that the Australian training sector could meet the demands of such an increase in output (leaving aside the obvious considerations of who would pay and where they would be trained)?

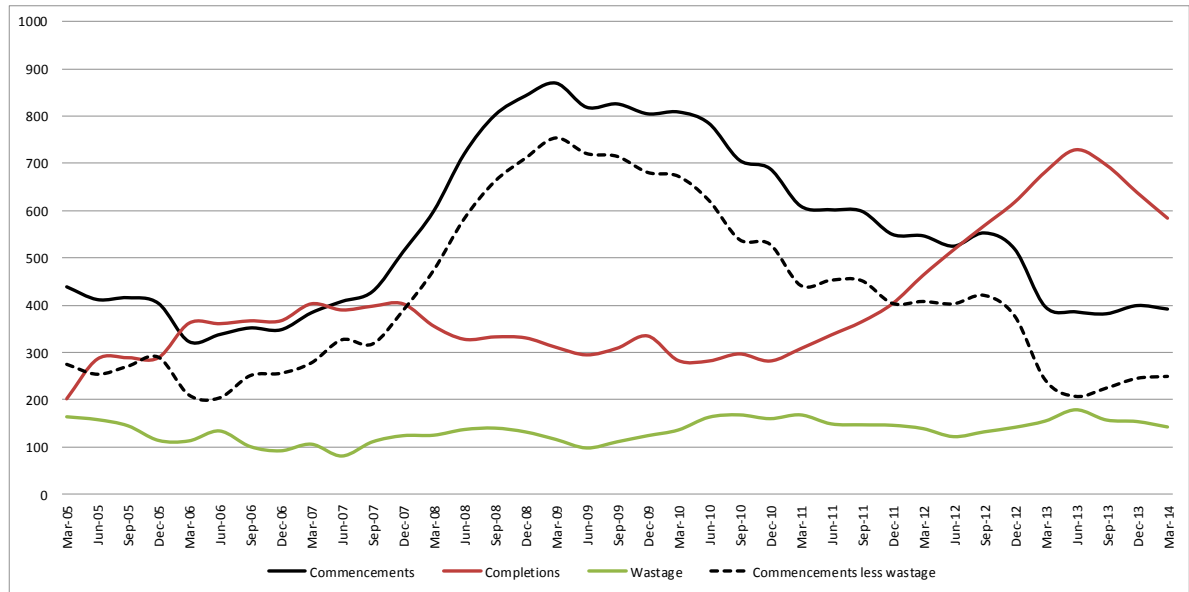
A careful look at the performance of the system over the last five years (Figure 10.3) gives little reason for optimism. Assuredly the number of apprenticeship completions at June 2013 showed an increase of some 130% over the output at the beginning of the 2008. However, this reflects a large spike in commencements which occurred in 2008 and has since been working its way through the system. Completions peaked in the March quarter of 2013 and were running at 20% below that peak a year later.

If we look at commencements instead, we see a virtually uninterrupted fall over the last five years, with the total for 2013 less than half that recorded five years earlier. For the March quarter (traditionally the busiest time for recruitment) the number of commencements in 2014 was the lowest this century and the third-lowest in the 20 years for which statistics are available.

At the same time the level of wastage (the combined impact of apprenticeship cancellations, withdrawals, suspensions and expiry) shows a small but steady rise since 2007, both in its own right and relative to commencements, with the loss of apprentices before completion increasing by some 10% over that period. This in turn has an impact on the critical statistic of net recruitment, made up of the number of new apprentices adjusted for the number who have



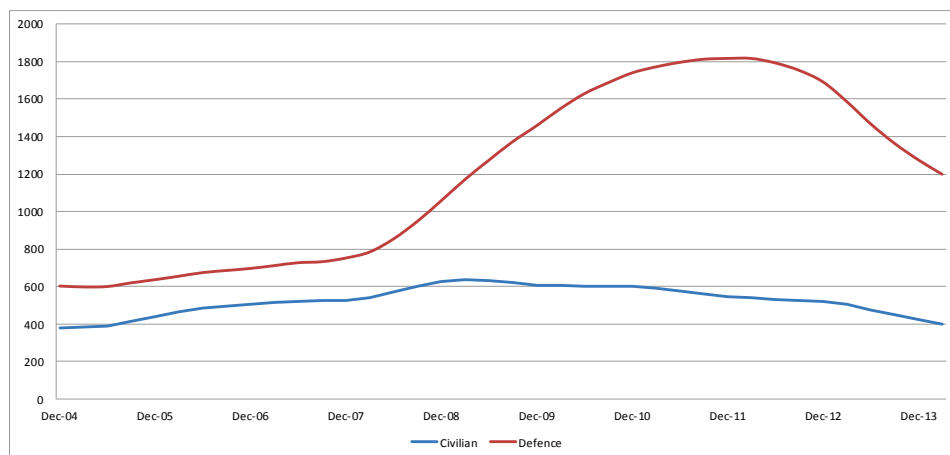
failed to complete their apprenticeships within the same time period; by March 2014 this net figure was less than two thirds of that for commencements alone.



Source: National Centre for Vocational Education Research (NCVER) Apprentices and Trainees, various years March 2005 to March 2014?

**Figure 10. 3 All AME apprenticeships by status - rolling 4-quarter average, 10 years to March 2014**

The collapse of activity becomes even more conspicuous when we take into account the relative contributions of the civilian and Defence sectors. Figure 10.4 below makes it graphically clear how quickly the contribution of Defence establishments to the total training effort has risen, relative to civilian employers, over this period, with the share of Defence rising from 28% to 77%. This graph, which tracks the rolling average number in training over four quarters, not only illustrates the magnitude and importance of the spike in commencements in 2008, and how its impact has tailed off in the last year, but makes it clear that this one-off surge in investment occurred purely within the Defence sector. Civilian activity shows a steady decline over the last five years, with the total number engaged at all points of the apprenticeship cycle falling by around 17%.



**Figure 10. 4 Apprentices in training by sector, 4-quarter rolling average, 10 years to March 2014**

The decline is perhaps clearest when we return to the crucial figure of net recruitment. While the trend for civilian commencements was essentially flat (punctuated by a small increase in 2011-12), the trend of Defence commencements has plunged from its peak in 2008, effectively re-joining the civilian curve by 2011.

There appears so far to be limited interest in reducing the recruitment deficit, at least on the part of the major airlines, and on the basis of the traditional apprenticeship model. The crisis within the formal training system – exemplified by the collapse of activity in leading-edge Technical and Further Education (TAFE) institutions which once set national and even world standards in the training of aircraft maintenance personnel - combines with the decline in activity at the industry level to stifle Australia's capacity to bring its output of skilled labour back up to acceptable standards. With many of the most active workshops now closed, the opportunity to provide workplace experience is becoming scarcer all the time. While the 10-year rolling averages used in the above graphs are useful for evening out chance annual variations, the actual figures for completions in particular spell out the problem much more starkly. In the year between September 2013 and September 2014, overall apprenticeship completions dropped by a third, while civilian completions went below 100 for the first time in nine years.<sup>20</sup> At the same time, commencements have fallen away to the point where Australia is locked in to a decline in recruitment, and hence in the size of the available workforce, until at least 2018.

The continuing decimation of the experienced workforce in the industry is leading towards the decay of a resource of practical knowledge which in better times would have been available to contribute to the practical learning of a new generation of apprentices. An impressive body of such knowledge still remains in the active Australian workforce, albeit mostly concentrated on more traditional aircraft technology. It would be wrong to dismiss this body of practical knowledge as outdated given that the transition to new-generation technology is expected to be a gradual one, with aircraft of the present generation (built roughly between 2000 and 2012) still likely to make up a high proportion of the commercial fleet in the 2020s, by which time many of them will be reaching the stage in their lifecycle when they will require more intensive maintenance.<sup>21</sup> Conversely, the present lack of mentors with a comparable depth of experience on new-generation aircraft poses an additional challenge when it comes to developing the workforce capability which Australia will need to exploit the new opportunities that may arise from changing business models linked to new-generation airframes, a subject to be discussed in more detail in Chapter 12.

At first sight, therefore, Australia seems ill placed to face a major world skills shortage. Yet if the world shortage reaches the proportions identified by the international authorities, it seems inevitable that Australia will eventually have to take back a significant part of the maintenance load which is currently either already offshore, or in the process of being moved offshore. Chapter 12 focuses primarily on the simple question: can this be done? and the less simple one: if so, how? The remainder of this chapter addresses the question of whether it would be feasible

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<sup>20</sup> Statistics quoted from this point onwards are for the year to September, since the latest fully disaggregated apprentice data to hand from the National Centre for Vocational Education Research (NCVER) at the time of writing were for September 2014. The rapidity of the decline in training activity makes it important to base projections on the most current available data. The value of their currency is partly offset by the risk that setting the cutoff in September rather than at the end of the year may result in an underestimate of the on-time completion rate. However, we believe this does not substantially compromise the accuracy of the trends we have modelled, given that our calculations cover a total period of 20 years (10 back, 10 forward) on the same basis.

<sup>21</sup> CAVOK, 2015, p.35

at all, even in the most favourable of realistically foreseeable circumstances, to build up Australia's skilled workforce to the level required.

The necessary modelling of future workforce supply is complicated, as already mentioned, by the uncertainty about our exact starting point. Estimating the present size of the active workforce (defined for these purposes as the number of qualified persons who are either currently employed or available immediately for employment in the occupation) is problematic because the last fully reliable estimate dates from the 2011 Census. Official estimates of the annual attrition rate varied widely from bulletin to bulletin right up to the point where the occupation was removed from the Skilled Occupations List. The last one, released by the Department of Employment in 2014,<sup>22</sup> suggests an average of only 3.16% per annum over five years, but earlier estimates, released by the former AWP (Australian Workforce and Productivity Agency) and DEEWR (Department of Education, Employment and Workplace Relations) before the 2013 change of government, sometimes put that loss at well over 10 % in a year.<sup>23</sup> This reflects once again the problems that can arise from relying on Labour Force statistics at this level of disaggregation<sup>24</sup>.

For the sake of simplicity and comparability with other sources, we have used the standard ICAO estimate of 5% annual attrition to calculate the projections in Figure 10.5 below. The active population for each year is calculated by applying this adjustment to the corresponding population in the previous year, and adding the number of apprenticeship completions in the previous (*not* the current) year, working on the possibly optimistic assumption that every graduating apprentice over the intervening period found a job in the occupation. Using the 2011 Census figure as our starting point, we estimate the active workforce in September 2014 at 13,473, reducing to 13,190 by September this year.

To project completions after 2014, we used data from the last ten years to calculate an average on-time completion rate (i.e. completions in each year as a proportion of commencements four years previously)<sup>25</sup> of 78.7% for the two main civilian employing industries (Air and Space Transport, and Aircraft Maintenance and Repair) and 97.5% for Defence apprentices. In

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<sup>22</sup> Department of Employment, 2014, p.36.

<sup>23</sup> A 2012 *Job Outlook* bulletin (Department of Education, Employment and Workplace Relations (DEEWR), 2012b) showed a short-term decline in employment of 30.5% over two years. In a subsequent brief to AWP, recommending removal of the occupation from the Skilled Occupations List ((Department of Education, Employment and Workplace Relations (DEEWR), 2012c), the Department estimated a 45% reduction in employment over 5 years. An earlier bulletin in the same series, current to May 2011, showed that even at a period when employment in the occupation had been growing, the proportion of workers leaving the occupation in a year was around 11.3% (Department of Education, Employment and Workplace Relations (DEEWR), 2012a; see also Australian Workforce and Productivity Agency (AWP), 2012).

<sup>24</sup> By way of comparison, a report released in August 2015 by the US Departments of Education, Labor and Transport estimates total separations of aircraft mechanics and service technicians in that country for the period between 2012 and 2022 at 73.4% of existing employment. Of these separations, only 34% were predicted to occur as a result of exit from the workforce (i.e. retirement, death or permanent incapacity), with the remainder resulting from transfer (whether voluntary or forced) to other occupations. (United States Department of Education, 2015, p.48).

<sup>25</sup> Our modelling is based on a four-year apprenticeship, i.e. the Certificate IV currently required to work as an AME without signoff privileges. This is the level of qualification at which 97.6% of those in training over the year to September 2014 were studying. In most cases, bringing these workers up to the licensed level would require another year of formal training to convert their qualification to Diploma, plus at least the same amount of work experience.

modelling the size of the civilian workforce, we assume that only those who have completed civilian apprenticeships will enter civilian employment during this period, though in reality we might expect a proportion of completing Defence apprentices to move to civilian work after completing their initial period of engagement.<sup>26</sup>

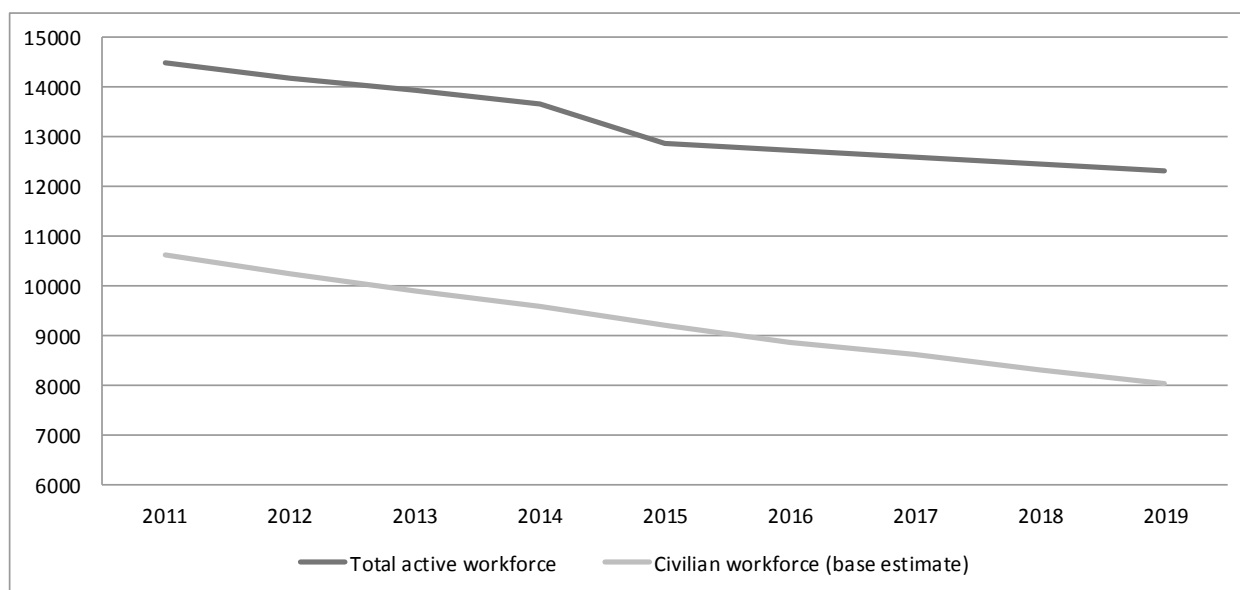


Figure 10. 5 Change in size of Australian AME workforce, 2011-2019  
(projected – see text)

Note, once again, that this trajectory is locked in until 2019 at the earliest. Even the most ambitious increase in apprentice intakes from 2015 onwards would not alter it until the new intake had worked its way through to join the qualified workforce. Working purely with Australian-sourced labour, the only ways to lift either curve would be to reduce the duration of the training (virtually impossible to do with trainees who are already in the system, even if the legislation, the facilities and the approved curricula existed now), or to provide conversion training to already qualified tradespeople in occupations sharing many of the same skill sets. While the latter option is certainly worth consideration (and will be modelled later in this section), there seems little likelihood that it could be practically implemented within the next 2-3 years, even supposing the will were there. The unavoidable conclusion is that for most of the rest of this decade, Australia is condemned by its past underinvestment in training to fall steadily further behind the rising demand curves. By 2019 (albeit based on some less than watertight assumptions), Australia's total and civilian active workforces in the occupation can be expected respectively to have reached 79% and 74.5% of their 2011 levels – this in a context of steadily rising world demand, coming on top of already entrenched undersupply in most regions.

The greatest problem to be overcome in any effort to rebuild the workforce is the impact of attrition. As noted above, official Australian estimates of annual attrition in the years to 2013 ranged from a high of nearly 11% to a low of just over 3%, while forward projections prepared

<sup>26</sup> It is important in this context to note the advice received from an industry insider that around 50% of the civilian workforce at any given time is working on Defence aircraft. Since we have been unable to find any statistical evidence to verify or qualify this advice, it has not been incorporated in these calculations. However, it merits further investigation, since if confirmed, it would significantly complicate the task of building up a workforce sufficient to meet the future needs of the civil fleet.

by the US government for its national labour market suggested an average annual attrition rate of around 6.75% for the 12 years to 2022, regarded as a period of strong demand growth. Working on the ICAO's assumed standard rate, it would be necessary to raise the output of the training system in each year by an amount equivalent to 5% of the number employed in that year before the overall workforce size started to rise at all. To keep pace with the ICAO's estimate of 4.4% growth in the workforce required for the jet passenger/freight segment (coincidentally matching CAVOK's prediction for world MRO activity by value up to 2020), it would thus be necessary to increase the output of qualified workers by a minimum of 9.4% in each year, a severe challenge for the capacity of the training system – especially since at the current wastage rate, this would mean raising apprentice *intakes* by almost 12%. Even this is ignoring the existing backlog: to bring the predicted workforce in 2019 back to its 2011 size would need an *additional* output of over 3,000 graduating apprentices.

Clearly the undertaking would be hopeless if all the figures – demand as well as supply - were to remain at the levels shown in Figure 10.5. However, our modelling has shown that the projected supply curve is sensitive to quite small changes in the wastage and attrition variables, both of which are susceptible to significant change as a result of policy intervention, and our calculations of what is feasible need to take this feature into account.

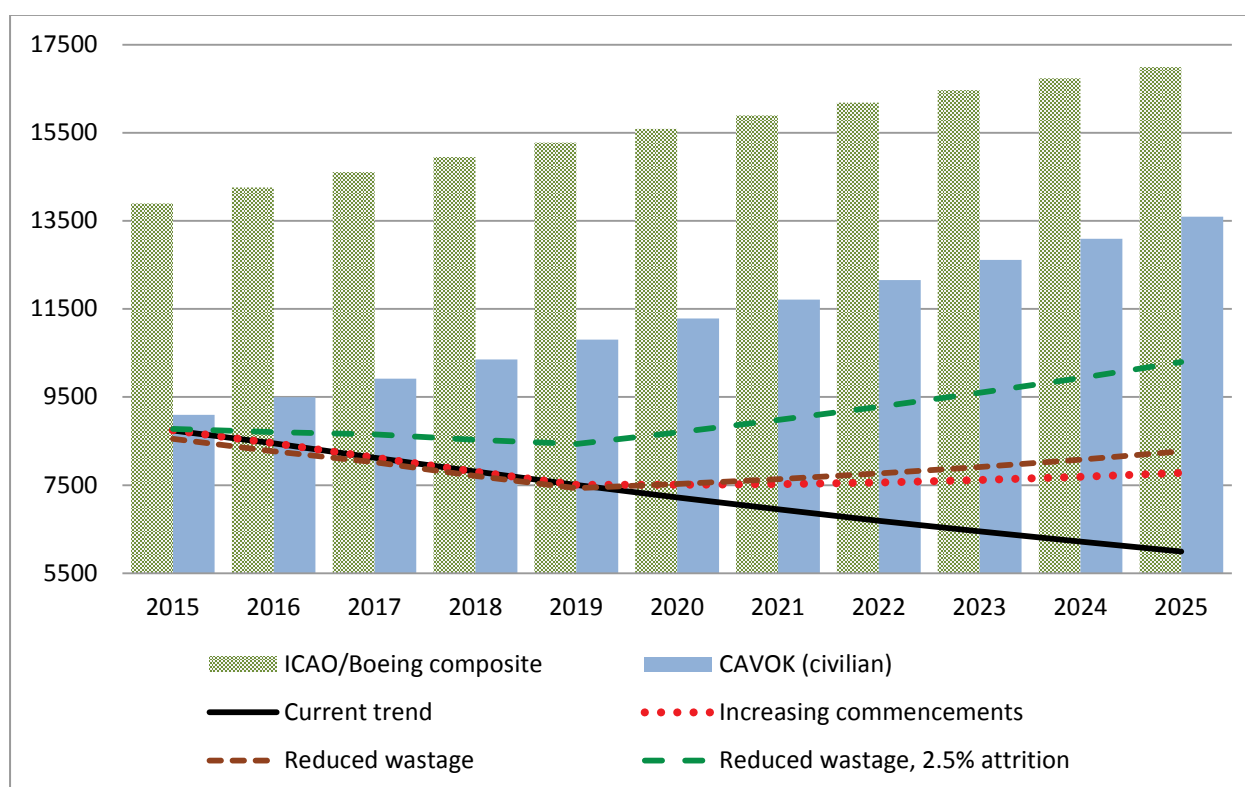
To illustrate how each of these features affects the outcome, we have modelled three notional scenarios highlighting the impact of each possible measure. None of these appears especially probable in the current state of the labour market; we have designed them to illustrate what could happen rather than what necessarily will happen. All of them start with the assumption that the apprentice intake will be sharply increased from next year, as no recovery is foreseeable if commencements remain at their present rate. The figure we have chosen for our first set of scenarios is 500 in 2016, rising by another 5% in each year. We consider this to be within the potential capacity of the Australian training system, given that it falls below the three largest annual intakes of apprentices in the last ten years (albeit as the combined intake of civilian and Defence training institutions).

For our next projection we look at the effect, on top of the increased intakes, of raising civilian completion rates to the same level as achieved by Defence, i.e. from its current six-year average rate of 78.7% to the 95.7% rate in Defence establishments over the same period,<sup>27</sup> and reducing attrition to the maximum extent which is theoretically achievable. For the purposes of this analysis we imagine the extreme case where every qualified worker entering the occupation at the age of 25 remains employed in the occupation and is not motivated to change occupations up to the current retirement age – i.e. where exit from the occupation occurs only as the result of retirement. If such a situation were ever to apply, it would theoretically be possible to reduce the long-term average attrition rate to 2.5%. Obviously we could not expect to see this theoretical minimum feasible rate achieved in reality over any sustained period, but it remains thinkable that by careful attention to continuity of employment and incentives to remain in the occupation, the rate could be reduced to around that point by targeted interventions for short periods, and held at a genuine 3.5% (i.e. more or less equivalent to the Department of Employment's last estimate of actual attrition over the five years to 2014) for a fairly extended period.

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<sup>27</sup> It should be noted, though, that these figures are averages over six periods starting in 2005, and conceal a high level of annual variation. This may partly be due to the September cutoff, which means that completions which actually occur within four years of commencement may not be recorded until the following year.

Figure 10.6 shows the results of these three scenarios, with the base scenario included for the purposes of comparison, set against the growth in workforce required by our two alternative demand scenarios. It is obvious that none of these, despite the bold assumptions involved, brings the output usefully closer to either of the demand scenarios. Simply increasing the intake does at least halt the decline from around 2019 onwards, though the trajectory from that point on remains little more than flat. Increasing the on-time completion rate introduces some net growth in the resultant workforce, but its impact is only marginal, suggesting a likely return to the 2015 level somewhere before 2030. The largest single contribution comes from the third scenario which combines these with a reduction in attrition to 2.5% per year. Manipulating this factor brings the dip in numbers down to only around 700 by 2019, after which they begin to rise encouragingly, though still not to the point where they would satisfy the likely demands of the labour market.



**Figure 10.6 Four scenarios of civilian workforce growth, 2015-2025**

*(September quarter, allowing for attrition in year to September)*

Even accepting that these initial scenarios involve investment at a level which we are unlikely to see in the next few years at least, it becomes clear that much more heroic measures would be needed to bring the workforce up to the required level within a decade. To begin with, any serious attempt to rebuild the workforce will need to involve some kind of joint cooperation between civilian and Defence training institutions, given the indisputable evidence in Figure 10.3 that Defence establishments have a capacity to cope with large one-off increases in the numbers in training, which does not currently exist within the civilian sector. This assumption seems reasonable in any case given the expectation, based on experience to date, that sooner or later a significant proportion of the Defence maintenance workforce will move on into civilian work. Over the next two decades we expect this crossover to be facilitated by three developments currently in progress: the pressure on Defence establishments to outsource their maintenance, or at any rate to have it done by civilian contractors rather than uniformed personnel; the expected transfer of much Defence apprentice training to the RTO sector, predictably leading to

more commonality in course content and qualifications; and growing commonality between the technology in use in civilian and Defence sectors, as technologies previously found only in military aircraft (e.g. all-composite construction, fly-by-wire controls) find wider application in the civilian fleet and common platforms come into use for non-combat aircraft such as the Orion replacement. As a result we expect the future AME workforce to be increasingly involved through independent MROs in a combination of civilian and Defence work, so that the two workforces will no longer be as strictly segregated as has been the case so far.

However, even if attrition can somehow be controlled to the bare minimum, it is clear that other inputs will be needed to bring about the necessary level of change. To this end we have calculated two alternative projections for what we describe as “boost scenarios”, since they would involve a major increase in effort by all parties, especially in the early years, to bring the output of qualified workers significantly above the attrition rate and closer to the levels of potential demand already calculated.

To begin with, it would be necessary to increase the growth in intakes to 10% (compounding) a year above the initial intake of 500 in 2016. This looks challenging at first sight, but still lies within the bounds of feasibility if Defence training facilities can be used to provide part of the boost, as even with this acceleration, it would not be until 2022 that the total intake passed 843, the maximum number that has been achieved by the combined sectors in a single year over the past decade. Since the corresponding amount of training was being carried out as recently as 2008 (or actually 2011, when the number of apprentices at all stages of their training was at its peak), the facilities should still be there (albeit mostly in Defence establishments), and there should in principle be an adequate supply of suitably qualified teaching staff still potentially available.

In a partial concession to realism, we raise the expected level of attrition to 3%, i.e. around the level implied (however improbably) by the 2014 Department of Employment estimate for the previous five years. We consider that it would be possible to hold attrition to around this level, at least until around 2020, though a problem may arise after that because of the age profile of the current workforce, which means that we can expect to see a spike of normal-age retirements at the beginning of next decade. Ignoring that practicality, this set of assumptions would be enough to bring the workforce back to roughly its 2011 level by around 2026. However, it fails to address the key deficiency of all the other scenarios up to this point, namely the big gap to the demand curves between around 2019 and 2021, when the skills shortage seems most likely to have its strongest impact on Australia, and indeed on the world generally.

For our final and most ambitious scenario, we assume two important additions to the supply which have not been covered in the projections so far. Firstly, we model the movement of Defence-trained engineers into the civilian workforce. Our assumption here (largely notional, as we have not been able to quantify the actual flow between sectors) is that one in three completing Defence apprentices will move into civilian work three years after completion (i.e., after working out their initial period of engagement). Secondly, and perhaps more significantly, we envisage a significant new accelerated component of training starting in 2016 and involving four annual intakes, which takes workers with similar skill sets displaced by the decline in manufacturing, and gives them a special two-year conversion training to qualify them as AMEs. We put the number so retrained at 500 in each year – once again ambitious, but feasible in the light of the amount of highly skilled labour likely to be shed from 2016 onwards as car manufacturing closes down in Australia. Assuming every one of these completes the program on schedule, this means an injection of 500 qualified recruits a year from 2018, two years before any additional investment in ab-initio training could have any impact on the overall numbers in the workforce.

This second boost scenario succeeds in bringing the workforce up to the point where it cuts the CAVOK curve in 2022, and tracks it fairly closely for the next three years. Effectively, it puts an “elbow” into the supply curve to bring it closer up the level of demand just at the point where the skills crisis is likely to be biting in Australia. A similar supplementary program would have equally useful consequences if it were added to one of the other, less ambitious strategies, though it would not bring the total up to the curve within this time period. By contrast, the transfer from Defence employment as modelled here does not contribute a great deal (a maximum of 188 in any one year, largely because we hold the level of defence completions constant at 120 after 2017), but would boost the size of the workforce appreciably in the longer term.

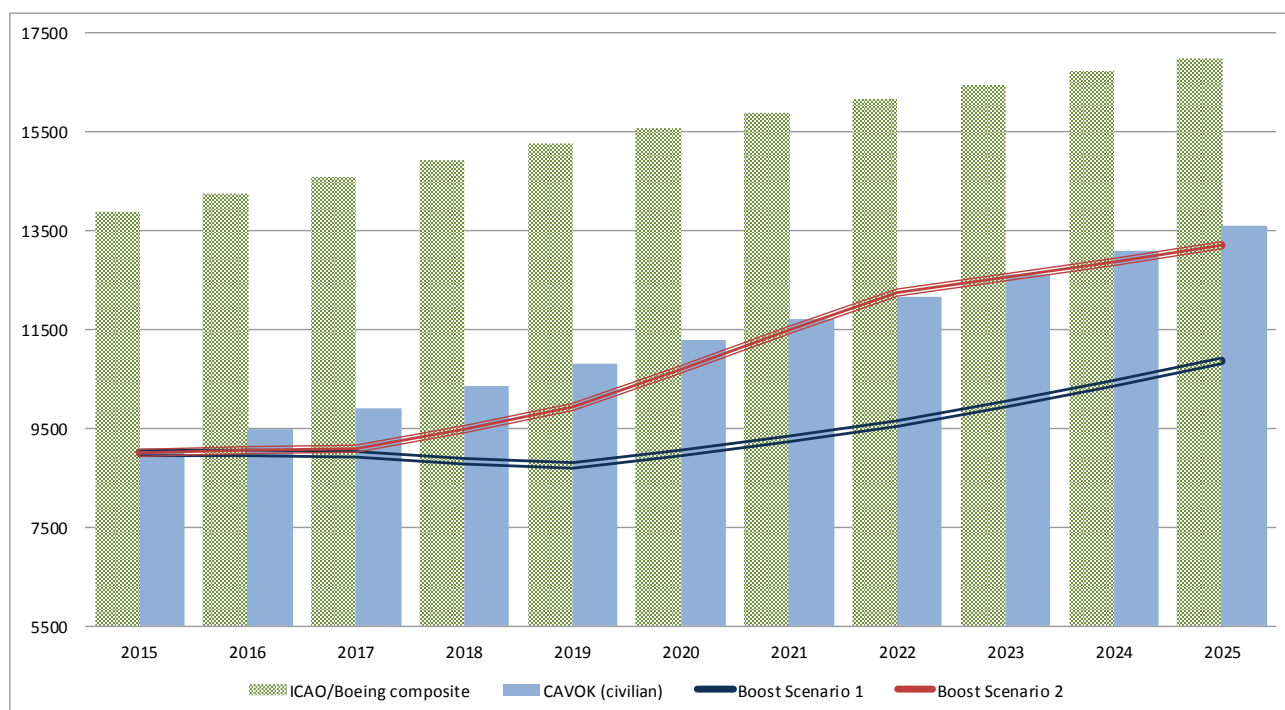


Figure 10. 7 Civilian workforce growth under two high-investment scenarios  
(September quarter, allowing for attrition in year to September)

We must stress once again that these calculations are put forward less as practical suggestions than for illustrative purposes, to show how the labour market works, and how much time and effort would be needed to bring the numbers in the skilled maintenance workforce back up from their present low point. The assumptions have been unashamedly manipulated to produce the best possible fit to at least one theoretical path of demand growth, and lend themselves to further manipulation to support an infinity of alternative scenarios which would be just as credible. Nevertheless, we feel confident that all the assumptions behind these models fall within the feasible range, suggesting that if the market demand, the investment resources and above all the political will were there, Australia’s aircraft maintenance capability could be built up again over the next decade.

On the other hand, while it would be possible with sufficient determination to build up the workforce in pace with the growth in global MRO activity, there seems based on these calculations to be very little prospect of Australia returning within the next decade to a position where it has sufficient skilled labour from its own resources to carry out all the work that has been offshored over the last decade. None of the scenarios tested has come anywhere near the composite ICAO/Boeing projection which lies at the lower end of the forecasts of labour need in



relation to fleet size and composition. It may need to be acknowledged that this opportunity has now been lost, for a long time if not definitively.

## 10.5 Conclusion

It seems increasingly clear that Australia is about to plunge unprepared into a world crisis of undersupply in MRO skills. The effect of that shortage – already a reality in many parts of our own region – will be to close off many of the easy options on which Australian carriers have relied to contain their maintenance costs. Even where those options remain open, prices seem certain to rise to the point where they will obliterate most or all of the savings which were originally made by moving the work offshore. Unfortunately the point has been passed where it would have been possible to undo the full consequences of ten years or more spent disinvesting in onshore capacity and underinvesting in civilian labour force development, as there seems now to be no practical prospect of Australia recovering the capacity to do all its own maintenance within the foreseeable future.

Certainly Australia still could, and should, regain a substantial slice of work currently done overseas. However, doing so would require a coordinated strategy that included combining the capabilities of civilian and Defence training facilities, managing the level of wastage within the civilian training system (e.g. through more stringent screening of applicants for apprenticeship and creating certainty that jobs will be available after graduation), and above all, serious investment in new training and retraining. More importantly still, it would mean applying the brakes on the current rate of attrition among those already employed. This implies the need for an immediate moratorium on further headcount reductions, backed up by incentives to retain existing workers in the industry, since the calculations in the previous section demonstrate clearly that Australia is doomed to fall further behind so long as it keeps prematurely shedding experienced workers.

Realistically, such a strategy would also need to be judicious about which areas of work take precedence for new investment. In particular, heavy airframe maintenance, now generally recognised as a labour-intensive, low-margin segment, no longer looks like the first candidate for onshoring — at any rate on economic grounds.<sup>28</sup> Nevertheless, as the combined arguments of chapters 6 to 8 suggest, there may well be a case for bringing more of it back on to Australian soil on grounds of safety, reliability or other considerations not reflected in cost or dollar return. Given that there are limits on the size of the skilled labour force which Australia can maintain from its own efforts, it would probably make sense strategically to concentrate resources on rebuilding capacity in an area such as engine overhaul where Australia's labour costs do not put it at such a cost disadvantage, and where the longer-term returns look like being sufficient to justify patient investment over the next few years.

Yet if the skills crisis does develop to the extent some have forecast, a time may come – most likely within the next five years – when Australian carriers will be grateful for any skilled workers they can get on home soil. Just as importantly, so will our region. Based on the CAVOK estimates of world technician population and our own projections of the Australian AME workforce since 2011, Australia in 2015 has some 2.65% of the world's stock of qualified technicians. In 2010, the ICAO estimated that the entire Asia-Pacific region had only 14% of the world maintenance

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<sup>28</sup> The economic case may change as the proportion of new-generation airframes in the fleet increases, since major inspections and overhauls on these aircraft are likely to involve more sophisticated and less labour-intensive processes, and OEMs are expected to take a greater share of heavy maintenance work on their own products. In particular, Boeing's strong on-ground presence in Australia may offer commercially viable opportunities for onshore heavy maintenance on the 787 and subsequent designs.

workforce. While it is virtually certain that this latter ratio has shifted substantially in the intervening five years, it remains a safe assumption that Australia's MRO workforce represents a substantial presence within the region, out of all proportion to its share of population or the size of its register, which is likely to be in growing demand as supply falls further behind the requirements of servicing the Asia-Pacific fleet. So long as Australia acts in time, there remains a very strong likelihood that by the early 2020s we can become a net exporter, if not of MRO services, then certainly of MRO skills and expertise.

The problem is that in 2015, though our most recent industry contacts have hinted at signs of movement, the general impression is that market forces in Australia are not yet responding to the anticipated spike in demand. As the calculations in the preceding section demonstrate, it is not possible to bring about a major growth in the qualified Australian workforce overnight. If Australia is to be in a position to seize the opportunities offered by the skills crisis, a major effort will need to be made now. However, there appears currently to be little enthusiasm from either the Commonwealth or the industry for making such an investment, and the training sector, bound as it is to a "responsive" investment model, necessarily continues to trail behind government and industry.

In other words, by the start of next decade, market forces alone could be enough to provide employment for the entire surviving Australian skilled workforce, and to support the necessary level of investment in workforce development. The challenge lies in bridging that gap until the Australian market responds.

#### **RECOMMENDATIONS**

- **RECOMMENDATION 20:** That an emergency initiative be funded to restore the number of apprentices in aircraft maintenance engineering at least up to replacement level.
- **RECOMMENDATION 21:** That in view of the near certainty that the world faces a serious shortage of qualified aircraft maintenance engineers, the occupation be restored immediately to the Skilled Occupations List.
- **RECOMMENDATION 22:** That immediate action be undertaken to identify the reasons behind the current level of wastage within the civilian training system and increase the rate of on-time completion.
- **RECOMMENDATION 23:** That incentives be provided to airlines and MRO providers to retain experienced L/AMEs in productive employment, pending a spontaneous recovery of the labour market, in order that Australia should continue to have a basis of expertise for training and mentoring the next generation of skilled workers.

# Chapter 11 Aircraft Maintenance – Future Role in Regional Development, Trade, Security and Innovation

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We turn to a consideration of how best to secure the economic contribution of the MRO industry and its workforce to regional development, to economic self-sufficiency and export earnings, to national security, and to innovation. The first step is to weigh the benefits and costs of ensuring a strong role for an Australian aircraft maintenance, repair and overhaul capability within a national aviation and aerospace industry.

## 11.1 Establishing impact, benefits and costs

We begin by identifying the most informative approach to determining the economic impact of the MRO industry. In cases where there are externalities such as safety, national security, regional development, and capacity for innovation, it is important to look beyond the annual budget cycle and short-term shareholder profits, in order to assess an industry's potential impact through a longer-term public policy approach. The contribution of all stakeholders — the three tiers of government, airports, training providers and associations of industry stakeholders (employer and employee organisations) — need to be considered, alongside the activities of individual air operators, original equipment manufacturers (OEMs), manufacturing suppliers and MRO providers and contractors. In the volatile aviation industry, the decisions of individual players such as air operators will almost of necessity prioritise short-term shareholder value. In a version of the prisoner's dilemma, cost-minimising maintenance approaches may then prevail over a longer-term investment approach and actually stand in the way of the benefits of adaptive innovation that a longer-term perspective would otherwise bring to the industry collectively, and thus to the national interest.

Metrics for calculating wider or longer term impacts of industry investment decisions include public accounting tools, such as benefit/cost analysis. This approach is normally used to choose between alternative investment decisions, based on a range of assumptions about time frames, the imputed value of non-market items, and discount rates (the relative social valuation of present and future benefits). Concepts used include: multiplier effects on local or national economies; accelerator effects, for example of research and development (R&D) ventures; and the spillover or diffusion effects of technology hubs, logistics chains or skill ecosystems.<sup>1</sup> In the case of aerospace, impact assessments need to consider lagged effects and geographically diffuse impacts.<sup>2</sup>

The methodology for calculating local, regional, state and national multiplier and catalytic effects is well developed in the US, particularly in relation to airport operation, where in 2008, no fewer than 58 such analyses were reviewed in a study carried out by Karlsson et al. for Federal Aviation Administration (FAA), under the auspices of the United States (US)

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<sup>11</sup> Boddy and Lovering, 1986; Finegold, 1999.

<sup>2</sup> Cole, 1989; Nioso and Maljinda, 2005. An Oxford Economic Forecasting (2006) study estimated the “ripple” effect of air transport usage across Europe over the previous decade as a 4% GDP increase, through direct impacts on trade and tourism, and catalytic impacts on business investment and productivity.

National Academies of the Sciences.<sup>3</sup> The review identified three main impact assessment methodologies. The first is the *input-out* method, typically summing impacts that are direct (site-based), indirect (off-site) and induced (generated economy-wide by successive rounds of spending). The second approach is the *collection of benefits* method, which assigns a value to quantitative and qualitative indicators of benefits and costs (such as time saved, capacity stimulation, social amenity and community benefits). The third approach is the *catalytic or spillover* method, identifying flow-on impacts on trade, investment and productivity.

The 2013 NSW Business Chamber study of the *Economic Impact of a Western Sydney Airport*, conducted by Deloitte, applied the second of these methodologies.<sup>4</sup> Whilst convincingly argued in the areas it covered, the Deloitte study focused heavily on the multiplier impact of passenger numbers and freight volume in building local service industries and did not consider the role of maintenance, maintenance training and the embeddedness of maintenance work in a technologically advanced manufacturing supply chain. The Karlsson review had found that other omissions were common in airport studies, and we add in brackets further aspects particularly relevant to MRO work:

Integration into global supply chains (including aircraft on the ground (AOG) work);

- Adjacent commercial development attracted to the vicinity (including manufacturers in the supply chain of components and processes used in MRO workshops);
- Reliance on aviation by industries such as research and development (and maintenance and flight training organisations);
- Growth in general aviation specialty modes such as business aviation, fractional ownership, very light jets in the context of globalisation, and the attendant maintenance business opportunities.

Even without these further impacts, the most conservative estimates typically calculate the value of indirect benefits as *double* that of the direct economic contribution.

A specific US example is available of the impact when an airport, with local and state government support, attracted an aerospace manufacturing organisation to establish new maintenance and manufacturing facilities onsite. Beginning in 2006, Savannah Airport Corporation, Georgia, offered infrastructural incentives for Gulfstream to establish a \$300m maintenance facility. Subsequently, with support from the Georgia state government in the form of tax incentives and 300 subsidised training places, Gulfstream added facilities for manufacturing, aircraft painting, R&D and a global parts distribution hub, as well as establishing linked maintenance facilities interstate. The development is estimated to have created 2,900 direct jobs between 2006 and 2015, and to have provided a net fiscal return to Georgia that was more than double government outlays.<sup>5</sup>

Another type of impact analysis carried out in the US is represented by periodic efforts to quantify the contribution of the general aviation (GA) sector as a whole to the national economy. These studies are commissioned from PricewaterhouseCoopers by eight industry associations working in the GA sector.<sup>6</sup> This group of associations, and hence the impact

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<sup>3</sup> Karlsson et al., 2008.

<sup>4</sup> Deloitte Access Economics, 2012.

<sup>5</sup> Lynch, 2014; Markiewicz, 2010; Mayle, 2014, Swickard, 2010.

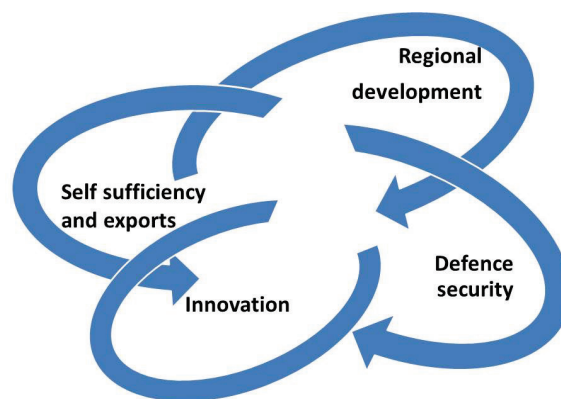
<sup>6</sup> PricewaterhouseCoopers (PwC), 2015.

analysis, cover aircraft manufacture as well as operation and maintenance. In the US, the GA sector is defined, not in terms of aircraft weight, but in terms of activity: it includes all FAA-airworthiness-certified aircraft not used for military or scheduled passenger flights, and thus includes business jets. Based on 2013 data, covering flight operations, component manufacture, maintenance and other activities, the study estimated impacts in terms of *direct* GA industry activity, *indirect* supply chain activity, *induced* employee and proprietor spending based on income from such activity, and *enabled* spending by visiting passengers. It found GA to have contributed between 0.6% and 0.75% of all US employment, income, output and gross domestic product (GDP). The total impact was approximately 4 times the direct impact in the case of employment and GDP and 3 times the direct impact in the case of income and output.<sup>7</sup> In other words, each job in GA created 3 other jobs, and each dollar of output created two more dollars' worth of output elsewhere in the economy.

These findings, from different types of impact studies, all seem to suggest that indirect social and economic returns from outlays in the aviation/aerospace industry have a value that is at the very least twice the value of direct outlays. To this return can be added the potential benefit if Australia moves quickly to meet the emerging maintenance and maintenance training gap in the Asia Pacific region, identified in Chapter 9. It is for these reasons that the support of governments at all levels, and coordinated action by aviation and aerospace industry bodies, are needed, in order to bring about overall benefits that could considerably outstrip the total impact of isolated initiatives.

## 11.2 Aviation/aerospace - hubs, clusters or networks?

The rest of this chapter examines the potential contribution of MRO and related manufacturing work under the four headings of the chapter title: regional development; trade balance (national aviation self-sufficiency and export potential); defence security and contribution to manufacturing innovation. It is somewhat artificial to isolate these benefits, because the best way of achieving them is through inter-related “lobes” of activities that are part of aviation/aerospace hubs, clusters or networks (Figure 11.1).



**Figure 11.1 Potential benefits of aviation/aerospace hubs, clusters and networks**

The concept of a “hub” is often used to describe geographically-concentrated clusters of aerospace and aviation activity, generally focused on an airport. For example the Chinese government is reportedly investing heavily in building an aviation hub or “airport city” at

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<sup>7</sup> PricewaterhouseCoopers (PwC), 2015.

Zhengzhou in land-locked Henan province. The elements of this airport cluster are international and national freight and passenger transport, linked to rail and highway development. The Chinese government has negotiated a memorandum of understanding with Boeing to explore the future introduction of aircraft assembly line, distribution and maintenance capacity in Zhengzhou.<sup>8</sup> This is a top-down model, heavily dependent on government infrastructure investment and planning.

There has been no shortage of other attempts to create “aerospace hubs”, some top-down (Abu Dhabi; Asia Aerospace City in Sebang, Malaysia),<sup>9</sup> others based on local initiative (Dayton, Ohio).<sup>10</sup> If only because of differences in geographical concentration, the Changi MRO cluster or over 100 companies – estimated to be 20% of the Asia-Pacific MRO market<sup>11</sup> – is not likely to be replicated in Australia. There was an unsuccessful attempt to create a “precinct” or hub around Avalon in 2013. It may be thought that the “hub” idea has been overworked, and that heavy investment in infrastructure is insufficient if the technological traditions and skills base are missing. Nevertheless, it will be argued below that Adelaide/Parafield and Williamstown are emerging as geographically-concentrated hubs, and that a greenfield site such as Badgerys Creek, is well-placed to form the nucleus of aircraft maintenance and maintenance training, in large part because of the existing concentration of defence contractors, small to medium MROs and aerospace manufacturers in Western and Southwestern Sydney.

Geographical concentration is not the only model for fostering the development of the industry: regional clusters and supply networks may be more geographically dispersed. The Queensland government has since 2011 been promoting the whole state as “An Asia Pacific aviation and aerospace hub”, claiming over 900 aviation and aerospace companies (said to be 30% of the national number).<sup>12</sup> Action plans such as that of the Queensland government, depend on public subsidies. They may either seek to attract businesses or support local businesses in export drives. The Queensland initiative adopts a wider definition of a “hub” than one based on a single airport identifying cluster strengths – pilot training for the Gold and Sunshine Coasts, GA around Wide Bay and Burnett; Defence links in Rockhampton-Townsville.

The notion of “cluster” is a better one than “hub” for describing such geographically dispersed networks, organically linked from “below”, through the initiative, for example, of industry organisations. An example relevant to Australia is the Polish Aviation Valley Association, formed in 2003, as a non-profit organisation with the objective of accelerating the development of the aerospace industry in south-eastern Poland. With a 2014 membership of 125 organisations, the Association aims to create a low cost supply chain of reliable sub-contractors, foster aerospace research and skill formation in order to improve the manufacturing base, attract foreign investors and protect aerospace businesses, influence government economic policy and develop

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<sup>8</sup> Andrews, 2015; Li, 2014.

<sup>9</sup> Al Majed, Z (2009); Asia Aerospace City (AAC), 2015.

<sup>10</sup> Ohio Aerospace Hub (n.d.).

<sup>11</sup> Civil Aviation Authority Singapore (CAAS), 2015.

<sup>12</sup> Asia-Pacific Development Reporter (APDR), 2011. This figure implies 3,000 nationally, compared with the 923 listed in Chapter 3. The discrepancy can be explained by our non-inclusion of small air operators with no maintenance capability, our counting only the headquarter state for companies with a presence across several states, and our culling-out of any firms whose current MRO-linked activity could not be verified from a website).

a relationship with other centres of the aerospace industry. It has been able to attract significant funding from OEMs such as Pratt & Whitney, Agusta Westland and Sikorsky.<sup>13</sup>

In Australia, there is a range of aerospace and aviation networks, aimed at sharing industry information and raising the profile of the industry. We return in Section 11.8 to a way of using such networks as an industry-government-airport catalyst to in interweaving and leveraging the four main types to be reaped from building a national, export-focused MRO industry: regional development; national economic self-sufficiency, defence security, and innovation. First, however we discuss in turn and in more detail, each of the four benefits.

### **11.3 Regional development**

Earlier chapters have documented the pivotal role played by safe, well-maintained aviation services in ensuring quality of life in regional and remote Australia. It has been demonstrated that regional airlines are particularly vulnerable when they operate routes carrying less than 30,000 passengers a year, that their fleets are considerably older than those on main route regional public transport (RPT) airlines, and that efforts to convert charter operations into RPT using smaller aircraft at or under the upper GA weight cut-off have been hampered by the lack of maintenance services. The latter problem has arisen from the (necessary) safety requirement that RPT aircraft be maintained by Part 145 approved maintenance organisations (AMOs), whereas most regional and rural GA sector MROs have not yet been able to complete the expositions required. Small operators in the regional and GA sectors have been particularly hard hit by the skill recognition problems attendant on the transition to the European Aviation Safety Agency (EASA) system. On the higher volume routes, the 30 regional airlines in Australia are operated by a mix of major airline subsidiaries, several low cost carriers (LCCs), and locally and overseas owned carriers. Many carry out maintenance in-house or use tied or independent MROs.

Chapter 3 noted that a 2014 NSW Parliamentary Committee recommended that regional RPT be classed as an essential service, and reported the Committee's finding that some regional and rural airports were being maintained at a loss by local government authorities because of the vital role of these airports in rural fire and medical services. The 2015 Federal budget has made provision for a 4-year RAAP (Rural Airport Access Program) to provide support for remote non-viable but essential aviation services and for airport upgrades. Unfortunately, support for MRO activities is not part of this arrangement.<sup>14</sup> Support for remote-area sign-off of MRO work remains an unresolved issue. Local government authorities have adopted various strategies to maintain the airports for which they have been responsible since the early 1990s and to address the MRO issue. Coonamble Shire has reported plans to employ a licensed aircraft maintenance engineer (LAME) on its payroll, in order to provide local sign-off for MRO work. Temora has made a (fully-subscribed) release of land and hangar sites adjacent to the airport to attract recreational aviators, in an effort to cross-subsidise other aviation and MRO work.<sup>15</sup>

Several larger regional centres have also made judicious use of government support in order to attract air operators and MRO activity. Tamworth Council was able to use a contract with BAE Systems for the use of the airport in the provision of basic Australian Defence Force pilot training, as the basis for establishing a control tower and subsequently for becoming a secure airport. As noted in Chapter 3, by contributing with State government support to the

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<sup>13</sup> Aviation Valley, 2014.

<sup>14</sup> Department of Infrastructure and Regional Development (DIRD), 2015.

<sup>15</sup> NSW Parliament Legislative Council, 2014, pp. 70-71.

construction of hangar space, the Council was then able to attract Qantaslink to undertake heavy maintenance of its Dash-8 fleet. In 2015, BAE Systems transferred its contract to Gippsland, so it is to be hoped that Tamworth Airport will continue to function as a training hub, based on networked arrangements between TAFE New England and South Western Sydney Institute of TAFE for joint delivery of offshore flight and maintenance training, for example to the Chinese market.

A further success story of the contribution of MRO to a regional economy is that of Williamstown airport outside Newcastle in the NSW Hunter Region. This example also illustrates the contribution of MRO national security, as Williamstown is one of several airports shared between Defence (the RAAF) and local government (In this case Newcastle City and Port Stephens Shire Councils). Jetstar, Qantaslink, Virgin, the regional airline Rex and small phoenix carrier FlyPelican currently use the airport, and the airport is exploring a contract with Air Asia. At present the largest aircraft to use the airport are Virgin's B737-800s, although there is runway capacity for heavy widebodied aircraft. Jetstar inherited Qantas' Williamstown maintenance hangars and upgraded them in 2005 as the ongoing site for its A320 fleet maintenance. Recent and planned extensions include apron upgrades for aircraft up to the A380 and B787. With infrastructure and financial support from the state government, adjacent civilian and Defence airport facilities have been undergoing rapid development, successfully attracting tenants such as Lockheed Martin, and contracts for ongoing and expanded activities by BAE Systems and Jetstar. Very significant regional multiplier effects have been attributed, not only to the Defence presence, but also to the Hunter network of small and medium manufacturing, engineering and technology firms that are being sustained by their roles in supplying airport MRO operations.<sup>16</sup>

The examples of Newcastle and Tamworth, however, are hardly typical of the rural and remote end of the non-urban spectrum. Chapter 3 has identified the need for a new RPT/charter interface at the borders between the GA and regional aviation sectors, as well as the need for innovation in the GA sector. At the moment, sectoral investment in innovation, such as very fast turboprops, is just beginning – with the first quarter's CASA-approved charter operation of a TMB 850, leased by Wagga Air Centre from a rural doctor.<sup>17</sup> A rural and regional aviation and maintenance innovation fund, to support the renovation of air operation in the sector, is greatly needed.

Northern Territory aviation illustrates some of the turbulence associated with the regional airline sector, and the characteristics of a small mixed-function GA sector. Regional airline Vincent Airlines collapsed in 2012, and from 2015, 85% of the former Capiteq ownership of Air North is now with Western Australia based global civilian/Defence contractor Bristow. Both Air North and the regional airline/charter operator Hardy Aviation, with its small aircraft subsidiary Fly Tiwi, operate out of Darwin, and along with RPT/charter operator Chartair, are the only three Northern Territory operators with Part 42 Continuing Airworthiness Management Organisation (CAMO) approval. Maintenance for Air North is carried out by tied contractor Capiteq/Air Logistics. Hardy and Chartair also have Part 145 AMO status.<sup>18</sup> Several helicopter operators have in-house maintenance capacity. At last count in late 2014, there were a further 6 MROs servicing the GA sector in Darwin and 8 in regional and rural areas, including one in Alice Springs and one in Katherine, ranging from avionics specialists through AOG service providers to mixed charter-maintenance businesses. It goes without saying that the Northern Territory is heavily dependent on aviation and hence on the MRO work that keeps its aircraft flying.

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<sup>16</sup> Williamstown Aerospace Centre, 2015.

<sup>17</sup> TMB Daher, 2015.

<sup>18</sup> Australian Broadcasting Corporation (ABC). 2014; Bristow, 2015; CASA, 2015b; Hardy Aviation, 2015;



Chapter 3 provided figures suggesting that, in numerical terms, GA operation, mainly charter and aerial work, accounts for 91% of fixed-wing aircraft and 76% of independent MRO businesses. An urgent case can be made for supporting the economically-vital rural and regional aviation sector, by assisting operators and MROs, particularly in the GA sector, to update their capacity and have it recognised. The most urgent need is to attend to the outstanding problems of licence recognition, skill upgrading and maintenance organisation and maintenance management approval, resulting from the very drawn-out process of completing the regulatory basis of the transition, in a way that does not preclude the continued use of long-standing expertise.

#### **11.4 Trade balance: National self-sufficiency and export potential**

Aircraft maintenance is an area of work with high export potential in an increasingly undersupplied world market, and governments should therefore provide the kinds of assistance and investment appropriate to an emerging export industry.

So far as the home market goes, a concerted policy effort is required, involving governments, airports, third-party MROs and OEMs as well as full utilisation of the airlines' own maintenance capacity, to repatriate as much heavy maintenance as possible within the few years before the skills crisis really begins to bite. This repatriation could most easily start with the domestic single-aisle fleet for which suitable facilities already exist in Australia, but it will also be important to seek out opportunities in the widebody segment as the number of widebodies in service on domestic routes grows to the level that would make this economic.

In all these regards, the 21 federally-leased airports, working with government at all three levels, can make an important contribution to ensuring that Airport Master Planning processes, undertaken every five years, are fully integrated into the project of working with air operators, MROs and OEMs in order to rebuild Australian maintenance and maintenance training and ensure the infrastructure that will allow Australia to play a leading role in meeting the projected Asia-Pacific maintenance and maintenance training shortfall.

The example of Brisbane Airport is instructive. Its 2014-2034 Master Plan pitches the airport as a focus for both national and state economic activity, and also as an international gateway. Although Archerfield is the main GA airport, the Brisbane plan also makes provision for expanded GA operations and business jet services. The plan allocates two new areas within the precinct for expanded maintenance work via runway and landside access, and new hangar facilities; as well as paint shops, and accommodation for upholstery repair, instrumentation, and component supply and maintenance; and for "associated training and education facilities". It also makes explicit provision for a wide range of industry and business uses, including manufacturing. Specifically identified are clean low impact industry research and technology facilities, knowledge creation and entrepreneurial activities and service industries compatible with urban areas (p. 85). The Plan caters for expansion by existing operators/OEMs (Qantas Airways, Virgin Australia, Five Star Aviation, Alliance Airlines and Airbus) and for attracting new airlines, and further relocations.<sup>19</sup> It is not altogether surprising then, that Qantas has used Brisbane airport for the refurbishment of its A330s, and that two of the nation's five Part 147 Category training MTOs are in Brisbane.

Where smaller aircraft are concerned, there is doubtless a temptation to assume that the Australian market is already captive and needs no further courting. However, this assumption ignores the acute requirements of the regional and rural aviation sector, identified in the

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<sup>19</sup> Brisbane Airport Corporation, 2014, pp. 70-83.

previous section, along with the ageing of the regional and GA fleets, and the impending requirement for new maintenance techniques and conversions, for example the installation of avionics upgrades in smaller fixed and rotary wing aircraft. It also ignores the growing pressures, especially among private aircraft operators, to seek exemption from the requirements of VH-registration, either by modifying their aircraft to qualify for the less demanding scheme administered by Recreational Aviation Australia, or by lobbying to have similar provisions extended to other small non-commercial aircraft. Indeed, there may well be a small but continuing consumer-driven market for third-party maintenance in non-VH recreational aviation even where regular inspections and overhauls are no longer strictly required by law, and may leave something to be desired in terms of regulatory stringency.

Looking further afield, there is also an opportunity to make Australia a regional service training hub for heavy maintenance and AOG services in the emerging and maturing helicopter, regional jet and business jet markets. With countries like China just entering the business jet scene, and yet to unleash the growth of GA, Australia would arguably have a first-mover advantage if it geared up to be both an exporter of on-ground maintenance services outside Australia, and an exporter of GA maintenance training. By combining both these avenues of potential expansion, it might be possible for GA maintenance providers to build up the economies of scale which many of them currently lack.

The helicopter market offers particular opportunities for exploration. For example Parafield TAFE, in South Australia,<sup>20</sup> is well placed to provide training in the installation of the helicopter autopilot upgrades now available.<sup>21</sup> The international MRO provider Helisota has recently commented on the maintenance skills gap in Brazil and other Latin American countries, resulting from the rapid growth of the helicopter industry. Helisota, Agusta Westland and Russian Helicopters are reportedly all planning to open South Pacific helicopter maintenance bases, but have expressed concern at the lack of skills training.<sup>22</sup> With Agusta Westland already a Sydney-based CASA-approved Part 147 type training organisation, there is an opportunity here to provide the international training market. With the right government assistance, there is a real opportunity for Australia to provide Southern Hemisphere helicopter maintenance training capability.

## **11.5 Security**

Safeguarding the strength of Australia's civilian MRO capability is in the last instance an issue of national security. Without domestic reserves of capability, Australia is dependent on offshore sources of MRO supply. Such supply lines would be vulnerable to disruption under certain international relations scenarios which may not involve outright hostilities but could be as simple as the refocusing of other nations' aviation/aerospace efforts.

Civilian contractors to the Australian Defence Forces tend to operate at the developmental and non-routine end of MRO work, and thereby contribute to a deepening of national MRO expertise. At this end of the spectrum, there is a continuum between MRO, OEM and Tier 1/Nadcap accredited supply chain work. The interlinking of Defence and civilian MRO work is to mutual benefit. The requirements of large civilian and Defence MROs call forth the project work-

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<sup>20</sup> During the course of writing this report, we understand that Parafield was close to gaining, or had gained, Civil Aviation Safety Authority (CASA) Part 147 category training approval, although the fact was not reflected on the CASA website.

<sup>21</sup> *Rotor and Wing*, 2015a.

<sup>22</sup> *Rotor and Wing*, 2015b.

based development of specialist techniques from advanced manufacturers. The application of these techniques tends to flow back and forth between Defence and civilian OEMs/MROs. The implication is that an erosion of this non-standard capability in both MRO work and advanced manufacturing, and a “thinning out” of the critical mass of skill in which the organisations using these technologies are participants, would constitute risks to national technological self-sufficiency, and could ultimately pose a security risk.

Examples of the civilian/Defence interface are listed in Appendix 3.23

At the airport level, both civil and Defence aviation stand to benefit from interaction. A number of airports are leased from the Department of Defence, unlike the 21 major civilian airports leased from the Department of Infrastructure and Regional Development. Newcastle Airport, already mentioned as a regional development exemplar, is a tenant of the Department of Defence. The RAAF provides infrastructure and services to civilian air operations at the airport, including an instrument-landing runway, able to take B737-800s and wide-bodied aircraft, staffing of the control tower and emergency safety services. The exchange works both ways: BAE Systems has had a presence at the adjacent Williamstown Aerospace Centre for almost 20 years, assembling two-thirds of the RAAF’s Hawk 127 Lead in Fighters, and collaborating with the training supplier CAE to install customized flight-training simulators. In August 2015 BAE Systems concluded a new contract, involving the recruitment of 116 new employees, to deliver “deeper and operational maintenance” to the Hawk fleet.<sup>24</sup> Townsville airport is partly leased from the Department of Infrastructure and Regional Development and jointly operated by the Department of Defence and Townsville Airport Pty Ltd, with the Department of Defence having control of runways and taxiways. In its most recent Master Plan,<sup>25</sup> the airport made provision for a post maintenance and testing facility in the aviation precinct — a further indication of the overall argument that civilian MRO capability is intertwined with Defence activity in such a way that the erosion of civilian MRO capacity will be to the detriment of national security.

The restriction of our current project to the future of the civilian MRO has prevented a detailed analysis of the interaction between Defence and civilian MRO work: a follow-up project focusing on Defence MRO work and training is required. What we have been able to ascertain, from the 708 respondents to Wave 1 of our 2013 AME survey, is that,

A total of 118 (17%) had begun their maintenance working lives in Defence;

Of these, the largest number (50) had ended up in Qantas, with another 21 finding their way into GA or helicopter maintenance and 14 into work with independent MROs;

Only one person reported beginning in civilian MRO work and ending up in Defence.

These figures probably reflect the simple fact that our survey was not distributed amongst maintenance engineers currently working in the Defence services. But they may signal the future possible benefits of a closer alignment of training and safety standards between the two sectors.

The examples provided, however, make one key point. A thriving Australian MRO capability, including a capacity for heavy airframe maintenance and component overhaul, is needed to enhance our capacity to take a role as a self-reliant nation in the region, working with OEMs, to participate in the civilian developmental and modification work that provides our Defence

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<sup>23</sup> In Appendix 3, see the Defence contracting and supply chain examples among the brief case studies under Tables A3.1 to A3.5.

<sup>24</sup> BAE Systems, 2015b.

<sup>25</sup> Townsville Airport Pty Ltd. 2011

services with advanced capabilities. The end result of diminishing our MRO training effort would be to risk compromising our national security.

## **11.6 Innovation**

Whilst Australia is at the moment a long way from being able to compete in the global MRO market in terms of volume, it can gear up to contribute to the impending shortfall, focusing particularly on niche markets, quality and innovation. The capacity for innovation is a reason why Australia is Boeing's second largest footprint outside the US, why Airbus has acquired a local presence through the acquisition of Australian Aerospace, and why the Swiss OEM RUAG in 2012 acquired Rosebank in Melbourne, employing its staff of over 100. It is almost as if OEMs have a better understanding of the value of the Australian skills base than the air operators.

Dr Ian Thomas, delivering the 55th Annual Kingsford Smith Lecture to the Royal Aeronautical Society as President of Boeing Australia South Pacific in 2013, noted that in integrated global supply chains, nimbleness is rewarded and Australia is "in there with a chance", because the key challenge is "not big beats small but quick beats slow". He outlined the importance of integrating R&D with manufacturing in a design/make/deliver model. As we have seen in earlier chapters, the growing importance of afterservice means that the model has become one of design/make/deliver/ maintain/repair/recycle. Maintenance capability is increasingly interlinked with manufacturing capability, both in terms of theoretical understanding, and in terms of working with the technology. Dr Thomas expressed the view that in developing automation, biomaterials, nanotechnology, robotics, molecular precision, flexible fabrics, micro production, and in the creation of light cheap high quality parts, Australia has a solid future and "can compete in the Asian century".<sup>26</sup>

The question then becomes one of whether the Australian MRO industry will be in a position to participate in this same nimbleness of response, in helping to meet the coming national and Asia-Pacific demand shortfall. What part can Australia potentially play, in meeting the ongoing need for maintenance, upgrading and parts recycling of aircraft such as B737s, which will continue to comprise half the global market until 2025? How well are Australian MROs being assisted to implement advanced diagnostic techniques on existing aircraft, such as hull-scanning robots and non-destructive testing of wheel assemblies and engines?<sup>27</sup>

None of the examples in this chapter gives rise to confidence that air operators on their own are in a position to be initiators, rather than adopters, of innovation. A national aviation/aerospace innovation strategy is needed, in order to identify strategic approaches to capitalising on the full potential contribution of aircraft MRO to the future of the industry as it transitions.

## **11.7 Capitalising on the full potential contribution of MRO to aerospace/aviation industry development**

This chapter has established that approaches to achieving the four goals of aerospace/aviation industry development — regional development, enhancing the balance of trade through supporting national self-sufficiency export potential, defence security and innovation — are intertwined.

Following on from Chapter 3, it has illustrated how MRO work contributes to, and/or benefits from, the work of:

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<sup>26</sup> Thomas, 2013.

<sup>27</sup> Kivits, Charles and Ryan, 2010. .

- Air operators in the international, main route domestic, regional and GA sectors, both as in-house maintainers and as contractors of maintenance services;
- Contractors to Defence, supplying a range of equipment and services, from whole-aircraft reconfiguration, through logistics, to the design and installation of integrated systems, and component through-life-service;
- Independent MROs, providing routine maintenance checks through repair, testing, on-wing and major component overhaul, interior reconfiguration and refitting, and nose-to-tail exterior repair and repainting, operating within and across the airline and GA sectors;
- OEMs and their supply networks of manufacturing and afterservice maintenance providers;
- Providers of MRO training, and maintainers of flight training equipment;
- Providers of aviation services such as full-service leasing;
- Providers of technical services ranging from maintenance management and auditing to the writing of manuals, testing and (re-)design approval.

The providers of these services may be linked together in supply chains, process networks and webs of interdependence. The linkages may be thought of in terms of hubs, clusters or supply networks; they may be collaborative or competitive or both at once; they may involve the sharing of information and resources; and they may or may not involve regional proximity.

Whilst Sydney airport is by far the busiest in Australia in terms of line maintenance, and has under-utilised engine overhaul capacity, we focus here on the lost opportunities for meeting future MRO demand that will occur if airport master planning processes focus on passenger revenue to the exclusion of MRO, maintenance training and maintenance R&D activity. While similar analyses could be carried out for other states/territories, the example analysed here is based on the very large Western and South Western sub-region of Sydney and environs, clustering around the second airport site, and potentially networked to civilian and Defence precincts stretching from Bankstown at its eastern end to the Illawarra in the south and to the Nepean and Hawkesbury regions in the north-west.

Planning for the new Sydney second airport at Badgerys Creek offers the opportunity to develop a specialised MRO hub, networked to civilian and Australian Defence Force MROs and OEMs elsewhere, including interstate. The second airport is located in a high-unemployment area that will benefit greatly from maintenance/aerospace industry development. It contains a range of technology parks housing engineering firms that are eager to embrace innovation. There are active programs to draw school students into science and technology. The region also contains two of Australia's five Part 147 category maintenance training organisations (MTOs) with the will and capacity to expand both maintenance and flight training as an export industry. What is required is catalytic support.

With runways built to handle heavier aircraft than the busy Bankstown airport can accommodate, and located within the Nowra/Richmond/Glenbrook network of the various Defence arms, as well as within Western and Southwestern Sydney advanced manufacturing networks, Badgerys Creek could provide a future focus for an innovative MRO and MRO training industry. Our conservative mapping exercise was able to identify 102 aerospace-linked organisations in the region, including GA air operators, Defence contractors, third party MRO and GA MROs; OEMs; providers of maintenance and flight training; providers of aviation services such as parts sales, aircraft sales or leasing; manufacturing and engineering firms supplying tooling, precision components and advanced manufacturing processes; and professional service firms, providing testing, inspection, design or reconfiguration approval services (Appendix 3).

With a systematisation of support for local and international networking and information exchange; with investment finance based on favourable terms and guarantees; and with affordable rent structures, and adjacent zoning priority for MRO-related work, the groundwork can be laid for a secure place for maintenance work within an aviation and aerospace hub. This is an opportunity for integrating, from the early planning stages, the development of a state of the art aviation and MRO hub, bringing together specialised services and advanced solutions. Specifically, Badgerys Creek could provide a hub for organisations supplying:

- Heavy maintenance of aircraft in the regional RPT and GA sector;
- Maintenance of helicopters and small jets (including regional export of maintenance and associated maintenance training);
- Maintenance support for aviation services, including fleet management for local and Asia-Pacific markets);
- Aviation-related professional services (R&D, design, approval and modification of aircraft; maintenance management, safety auditing, weighing, and non-destructive testing (NDT));
- Recognised maintenance training for Asia Pacific MROs (expanding and developing the well-equipped Padstow Aeroskills registered training organisation (RTO) facility) and flight training providers;
- Third party specialist overhaul services such as non-destructive de-painting and repainting, interior refurbishment and avionics upgrades;
- AOG services, including mobile repairs to composite structures accompanied by the requisite NDT;
- Defence contracting and procurement, including R&D;
- Links with local advanced manufacturers in the supply and testing of specialised and highly engineered components to global OEMs and Defence;
- Tie-ins with OEMs for the provision of afterservice maintenance;
- R&D for a post-oil aviation future and solutions to emerging requirements such as parts recycling management;
- Storage and dispatch of exchange parts, linking Sydney into the regional maintenance supply networks of original equipment manufacturers.

Brisbane Airport's success as an aviation hub in attracting maintenance and maintenance training has already been mentioned. It is part of a Queensland government strategy based on more extensive clusters strengths – pilot training for the Gold and Sunshine Coasts, GA around Wide Bay and Burnett; Defence links in Rockhampton -Townsville.<sup>28</sup> The Queensland examples under Table A3.2 in Appendix 3 illustrate these more dispersed, mainly coastal clusters of regional and rural MRO and aerospace activity, again indicating the importance of Defence linkages and also showing the role of airports, GA maintenance and larger independent MRO businesses, and both their strengths and their vulnerabilities to the turbulent regional market. The Australasian Aviation Group – Cairns (AAG-C), mentioned in Chapter 3, began in 2006 as an airport-based cluster, combining MROs servicing both regional airlines and GA operators, as well

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<sup>28</sup> Queensland Government, 2015; Asia-Pacific Defence Reporter (APDR), 2011.

as training facilities. Several of its members have approvals for offshore work in Indonesia, Papua New Guinea (PNG) and the South Pacific, including in aircraft refurbishment.

Nevertheless, there are concerns. The endemic issue of regional aviation viability, outlined in Section 11.3, expressed itself in 2015 when Queensland Airports sold their well-equipped Avix hangar in Townsville to Rex, who then closed it down within months; a contributing factor was said to be the transfer by Virgin of its ATR fleet maintenance to Brisbane.<sup>29</sup> These risks to the independent and GA MRO sectors are likely to be repeated across Australia as a result of the ongoing vicissitudes of the regional aviation sector, unless a stabilisation plan is put in place, as part of a broader growth strategy. As already argued, the economic and social contribution of this sector, and its longer-term growth potential, outstrip short term considerations of individual operator profitability. The passing of the mining boom peak is likely to put further pressure on Western, Northern and Far Northern Queensland MROs. Without a regional and rural MRO strategy, the result is likely to be a further net loss of capability. Just as the growth of MRO activity has been shown to provide a growth and innovation stimulus, so the closure and underutilisation of capacity has a negative ripple effect, particularly on regional economies.<sup>30</sup>

The South Australian cluster under Table A3.3 in Appendix 3, centred on Adelaide and Parafield, illustrates the importance of Defence contracting in capacity building, and its flow-on encouragement of civilian MRO contracting, supported by specialist manufacturing supply networks. The Adelaide headquarters of Cobham, BAE Systems, TAE and Australian Aerospace also illustrate the point that clusters may have an interstate reach, rather than being geographically concentrated. Adelaide is a site of aerospace and Defence innovation, based on both small and medium enterprise (SME) specialist firms, and on the attraction of global aerospace partners. There is need to consolidate local expertise, build on it and to ensure that it is handed on intergenerationally. Adelaide Defence and civilian aerospace suppliers include firms designing and installing sub-systems or developing new methods for testing and fabrication. They are developing lubricants, adhesives, non-destructive paint-stripping techniques, new approaches to strengthening materials, bonding metals and composites, flammability testing and metrology- and 3D-printing-based precision engineering. Given the high safety costs of component failure, it is important for security and safety reasons to ensure the stability and growth of this manufacturing sub-contracting industry, allowing the MRO supply chain to operate at the cutting edge of technological capability. A national aviation and aerospace industry development strategy would look to South Australia as a component manufacturing hub, networked into a national and international aerospace manufacturing and maintenance supply chain.

Similarly, the Victorian examples under Table A3.4 in Appendix 3 focus on MRO and advanced manufacturing activity, linked to the three Melbourne airports but primarily supplying an OEM (Boeing) and nationally networked to Defence supply chains. In terms of aviation links, there is also further unused capacity that could be brought back onstream at Avalon. The very strong presence of Boeing, including the large Boeing Australia Component Repairs (BACR) and two Aviall supply outlets, points to the potential for a strong Victorian contribution to the high technology end of the international MRO industry, with OEM, R&D, Defence and advanced manufacturing supply chain links. Victoria is the home of 12 Part 145 approved third party MROs. As well there are several predominantly GA MROs with Part 145 approval.

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<sup>29</sup> Anderson, 2015.

<sup>30</sup> Cole, 1989; Feloy, Field and Dickinson, 1992.

One of the first tasks in rebuilding national aviation/aerospace capability in Victoria, however, is to restore the capacity for workforce development. Since Kangan Batman TAFE relinquished its Part 147 category training authorisation, there is no public MRO training capacity in Victoria, and we would argue that this is a matter requiring swift remedy, if Australia is to meet its own MRO workforce development needs and put itself forward as a serious contender in helping meet the MRO training shortfall in the Asia-Pacific region.

The Western Australian examples (under Table A3.5) reflect the changing shape of aviation and maintenance in a resources state, but also the potential to market MRO and training services into the Asian region. At the start of the mining boom, Qantas took over Network Aviation, a charter/RPT subsidiary, and as the boom peaked, absorbed it into Qantaslink. Qantas and Virgin have MRO subsidiaries in Perth – Network Turbine Solutions and Virgin Regional respectively. Like Queensland, Western Australia has developed an export industry in flight training (China Southern West Australian Flying College; the Jandakot branch of Singapore Flying College), and whilst these are private ventures — the first a CAE Oxford operation, the second wholly-owned by Singapore Airlines — they illustrate that air operators in the Asia-Pacific region are already prepared to look to Australia for training.

This section has outlined a diversity of potential starting points for developing existing MRO capability and building it into a self-sufficient industry, with global links and export potential: the discussion in Section 11.1 indicates that the value of the national economic returns to doing so will at least double the investment outlaid. It has also shown how promising initiatives, particularly in the vulnerable regional and rural sector, need investment support in order to consolidate and regenerate, particularly in addressing shifts such as the transition out of the mining boom, in establishing a new export venture, or in capitalising on technological innovation.

The value of airports as regional development hubs for technology-based industry is widely recognised in the US, where it has achieved spectacular payoffs in a number of well-documented cases. Australia could well duplicate some of this advantage with appropriate legislative backing. One simple and easily enforced measure to support this kind of development would be to ensure that laws governing additional uses of airport land give preference to uses which are directly aviation-related, rather than allowing unused space to be sold or let to retail or other non-aviation businesses who may simply want to evade local government rates and planning requirements.

More generally, and by no means exhaustively, this section has provided some indication of the different areas of strength in different Australian states and regions. A National Aviation/Aerospace Manufacturing and Maintenance Development Strategy, supported by an Aviation/Aerospace Innovation Fund, is required to develop and support well-worked-out regional and export-oriented initiatives, based on potential hubs, clusters and networks such as those which this section of the report has started to map. Such a funded Strategy is required to building on existing initiatives and strengths, in order to generate a national, diversified MRO and MRO training industry, capable of helping to meet the unmet demand foreshadowed for the Australia and the Asia Pacific region.

## **11.8 Implementation – A new aircraft manufacturing/maintenance industry strategy**

It has been argued here that the Australian MRO industry needs to meet the challenges of the new diversified model of maintenance, involving relationships among Air Operators, OEMs and independent MROs, and crossing civilian and Defence. Increased cooperation is needed among segments of industry which have so far had relatively little to do with one another, generally serving distinct product markets, operating under different legislative provisions, in different



labour markets with different qualification structures and employment practices. These commercial and regulatory silos have made it difficult for skilled labour to move across the different aviation and aerospace sectors, broadening and deepening expertise in order to take part in innovation.

A way of bringing together these sectors and markets is by building on emerging hubs, clusters and supply chain networks, drawing in under-utilised infrastructure and creating new capacity. As well, expansion of the MRO industry to meet emerging opportunities in the Asia-Pacific region will need to be underpinned by the swift implementation of a workforce development strategy. It is important to ensure that skills are not lost to the industry in the process of company restructures, and above all, it will be essential to reverse the recent decline in the nation's capacity to provide broad-based training effort.

The final chapter outlines unresolved issues that will need to be considered as part of the agenda of such an industry and workforce development strategy, taking account of the strengths and needs of each aviation sector, and the potential offered by its interface with the aerospace industry. It will outline the role of:

- A National Aviation/Aerospace Industry and Workforce Development Strategy, bringing together each aviation sector and aerospace supply network, both civilian and Defence, to identify the measures required to turn around our national MRO industry and ensure that it contributes optimally to regional development, economic prosperity, defence security and technological innovation
- An Aircraft Manufacturing/Maintenance Industry Forum to provide information and advice on the development and implementation of the strategy, interfacing with the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established, in the monitoring of emerging workforce development needs, and skills planning, for new intakes, skill upgrades, career transitions and maintenance education exports
- The establishment of a regionally networked, cross-sectoral National Aviation/Aerospace College, for the purposes of high quality workforce development, broad-based exchange of knowledge and innovation capacity across both aviation and aerospace, and export of high quality education and training.

## **RECOMMENDATIONS**

- **RECOMMENDATION 4:** That Federal and State/Territory Governments adopt the recommendation of the 2014 NSW Parliament Legislative Council Inquiry into Regional Aviation Services, that regular passenger transport services in regional Australia be seen as an essential service, and that a dedicated grant/loan fund be established to assist local government authorities to support the consolidation of MRO services.
- **RECOMMENDATION 5:** That the Aircraft Manufacturing/Maintenance Industry Advisory Forum (see Recommendations 1-2, Chapter 12) and those developing Airport Master Plans, including those working on the Badgerys Creek Second Sydney Airport, include plans for precincts that will attract clusters of MROs, maintenance training providers and OEMs, networked to aerospace manufacturing and engineering providers.

*This will facilitate the role of airports as hubs linking air operators, MROs, R&D, advanced manufacturing and the export of maintenance training. Overseas evidence suggests that multiplier and catalytic effects on local economies repay government developmental support several times over in revenue returns.*

## Chapter 12 Conclusion: Findings, General Recommendations and Priorities

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### 12.1 Introduction

The last decade has been a period of crisis for the Australian aircraft maintenance industry. This project was commenced to consider options for addressing this crisis. Several factors mean that aircraft maintenance is different from some other areas of Australian manufacturing, in that it is simply not possible to offshore the maintenance of large portions of the Australian fleet. Nor is it possible to do without the latter's vital contribution to many aspects of life in a large, remote, sparsely-populated continent. Australia will always require the capacity to work on most of its own aircraft.

Periods of crisis are also periods of opportunity, and this one is no different. The looming global shortfall of trained and licensed personnel is also an opportunity to develop an export industry in maintenance training services, as well as to take on a more prominent role in the global maintenance repair organisation (MRO) industry itself. Shortages of skilled and licensed personnel to some extent derive from the explosive growth in the industry as a whole. Global third-party MRO has grown into a \$AU 67.1 billion industry. Its cumulative annual growth rate (CAGR) is expected to average 4.1% over next ten years, taking it past \$AU 100 billion around 2024.

Among the major regions, Asia-Pacific is predicted to show the highest annual growth rate in MRO activity at 5.6%.<sup>1</sup> International authorities have been warning for some years that the region as a whole suffers a serious deficit of MRO capacity (especially skilled workers), which is only likely to worsen as the growth of its fleet outstrips the growth in resourcing. As argued in Chapter 10, the International Civil Aviation Organisation (ICAO) estimated in 2010 that the Asia-Pacific region as a whole employed only 14% of the world's technicians, whereas based on the same estimates, we have calculated that Oceania alone had some 4%. By 2034, Boeing forecasts that the region will need to increase its numbers to 40% of the world technician population. Based on the same ICAO projections, the capacity of the world training system in each of the twenty out years was expected to fall at least 25% below the annual growth in labour requirements, while in the Asia-Pacific region, achievable output was running at only a third of the required level. This implies an annual shortfall of over 18,000 qualified new maintenance workers, 80% of them concentrated in the Asia-Pacific region.

Even allowing for the fact that several Asian countries have made serious efforts since 2010 to build up their maintenance training capacity, it becomes clear that Australia's experienced and mostly well-trained MRO workforce is becoming a significant asset not just for Australia but for the entire region. This asset will only increase in value as supply problems escalate across the world industry. The growth in demand across the region represents an opportunity to put to productive use the many skilled aircraft maintenance engineers (AMEs) who have suffered interrupted careers in the current period of intense restructuring. Conversely, the greatest threat to Australia's chances of realising its potential in the emerging world market lies in the possible loss of much of that base of expertise if its most skilled members continue to leave the industry against their will, or if the recruitment of new skilled workers continues to stall.

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<sup>1</sup> CAVOK, 2015

Provided the Australian maintenance industry, and the training sector in particular, can respond in time, the Asia-Pacific region has the potential to become an important source of demand for Australian expertise and input, representing a basis for Australian providers to exploit economies of scale which were not previously achievable within the domestic market.

One of Australia's biggest potential assets in terms of aircraft maintenance is its large, unexpectedly diverse resource of small and medium MRO firms, some of them linked into the advanced manufacturing sector, and into the supply chains of the global major aviation firms. But that potential has so far been limited by geographic dispersion, poor communication, inadequate scale and above all the absence of the necessary coordination, despite the serious efforts made by several State governments to provide such coordination over the last decade. Australia at the national level needs to marshal these resources into an industry strong enough to serve its domestic needs, as well as into a competitive weapon – a task that is far from beyond its capability, provided the political will can be mustered.

Yet there have been, and still are, serious indicators that Australia's capacity to carry out this coordination and consolidation of capability is in decline. These indicators include the highly visible loss of jobs in the heavy maintenance sector despite a looming skills shortage of global proportion. In the absence of concerted action to nurture and build Australia's aircraft maintenance industry and the training system on which it depends, the cost will be not only the loss of export revenue and employment opportunities, but the exposure of aircrew and passengers in Australia's planes to unacceptable levels of danger.

This concluding chapter draws together the main evidence for this assessment, before outlining a set of proposals for an approach to consolidating, coordinating and building maintenance capacity in order to contribute to four goals — regional development, economic growth based on self-sufficiency and exports, defence capability and innovation.

## **12.2 The long transformation: maintenance industry diversification**

At the beginning of this project, it appeared as though Australia was witnessing the terminal decline of the domestic heavy maintenance capacity of its regular public transport (RPT) fleet. Qantas was publicly shedding large numbers of maintenance jobs and Australia's largest independent civilian maintenance facility for large aircraft, the John Holland Aviation Services (JHAS) workshop at Avalon, eventually closed down. Work on the B747s, previously expected to continue being undertaken in Australia until the type was retired, was moved offshore. The number of Australians in training for aircraft maintenance qualifications turned down sharply from around 2013 onwards, and reputable estimates of the loss of employment in the occupation ranged as high as 45% in five years, with total employment predicted to continue in decline at least until 2017.<sup>2</sup>

None of these indications is misleading in its own right. However, to focus on them too exclusively is to ignore the steady rise of innovation in MRO and the growth of a new related industry sector, in Australia and globally, more or less under the radar of public debate on the maintenance of the major passenger fleet. What we are seeing in effect is a transition to a greater diversity of MRO industry structures. The original model, at least in the airline sector (although not in General Aviation (GA)) was one in which maintenance was done primarily *in situ* on the plane, on the operator's premises, by a group of workers with specific high-level skills in aircraft maintenance who were employed by the operator, and where invasive checks were

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<sup>2</sup> Department of Education, Employment and Workplace Relations (DEEWR), 2012c

needed at scheduled intervals to detect latent structural and mechanical faults before they led to disastrous consequences.

The emerging model is one in which much maintenance work will be distributed among contract MROs and light manufacturers in complex supply chains, potentially under a variety of employment arrangements. A greater amount will likely take place remotely from the hangar through the replacement, repair and remanufacturing of large component assemblies; equally, some will be brought back on site and performed, for example, by specialist maintenance staff also potentially under diverse employment arrangements (e.g. on-wing engine maintenance). Some airlines such as Lufthansa have opted to contract in maintenance from other airlines as a profitable business sideline. An increasingly large share of the work will be controlled directly or through subcontracting by original equipment manufacturers (OEMs) in the context of a distributed global industry. Many of the traditional checks will have been replaced by sophisticated diagnostic equipment and self-monitoring capabilities built into the aircraft, and the length of time between D-checks is expected to increase significantly. The outcome of these new arrangements, driven by a mix of technological change, economic restructuring and regulatory change, is difficult to predict.

This change is also generational in the sense that it is unlikely to occur overnight. Parts of it had already begun before the turn of the century, much of it will be incremental rather than a steep-change, and will take at least another 15-20 years before it is complete. Even now, around half the world's heavy maintenance (the first segment of MRO to show a significant impact of changing practices on industry structure and the labour market) is still being done on the air operator's premises, and the figure is almost certainly much higher in Australia. So far the OEMs have achieved limited penetration of that maintenance market, and cannot be expected to do so until composite airframes make up a much larger segment of the fleet. The coming generation of high-efficiency jet engines is only now beginning to come off the production line, and the collapse of jet fuel prices over the last few years can only have reduced the short-term incentive for operators, either to buy new types built around them, or to repower their existing aircraft.

The pace of change in technology across the Australian fleet is difficult to predict accurately; this is one reason we have chosen to restrict our labour demand projections to ten years out, whereas the ICAO, the International Air Transport Association (IATA) and Boeing, with more insider knowledge and data at their disposal, all use a 20-year timeframe. However, based on the current age profile of the Australian main-route passenger fleet and known orders for new airframes, it seems reasonable to predict that the broad pattern of technology requiring maintenance in ten years' time will not be that much different from the way it looks today. Certainly we would expect by then to see a higher penetration of new-generation aircraft, notably the B787 and A350, along with the B737MAX and A320XLR (more suited than the former to the needs of domestic carriers), which will use new-generation engines in largely current-generation airframes. The oldest and most labour-intensive types will have been retired: all the B767s are already retired from Australian service, except for one reportedly destined for conversion to a freighter; there is no indication that any of the 747s will be replaced by the newer -8 series, and the B717 (a long-standing design although the examples in service in Australia today were built in or after 1999) will surely by then have been displaced from its present routes either by one of the new-technology regional jets now coming on to the market, or by one of the smaller current single-aisles. With these limited exceptions, the commercial passenger fleet in use on the main inter-capital routes is likely to remain dominated by aircraft of the generation currently in production, on which even the younger members of today's AME workforce have been trained, and which will continue to rely for their safe operation on the skills held by the current generation of airline engineers.

This outcome seems even more likely for the regional fleet, as the large number of new regional turboprops acquired over the last 5-10 years means that these designs (which typically have a

longer lifespan in service than jets) should remain in use well into the late 2020s if not longer, while the “tail” of older small twin turboprops (F80s and the like), many of which were imported for fly-in fly-out (FIFO) use during the investment phase of the mining boom, can be expected to gradually find their way out of Australian service now that this phase is over. If anything, the impact in the medium term may be more noticeable in GA, where the fleet is currently made up overwhelmingly of designs first developed many decades ago, even if some of them were manufactured in recent years and many of the old ones now do very little flying. Yet most of the types first developed in the last decade or so use quite modern technology such as all-composite hulls, glass cockpits, and advanced engine designs including the latest generation of lightweight aeronautical diesels, in the interests of more economical operation. The more intensively such smaller planes are used, the more likely it is that their lower operating costs will outweigh the higher cost of buying new. This suggests that the proportion of total GA hours flown by this new generation of light aircraft (and hence its share of the maintenance load) will grow much faster than their proportional representation on the Civil Aviation Safety Agency (CASA) Register.

All this indicates, emphatically, that a reduction in the size of the Australian MRO workforce would not be an appropriate response to this changing environment. While there may well be an incremental reduction over the next 10-15 years in the average maintenance load relative to the size of the fleet in service, this is likely to be offset if not outweighed by the expected growth of the fleet.<sup>3</sup> Just as importantly, the overall safety of Australian aviation will continue to depend on present-generation maintenance skills well beyond any realistic planning horizon, with the global skill shortage leaving Australia steadily more reliant on its own resources.

It follows that the workforce as a whole will increasingly need to exercise a spread of skills spanning the requirements of several generations of technology, from the traditional mechanic’s hand skills through to the use of highly advanced electronic diagnosis equipment, including remote access to such technology while a plane is actually in the air. While it can be expected at least in the short term that different workshops will specialise in different generations of technology, the steady interpenetration of newer designs into the existing fleet, together with the geographic dispersion of Australia’s maintenance facilities and activity, will make it more important over time for the average Australian AME – even or especially in GA – to become more diversely skilled and develop the flexibility to move across different segments of work as the fleet and the industry evolve. Equally, as the boundaries between MRO and the related cluster of industry sectors are reshuffled, it will be necessary to equip both the present and the future workforce with a skill base and a qualifications and licensing structure that enable them to move between what have hitherto been separate labour markets as the pattern of activity and demand shifts. Both these requirements will pose new challenges for a training sector which currently struggles to cope even with the traditional requirements of the MRO labour market.

Treating the process in these terms – not as a decline, not as a resurgence, but as a transition taking place over several decades – makes it easier to link the different themes which have emerged over the course of this project. Most of the developments which have raised concern have either originated or been rationalised as responses to the emerging transition; or to put it differently, most of the problems have been the results of poor handling of that transition:

- The shift to the European Aviation Safety Agency (EASA) licensing scheme, widely contested in its initial stages, is now seen in many quarters as an essentially rational response to the increasing globalisation of the MRO labour market; its failings to date

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<sup>3</sup> This was explicitly recognised by Boeing in its 2014 *Pilot and Technician Outlook*. See Boeing, 2014.

have stemmed from inadequate or inappropriate mechanisms to shift from one system to the other while still retaining the full productivity of the workforce.

- The associated rise in the base qualification from Certificate IV to Diploma is an acknowledgement of the inevitable professionalisation of the occupation and the gradual shift in the balance of activity from mechanical to theory-based diagnostic skills; but that process of adjustment has been blocked by the failure of the funding system to keep pace, and counteracted by loopholes in the licensing regulatory framework that potentially open the way for critical certifying functions to be carried out by employees less qualified than most of those who currently certify for work on aircraft in Australia.
- Though the optimum ratio of workers to fleet size will most likely continue to fall over the longer term, the job-shedding that has taken place over recent years has occurred well in advance of the fleet modernisation which was its ostensible justification. It assumes away some important issues which only future experience can resolve (notably what teething problems are likely to show up with the new-generation engines, and what vulnerabilities might emerge in composite hulls after several years of airline service far more intensive than anything previously experienced by their predecessors in military applications), and has pre-empted some future options for adjustment by depleting the skilled workforce while at the same time crippling the capacity of the training system to restore its numbers when they are needed again.
- Similarly, the increasingly relaxed attitude towards safety precautions which has been in evidence over recent years, though it has been justified in part by the growing adoption of ostensibly failsafe technologies, has arguably run ahead of both the effectiveness and the ubiquity of those currently in service.
- Periods of transition invariably mean higher aggregate costs than periods of stability, whether in technology or in institutions, because of the need to keep an old and a new system running side by side. Unfortunately, the start of this period of transition in the global aviation industry coincided with a period of strong competitive pressures, driven largely by a combination of unprecedentedly high fuel costs and unprecedentedly low barriers to entry into the world passenger market. These pressures almost invariably resolved themselves in short-term cost minimisation, resulting in a temptation to seek the premature harvesting of savings which are still only potential. The imperative to cut costs should in theory be reduced now that the world's airlines have practically all returned to very healthy levels of profit,<sup>4</sup> but in practice the competitive strategies adopted in the period of shared financial stress may not be as easy to reverse.

All these adjustment problems can be overcome, provided they are individually acknowledged and collectively approached in a coordinated manner. The recommendations which follow are put forward as a strategy for unblocking the transition and opening the way for the resurgence in business and in employment which it promises. Meanwhile we must return first to the problems created by inadequate policy responses to the emerging transformation.

We begin with the emerging global skills crisis, which casts a shadow over the whole aviation industry. As Chapter 10 argued, information from authoritative international sources — IATA, ICAO, Boeing, CAVOK — has established that the aviation world is heading into a crisis of global

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<sup>4</sup> Financial data released in September 2015 by the Department of Transportation show a combined reported net income for US airlines of \$5.5 billion for the June quarter, a 53% increase over the same period last year. Qantas also reported a spectacular return to profit in its 2014-15 results, barely a year after it had been seeking government assistance.

proportions in the supply of skilled and licensed personnel. The biggest shortfalls are expected to arise in precisely those parts of the world (Southeast Asia) to which Australian carriers are increasingly turning to meet their maintenance requirements. Indeed, this is already happening.

Shortages of skilled labour in these regions will necessarily affect both their capacity to take in work from countries like Australia, and the quality of that work. They will affect the prices they will be able to charge in what will progressively become a seller's market. In the medium term, this is bound to mean a compression of the cost differential between performing maintenance in Australia and outsourcing it; eventually it could undermine much of the economic case for offshoring Australian work. It could also force Australian airlines to offshore work to second-tier MRO suppliers of dubious quality. Australia will face a genuine threat to the safety of the planes which it offshores unless it is able to rebuild sufficient capacity to handle at least a reasonable proportion of the work which has been lost overseas.

This report has described the growth in third party MRO services, associated with the first wave of outsourcing and offshoring, initially to regions characterised by cheap labour and lax regulation. We do not make sweeping claims that offshored maintenance is universally or even predominantly unsafe. However, the research has found some evidence of some unsafe procedures in some offshore MROs to which Australian carriers have offshored maintenance. One of the major themes of the report has been safety and safety oversight and regulation, to which we now turn.

### **12.3 Offshoring and safety**

There is no doubt that statistically, main-route passenger aviation today is by far the safest of all modes of travel, and it is slowly becoming even safer. But the low probability of having an accident has to be balanced by the high impact of those accidents which still occur. It is also salutary to note that some of the most costly accidents in postwar civil aviation have been directly traceable to maintenance. The most authoritative literature indicates that around 10% of accidents are attributable to maintenance. Yet the number and rate of accidents is too small to support any statistical association between the frequency of accidents and the location where maintenance is carried out, or even to outsourcing *per se*. Our sources mainly examined accidents and incident rates of large RPT planes, but the accident rates for General Aviation are 3-4 times higher than for RPT – and they are actually increasing.

Safety generally exists as part of a tradeoff between the extent and number of defences against a disastrous outcome, and the costs of those defences. As one of the most cited gurus of safety, James Reason, puts it, safety exists in a tension between protection and economic efficiency (the latter interpreted in terms of short term profits). While there is ample literature linking adverse occupational safety and health outcomes to outsourcing and offshoring, relatively little has been written on the links between offshoring and aviation safety. This project has explored these links in the case of the United States (US), where several aviation accidents have been directly linked to outsourcing and offshoring of maintenance. It has identified known risk factors that are associated with poor safety outcomes in occupational health and safety (OHS), and explored the possibility that these may affect the safety of maintenance. Outsourcing and offshoring have been shown in the OHS literature to increase vulnerability due to *pressure* of various sorts, including financial pressure; *disorganisation*, including communication failures; and, in particular, *regulatory failure*. These can increase error rates through work intensification and high working hours; and the use of unqualified and inadequately trained workers, and the potential entry to the supply chain of unapproved parts.

The act of outsourcing itself creates a number of *agency problems*, endemic to contractual and time-bound and time-pressured arrangements. The interests of the agent (the third party MRO service provider) and of the principal (the airline) do not always neatly coincide, and this can



cause under- or over-servicing. While the former is a more serious problem, the latter is not without economic effect.

In response to concerns about the safety of offshored maintenance, political pressure in the US has obliged the Federal Aviation Administration (FAA) to intensify safety oversight of offshored facilities.

In the light of similar safety concerns raised in Australia (detailed in Chapter 6), a particularly important area of policy focus needs to be the regulatory oversight mechanisms for offshore maintenance (Chapter 7). Here, in 2015, there appears to be a case of regulatory failure. CASA is responsible for the safety oversight of offshored maintenance. Yet the legislative and other instruments that govern CASA also may allow it in effect to devolve this responsibility “offshore”, for reasons explained in the next paragraph. This apparent transfer of regulatory responsibility is occurring at the same time as a shift in the process of safety inspection – from monitoring of actual practice to auditing of the documentation of process – a trend already noted with concern by IATA in its 2013 Safety Report, which observed that *MRO certification is not a guarantee of work quality*.

ICAO regulation is somewhat at cross purposes, producing a regulatory tangle such that it may not be entirely clear who bears the responsibility for regulatory oversight of offshored maintenance. Article 31 and Annex 8 affirm that the safety oversight of offshored maintenance is the responsibility of the state of registry. Yet Article 33 allows, or arguably even requires, that each country accept the regulatory arrangements of another country – provided they meet or exceed ICAO minimum standards. Chapter 7 describes how the bedrock of the ICAO safety system, the Universal Safety Oversight Audit Program (USOAP), which assured signatory states of a degree of compliance with ICAO standards and recommended procedures (SARPs), is now no longer in use, and its putative replacement (a “continuous monitoring approach”) lacks visibility. The research as a result is unable to express confidence in the international system of safety oversight based on the 1944 Chicago Convention. The emerging paper-based approach to risk management calls into question the current trend to cede the safety oversight of Australian registered planes to the national aviation authorities of other countries, including via bilateral aviation safety agreements (BASAs) and “technical agreements”. CASA’s acceptance of it appears to be at odds with the intensification of regulatory oversight of FAA registered planes offshored for maintenance from the US.

This report therefore recommends an intensification of regulatory oversight of maintenance offshored from Australia. In order to follow the lead of FAA in stepping up this oversight, two obstacles need to be addressed and worked through. The first of these – the principle of national sovereignty – prevents unannounced inspections, and otherwise limits the scope of retaliatory action against non-compliant MROs. So it will be instructive to identify how the FAA has addressed this question, and to explore ways of aligning Australia to the FAA approach. The second concerns the capacity of CASA to engage in the sort of inspection required by the shift from shopfloor inspections to auditing of safety management systems (SMS). Two major inquiries – the ICAO USOAP itself, and the more recent Aviation Safety Regulation Review (ASRR), have cast doubt on the capacities of Australia’s civil aviation safety inspectorate to fulfil this role.

For it to do so would require a significant infusion of resources, in the form of increased numbers of inspectors, and greater training activity – something this report recommends. This report also recommends that the increased intensity of inspection of overseas facilities be funded, in large measure, by cost recovery from offshoring air operators. This would act as an incentive to bring some offshored maintenance back to Australia.

One aspect of the concern about practices in overseas MROs is a need for quality assurance regarding systems of aircraft maintenance licensing and training. As the next section argues,

there are concerns about aspects of the training and certification system in Australia also and these concerns point to the need for a wider study of the question of the skills and licensing, and the certification practices, employed in the MROs in the countries to which Australia offshores. Confidence in these capacities and practices is supposed to flow from the international system of safety oversight, based in the ICAO regulations, for which a mutual exchange of approvals appears to be a weak substitute.

One approach to MRO quality assurance would be for Australia to initiate and participate in an Asia-Pacific intergovernmental project to establish best practice standards for training, certification and licensing, across aviation sectors, in response to technological change in the region. Manufacturing Skills Australia, when engaged by the Australian Government to do so, has already successfully taken a major role in some Asian intergovernmental/industry-level work on comparable engineering/manufacturing skills standards and specification of training needs. We strongly advocate that this international collaborative role continue to be pursued by the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established.

In the context of the emerging overall skill shortage in the region identified in Chapter 10, and the multiplier benefits identified in Chapter 11, government and airport support is needed to assist air operators, MROs and OEMs in repatriating maintenance work and in making Australia a training hub for the Asia-Pacific region. The development of a strategy for enhanced assurance of compliance with national and offshore safety standards, across the airline and GA sectors, will be an important brief of the Aircraft Maintenance/Manufacturing Industry Forum, recommended in Chapter 11.

## **12.4 Licensing and reform of the suite of maintenance regulations**

We now turn to the issue of licensing reform, discussed in chapter 8. In 2007 CASA began implementing the new suite of maintenance regulations, based on the European Aviation Safety Agency (EASA) system. New licences were issued in July 2011. The new licensing system (regulated under CASR part 66) had two broad categories. Licence Category B1 subsumed the former airframe, engine and some electrical categories, and the B2 subsumed the former electrical, instrument and radio categories. Significantly there were two new categories of release-to-service licensed engineers – Category C released planes to service following base maintenance, while, controversially, a new Category A licence holder, qualified at Certificate II level, could perform limited tasks in line maintenance, and release a plane to service. Inevitably, there were transition problems, in that many licence holders, initially at least, were unclear about what they could sign for, because of the new, more complex licences.

The importance of licensing, under ICAO Annex One is clear – to certify for the safety of stages of maintenance, as well as to release the plane to service following maintenance. While Annex One does not exclusively mandate a state-based licence system, it does make the important specification that “certifying employees” who operate under a different institutional arrangement must hold qualifications and experience equivalent to those required of a licence holder. Australia has opted for a state-based licensing system – although, interestingly, when the new licences were issued in July 2011, they did not contain reference to Annex One (an oversight subsequently corrected). Also importantly, the LAME’s privileges are cross-cut by obligations to their employer, and there is endemic tension between these pressures. Interestingly, in a potentially crucial industrial relations determination in 2012, known as the Sunstate Case, the Federal Court found that employers’ prerogative overrode the licensed aircraft maintenance engineers’ (LAMEs’) obligations, under Civil Aviation Safety Regulations (CASRs), to report a defect when one was detected. This may have portentous implications for the balance between safety and efficiency, when the key part of the LAME’s role is to safeguard the former.

The CASA Regulatory Reform Program lends itself to the erosion of the control that LAMEs have over certification work, with potentially serious implications for safety. Certification work can potentially “leak” to people not qualified or licensed to perform it, due to the deployment of ambiguous terms like “certifying employee”, which can refer to a licence holder performing certification work, or a non-licence holder doing the same work or similar. MRO employers have powers of “approval” over who performs “certification work”. There are clear regulations, based in the Chicago Convention, detailing the importance of the licence and defining the scope of the work, to which Australia is committed by international treaty and its own legislation giving effect to that ratification, and it is of crucial safety importance to safeguard against any departure from these strictures.

There has been much concern about the Category A licence. In the CASRs, this is able to be achieved after (depending on the precise type) 620-800 hours of training, and the attainment of a Certificate II qualification. This reduction in training and qualification requirements speaks to the expressed desires of certain employers for a sub-trade qualification and licence. Such a qualification, however, has never been seen in Australia before, and indeed the leading European countries have not embraced such a licence, with “return to service” privileges attainable after such a low level of training. Rather, in leading European countries the Category A licence is either not used at all (as in Sweden), or is attainable after a 3 year apprenticeship (as in the United Kingdom (UK) and Germany). It is important to explore whether the Category A licence at Certificate II level is in fact compliant with ICAO Annex One. This is an issue that needs to be addressed by the proposed Aircraft Maintenance/Manufacturing Industry Forum.

The EASA regulations disguise tensions between proponents of a national licensing scheme, and a “company approval” scheme, which would give broad approval powers to employers. The precise ways in which this tension plays out in other countries remain a subject for further research, but in Australia the ambiguity of such terms as “certifying staff” introduced an element of uncertainty about the level of certification necessary for certain tasks. This is why this Report supports the ASRR’s recommendation that the CASR 1998 regulations be re-written in a plain-language “third tier”. The very act of doing so would force to the surface the dangerous lack of clarity in the regulations.

Apart from issues of the scope of certification work, there are a number of issues at the interface between the licensing system and the training system, discussed in Chapter 9. First, and most importantly, the base qualification required for a B licence is now a Diploma, whereas many existing LAMEs are likely to have qualifications to Certificate IV plus the CASA Basics.<sup>5</sup> But State governments have almost uniformly refused to fund the 1,000 hours difference between the Certificate IV and the Diploma, leaving this significant cost to the individual. Second, at a stroke, many of these licence holders faced “exclusions” – their licences were deemed “partial”, and this had career consequences. These included that the licences were no longer recognised overseas, even in Europe, and that to gain full B level licences, they had to undergo further training and/or assessment – again at their own cost.

Third, EASA B licences apply to the large planes (above a threshold of 5700 kg maximum takeoff weight (MTOW)) in the (RPT sector, which means a separate licence is needed for the small plane GA sector. This change breaks from a defining feature of the former CAR31 licensing system – that a person could move smoothly from group licences to type rated through

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<sup>5</sup> Under the “old” licensing system, LAMEs were allowed to rely on the may have been the CASA Basics plus their Schedule of Experience (SOE) and type training. While trade training was not mandatory, in the airline/large aircraft sector, the Certificate IV was also required, this was not always the case in GA.

specialised self-study and the accumulation of experience. Defining the structure of this licence has been a persistent problem, including for EASA itself.

Australian authorities have set the underlying qualification level for any aircraft maintenance work at Certificates III and IV. This makes some sense for GA, in that while much of the GA fleet is technically unsophisticated and capable of being covered by the old CAR31 “group” system, an increasing number of small planes are built to new designs, as explained earlier, and have, or have been retrofitted with, sophisticated technology, requiring high level theoretical knowledge, diagnostic skills and therefore specialised training for which a type rating is appropriate. Perhaps more importantly, the currently proposed Certificate III/IV in Mechatronics (as it is called), designed to underpin the proposed small plane license, cannot easily act as a stepping stone to the Diploma – undermining the possibility of career beginning in GA and moving to RPT.<sup>6</sup>

At time of writing the licence structures and qualifications for the small plane sector are unresolved. It is essential that they be so resolved, and that the process of its resolution pay attention to how (and when) the same issue is resolved in Europe, as well as China – potentially a large market for training, given that its GA sector is about to be opened up to greater participation.

State government funding of the costs of meeting the training gap between the Certificate IV and Diploma is an issue for immediate resolution by the Commonwealth Government or the Council of Australian Governments (COAG). The issue of licensing career paths between sectors, both GA and airline, and Defence/civilian aviation, is an important agenda item for the Aircraft Maintenance/Manufacturing Industry Forum.

## 12.5 Training

We turn now to the training issues, discussed in Chapter 9, and supplemented from a different perspective in Section 10. This material has documented a serious decline in Australian aircraft maintenance training, in terms both of quantity and of quality. As regards quantity, the numbers in training in 2013-14 are the lowest since statistics have been available. As mentioned, State governments almost uniformly have refused to fund the additional cost of studying for a Diploma, meaning that 97.6% of the (relatively few) apprentices still in training are studying only for a Certificate IV. State governments have also (mostly) refused to fund the cost of training and assessment for exclusion removal. Partly as a result, in the four years to September 2014, only 90 apprentices commenced study for a Diploma (83 of them in the year to September 2012), and of these only 39 had completed the qualification, with another 37 still in training. More alarmingly, there had been no new commencements at this level since June the previous year, and 30 had withdrawn or cancelled in the June quarter 2014 alone.<sup>7</sup> This indicates that the attempt to upgrade the qualifications of Australia’s licence holders to diploma level has to date not succeeded — a situation that needs to be addressed forthwith, if Australia is to achieve its potential as a thriving maintenance hub.

This study found a widespread perception that the quality of training has declined. Our interview database contains many accounts of graduates with poor skills, particularly hand skills. As we write, the Australian training system is coming under increasing criticism over its ability to issue

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<sup>6</sup> Opportunity for progression from the proposed B1/B2 (Small Aircraft Licences) to the “full” B1/B2 levels for RPT is envisaged to be supported via skill sets that provide training pathways within the MEA training package (skill sets). Similarly, skill sets are under development to allow SAL holders to work on more advanced technologies emerging in certain small aircraft.

<sup>7</sup> Revised figures supplied by Manufacturing Skills Australia (MSA), email, October 2015.

valid qualifications, and over a decline in assessment standards. Yet at the same time as the training system is under investigation by the vocational education and training (VET) reform taskforce, CASA's Regulatory Review Program (RRP) has turned over to it the responsibility to develop and assess the skills of Australian AMEs, licensed as well as unlicensed. As CASA has put it, under Part 147, the competency-based system "replaces the knowledge tests and experience schedule". If Australia is to play a leading role in contributing to high standard maintenance capability in the Asia-Pacific region, it needs to attend to quality issues relating to training, and again the opening up of a conversation on this question could be a role for the Aircraft Maintenance/Manufacturing Industry Forum.

The system in place to December 2015 assigns to Skills Councils the responsibility of developing competency standards, qualifications, and training packages, but allows them at most the right to provide some limited support documents to assist in the design of training programs, their delivery, and above all their assessment in a training market.<sup>8</sup> Industry Skills Councils may take the initiative in issuing guidance to training providers about the interpretation of the Standards and training packages, but there is limited capacity to ensure that such guidance is followed.<sup>9</sup> This arguably opens the way to quality gaps and is significant weakness of institutional design, cutting across the training process, and moving Australian maintenance training out of alignment with emerging international training practices.

It might be thought that the CASR Part 147 approval process and subsequent auditing of maintenance training organisation (MTOs) would mitigate any tendencies towards poor quality. Yet there is a loophole in this system, since several more registered training organisation (RTOs), within the training system but not approved as MTOs by CASA, are permitted to deliver, assess and accredit aircraft maintenance training to the level of Certificate IV. Only RTOs approved by CASA as Part 147 MTOs are allowed to deliver category training — that is, training that counts towards a licence. Yet the principle of mutual recognition (a measure designed to require RTOs to accept each other's qualifications) makes it obligatory to recognise certificates of attainment issued by any other RTO, and this also applies to those RTOs that are *not* approved by CASA as Part 147 MTOs. It allows competencies passed at a lower standard (e.g. for Certificate IV training) to count towards the Diploma. According to the Part 66 Manual of Standards (MOS), the pass mark for category modules must be 75% — yet mutual recognition requires that RTOs/MTOs grant prior standing to certificates of attainment from non Part 147 organisations — which can have a pass mark of 50%. The result is that training done outside the CASA-regulated system can indeed count towards a licence, making the rationale for specifying that category training take place only in Part 147 organisations somewhat redundant. This is a tension or contradiction between CASA and Australian Skills Quality Authority (ASQA) regulations.

This research has also examined debates over more fundamental aspects of the Australian training system, including the use of competency based training (CBT) methodology. CBT as the

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<sup>8</sup> As an example of guidance materials under development, see Manufacturing Skills Australia (MSA) (2015c).

<sup>9</sup> Australian Skills Quality Authority (ASQA), 2014. This citation refers to a 2013 report by PwC, as part of a review of ASQA processes, which found that neither Industry Skills Councils nor ASQA nor the now-defunct National Skills Council that endorsed Training Packages had responsibility for providing guidance on standards and training packages. Whether the self-regulation of even high quality MTOs is advisable in a safety-critical industry is a moot point. Trainers working for providers are likely to have limited purchase in arguing for resources, that are not mandated but may be integral to the rigour of teaching and assessment: "There will be many examples that experienced maintainers could identify and their use depends on the training organisation being able to muster the manuals and data sources required for the scenarios" (Correspondence from Training Package developer, October 2015.)

central “language of capability” has been somewhat controversial in the Australian Training System. Part of the reason is people talking past each other, meaning different things by the term. Critics argue that CBT is not effective for specifying high-level theory or the skills and knowledge levels such as those for the B licence that have moved beyond “trades” knowledge and have entered the realms of paraprofessional and technician level understanding and its application; supporters point to standards that do cover require complex decision-making, based on theoretical understanding. Chapter 9 documented how competency standards, while they can fairly be said to cover theoretical content, by their very nature do not specify it in sufficient detail to be informative for educators. At present, despite recent efforts, there is arguably still insufficient guidance being provided to educators, who decide what theoretical content a trainee needs to meet the requirements of the EASA syllabus.

It may be argued that it is reasonable, within a CBT framework, to expect that those developing theory modules will have the rigour required to cover the knowledge and to use it to build the competency required to understand complex elements, and meet demanding performance criteria under a range of conditions. But in a safety-critical industry, this is another case of the need to balance trust and proof. It is difficult to achieve the common standard of knowledge set out in the CASA syllabus when a number of RTO/CASA MTO organisations deliver training. Further guidance and oversight are required to ensure a common level of content that both satisfies the CASA syllabus requirement (Part 66 MOS) and has been developed at local level through training needs analysis. This is even assuming that all training providers have the commitment, curriculum design expertise, resources and training hours needed, in order to develop and assess the required theoretical knowledge and the capacity to apply it.

In the international sphere, aviation training appears to be in the midst of considerable reform, in particular through ICAO’s Next Generation of Aviation Professionals (NGAP) program. The ICAO Training Manual has been the basis for international standards around training, and it contains – specified in detail – knowledge, skill and experience requirements, complete with levels of proficiency and numbers of training hours deemed necessary to attain them. In our assessment, admittedly limited by problems of comparison, Australian training is falling short of the requirements specified in the ICAO training manual, in respect of funded hours allocated to certain modules in the diploma.

Thus, returning to Chapter 10, the report finds little reason for optimism that the challenge posed by the looming skills shortage can be met, without a really significant and high priority commitment to change. Completions are 20% below their peak in June 2013, commencements in 2013 were less than half that recorded 5 years earlier, while in the 2014 March quarter they were the lowest this century, and third lowest in the last twenty years.<sup>10</sup> There has been a small but steady rise in wastage since 2007, while in the Defence sector most of the increase since 2008 has now worked its way through the system, leaving recruitment back at the same level as the civilian average, even at a time when the apprenticeship programs of airlines have collapsed.

This may seem like a pessimistic conclusion, but Chapter 10 also models two “boost scenarios”, in which an increased sense of focus and purpose and, it has to be said, a significant influx of resources starts Australia on the road to meeting the challenges outlined in the previous sections of that chapter. It is also the case that there are significant resources existing in the sector that could be marshalled behind a coherent industry policy. A signal from government that it takes the needs of aviation seriously, simply for pragmatic reasons, combined with some adroit policy innovation, could well put the Australian aircraft maintenance industry on a renewed growth path.

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<sup>10</sup> Manufacturing Skills Australia (MSA), 2015d, pp. 46-47.

## 12.6 A priority: A strategic approach to aviation/aerospace industry and workforce development

In light of the impending shortfall of skilled aircraft maintenance labour, and the lead-time required to reverse this decline, one of the priority projects arising out of this research would be to develop a workforce strategy aimed at ensuring the industry's future needs for skilled labour. Government support this strategic planning process would be needed, via seed funding, for example from the Industry Skills Fund, for the consultative development of an Aviation/Aerospace Industry and Workforce Plan, providing for a coordinated workforce development strategy across the sectors.

Aircraft maintenance is a manufacturing industry sector that straddles the worlds of aviation and aerospace. In Australia, the greater geographic dispersion and lower capitalisation of the regional and general aviation sectors present technological challenges to the safe operation of these sectors whose very rationale is to overcome that isolation. Moreover there are difficulties in the transfer of maintenance training and experience, and qualifications and licences, between Defence and civilian MRO: even though civilian maintenance contractors and manufacturers are significant Defence suppliers.

The Australian MRO industry needs to meet the challenges of the new diversified model of maintenance, involving relationships among Air Operators, OEMs and independent MROs. It must flexibly embrace work across the civilian and Defence sectors, as well as across the airline, regional and GA sectors. Moreover, the networks between OEMs and their advanced manufacturing suppliers, linked to the growing role of both OEMs and contracted MROs in the provision of afterservice, point to the need for mobility between maintenance and other skilled aerospace activity. Increased cooperation is needed among segments of industry which have so far had relatively little to do with one another, generally serving distinct product markets, operating under different legislative provisions, in different labour markets with different qualification structures and employment practices. These commercial and regulatory silos have made it difficult for skilled labour to move across the different aviation and aerospace sectors, broadening and deepening expertise in order to take part in innovation.

A way of bringing together these sectors and markets is by building on emerging hubs, clusters and supply chain networks, drawing in under-utilised infrastructure and creating new capacity. As well, expansion of the MRO industry to meet emerging opportunities in the Asia-Pacific region will need to be underpinned by the swift implementation of a workforce development strategy. It is important to ensure that skills are not lost to the industry in the process of company restructures, and above all, it will be essential to reverse the recent decline in the nation's capacity to provide broad-based training effort.

The proposed avenue for achieving these goals has three elements:

- **A National Aviation/Aerospace Industry and Workforce Development Strategy,** covering each aviation sector and aerospace supply network both civilian and Defence. Development of this strategy will involve work to identify the measures required to turn around the nation's MRO industry and ensure that it contributes optimally to regional development, export earnings, defence security and technological innovation.
- **An Aircraft Manufacturing/Maintenance Industry Forum.** This forum foster the gathering and sharing of information, and to provide structures for the collection of advice, first on the development and then on the staged and multi-faceted implementation of the on the development and implementation of the strategy, interfacing with the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established, in the monitoring of emerging

workforce development needs, and skills planning, for new intakes, skill upgrades, career transitions and maintenance education exports.

- The establishment of **National Aviation/Aerospace College**. This will be regionally networked, with local branches in all states and territories, reflecting different aerospace manufacturing and aircraft maintenance clusters of strength and needs strength and need — Defence, airline, regional aviation, GA and recreational. It will cross the divide between the vocational education and training sector and the university sector. It will provide high quality workforce development programs, allow broad-based exchange of knowledge and innovation capacity, and make a strong contribution to the export of high quality education and training.

These three initiatives are considered in turn.

## **12.7 Steps to creating and implementing the industry workforce development strategy**

### **12.7.1 A National Aviation/Aerospace Industry and Workforce Development Strategy**

To encourage the development of a thriving MRO sector, networked to both air operators and OEMs and their suppliers, impetus is needed from the maintenance and aerospace industry through an industry-owned approach to developing a concerted and innovative strategy for renewal is required.

This strategy would involve the development and implementation of approaches to:

- Building a new domestic MRO industry capable of competing aggressively in the highest-value niches of the global market
- Rebuilding sufficient domestic MRO capacity by 2020 to permit Australia to handle a high proportion of its own requirements
- Establishing a system of quality control safeguards adequate to guarantee that maintenance on Australian aircraft, whether done in Australia or elsewhere, is carried out to best international safety standards
- Ensuring that as many as possible of the present generation of L/AMEs remain productively employed, and their skills and knowledge are kept current, until such time as market demand revives in Australia
- Reforming and rebuilding MRO training to ensure that a new generation of properly qualified L/AMEs will be available to replace the current one as it retires
- Developing the interface between the aviation, aerospace and MRO industries, and between civil and Defence aviation maintenance
- Fostering the transfer of technical innovation.

The development of such an industry and workforce development strategy would both require and result in improved communication among parties within the current industries. Plainly such joint planning approach will not work unless it is “owned” by the industry parties (employer organisations, industry bodies and front-line employees and their unions).

The success of the Hunternet initiative is an illustration of the effectiveness of planning processes, as is the strategic approach of the Queensland government and various airports in that state. But such planning needs to be on a state and national level, and to involve a stronger integration of sectors — the case studies in Chapter 11, from Poland’s Aviation Valley to airport initiatives in the US, attest to the importance of strategic coordination for industry and workforce development. Local workforce development planning may go back to the need to for a



coordinated strategy to create industry awareness amongst school students and to promote science, mathematics and engineering studies.

### **12.7.2 An Aircraft Manufacturing/Maintenance Industry Forum**

The opportunity for building a thriving MRO sector, networked to both air operators and OEMs and their suppliers, depends on improved information-sharing and a means for negotiating the range of interests in the industry —those of tiers of government, of regions and aviation sectors, of employer and employee organisations, and of air operators, airports, MROs and manufacturers, whether global companies or nimble small and medium enterprises. It is suggested therefore that the task of initiating conversation around a national aerospace/aviation industry strategy be assigned to an Aircraft Manufacturing/Maintenance Industry Forum, as described below.

The Aircraft Manufacturing/Maintenance Industry Forum would function as a consultative body, an advisory body and an avenue for aerospace and aviation maintenance information-sharing. Governments will need to endorse and facilitate the creation of this Forum and provide secretarial and other support, as long as the initiative comes from the industry in the first place.

Because of the importance of skill transfer and mobility between civil and Defence aviation, and the growing convergence between civilian and Defence platforms identified in this report, the composition of the Aircraft Manufacturing/Maintenance Industry Forum should include representation from Australian Defence Force aviation.

The basis for such a Forum or Working Group already exists, in a range of interest groups and networks. They range from sectoral industry associations such as the GA-based Aviation Maintenance Repair and Overhaul Business Association (AMROBA) and the Regional Aviation Association, through industry sub-sectoral groups of employers and employees such as the Aircraft Electronics Association, to local but cross-sectoral bodies such as the Sydney Aerospace and Defence Interest Group and the relatively new body, Aviation/Aerospace Australia, recently formed to raise the Australian industry's profile. In itself, none of the existing bodies can speak for the industry as a whole, and thus a new Forum is required, spanning all interests. A comparable model is the National Resources Sector Workforce Strategy, seen as a dynamic example of action on an urgent skills priority, needed to meet national economic objectives.<sup>11</sup>

Such a body will need to interface as appropriate with the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established. Together they should play a key role in the monitoring of emerging workforce development needs, and skills planning, for new intakes, for skill upgrades and skill and career transitions.

The Aircraft Manufacturing/ Maintenance Industry Forum should have the brief to take submissions, establish specialist forums and coordinate work on the elements of the national aviation and aerospace industry and workforce development plan.

The Forum should also function as a clearing-house for strategically important information. It was clear from the project's survey of MROs, that many individual firms' development strategies would benefit from a more systematic business planning approach. There is certainly plenty of information available, including from industry skills councils/skills service organisations. But identifying specific organisational requirements, and knowing how to navigate the available information in order to find a solution, are often tasks of daunting complexity when it comes to managing a technical business in a fast-changing globalized economy. MROs reported being too busy to read information or attend events, and confused by changing regulatory requirements

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<sup>11</sup> Australian Workforce Productivity Agency (AWPA), 2012.

especially when these are not translated into “plain English” versions. Targeted, trusted and timely information sharing can be essential, whether firms are startups or are growing, or transitioning. They may not be fully aware of their global supply chains, or they may be innovators searching for opportunities that they did not know existed. In the effort to remain competitive and identify market opportunities, they need to know how to connect to funding sources, targeted research, and strategic alliances.

### **12.7.3 A National Aviation/Aerospace College (NAAC)**

The third element of the turnaround strategy, the proposed National Aviation/Aerospace College (NAAC) represents a strategic approach to providing the training capacity to rebuild national aeroskills and career paths, and to ensure that maintenance training makes a significant contribution to Australia’s education exports.

- This National College should consist of networked local branches in each state and territory and draw on the combined resources of the university and TAFE sectors, linking existing and new providers
- It should have recognition as Part 147 category Maintenance Training Organisation, a Registered Training Organisation, and a nationally registered higher education provider
- It should provide quality-assured programs allowing for career pathing through qualification structures that provide for smooth progression between advanced manufacturing, aeroskills, licensed maintenance, engineering specialisations and maintenance management roles
- It should offer qualifications that are fully EASA-and NGAP aligned , in order to attract international enrolments, playing a significant role in educational exports to meet the coming Asia-Pacific aeroskills shortfall
- The approach could combine the capabilities of civilian and Defence training facilities, making greater provision for group apprenticeships and other mechanisms, to provide new trainees with the diversity of workplace experience which will be needed to create the flexible and versatile workforce required by the coming decade of transition
- It will be necessary to ensure support from aerospace and aviation industry employers for intensive shopfloor practical skills training and experience.

To avoid an over-centralised model of training provision, we propose the use of existing TAFE and university facilities as locally-accessible branches of the NAAC. It would be funded separately from the mainstream VET framework, and subject to the stringent quality assurance requirements that apply to high-risk occupations, combining the capacities of VET and higher education institutions, to take carriage of the training of Australia’s aircraft maintenance engineers. The great advantage of this approach would be its potential to tap the large and profitable market which is likely to exist across the Asia-Pacific region for aircraft maintenance training and qualifications. Taking in large numbers of international students would allow such an institution to achieve the kinds of economies of scale which are signally lacking in the present unusually depressed Australian market, making it possible to offer a range of specialisations which it would be uneconomic to provide purely for a local market even in healthier times.

To attract international students, such an institution will require a curriculum (ideally building on the joint civilian/defence curriculum known as NAC95 which was developed in the 1990s and formed the basis for Aeroskills training in Australia until it was ruled by the Australian National Training Authority (ANTA) to be incompatible with the separation of roles under the VET framework) that faithfully reflects the EASA syllabus as well as meeting other international standards, in particular those in the ICAO training manual. The College would also need to take responsibility for monitoring developments in international training reform, in particular the

NGAP program, to ensure that Australian training and qualifications adjust proactively to ensure continuing alignment with international ones.

Returning to a more immediate need, for those candidates seeking initial employment in GA maintenance (or for that matter, experienced AMEs retrenched by the airlines and seeking work in GA), the qualification structure and Training Package should be revised to provide a seamless pathway between small aircraft and RPT (remembering that over the next decade, both sectors are increasingly likely to require the capability to work on a range of technologies of different vintages), as well as a smooth transition from Certificate IV to Diploma. Group category endorsements would apply for many small planes, and these could be added as an endorsement to a Diploma-based B license, as well as to a Certificate IV-based SAL. Type ratings with appropriately specified skills, knowledge and experience would be available for selected small planes. This implies an exercise to 'rate' all small planes (including retrofitted ones) in terms of their technical characteristics.

## **12.8 Conclusion**

This project was undertaken at a turbulent time for the Australian aerospace/aviation industry. What seemed, four years ago, as a major threat to the future of the industry, has emerged as a significant opportunity for renewal. Nevertheless, a looming impediment needs to be addressed, before this opportunity can be grasped. It has been established clearly that Australia will find it increasingly difficult over the next 20 years to source its maintenance requirements offshore, in a regional and global environment where qualified technicians will be in increasingly short supply. Thus, there is the very real need to prevent a further wastage of industry talent, and to move swiftly to put in place the measures needed,

- To ensure the supply of highly-trained workers for all sectors of the domestic aviation industry
- To help turn aircraft maintenance engineering training into a significant national export.

Three practical measures have been suggested for starting the renewal process: the development of a strategic, cross-sectoral, industry-led planning process, the initiation of this process by a aircraft manufacturing/maintenance industry forum, and the creation of a nationally-networked aviation/aerospace college, oriented both to building the local workforce and to the export market. A more specific set of reforms is outlined in the 23 recommendations at the front of this report.

Provided these measures, or equally effective ones, can be implemented in the near future, there is every reason to believe that the loss of skilled employment in Australian MRO will be reversed in a few years and the occupation will emerge stronger, more relevant and more productive than ever. On the other hand, if the opportunity is missed, there is every risk that the decline will become irreversible, most of the new business opportunities will be pre-empted by other countries, and Australian operators, crew and passengers will be exposed to the worst consequences of a global maintenance skill shortage. The choice is a stark one, and will need to be taken very soon if the opportunities are to remain open.

## **RECOMMENDATIONS**

- **RECOMMENDATION 1:** That a new Aircraft Manufacturing/Maintenance Industry Advisory Forum be established, with Federal Government infrastructural support, to provide a clearing-house for industry information and to act as a participatory planning body to support the transformation of the MRO and MRO training industry, as part of the broader civilian and Defence aviation and aerospace industries.

*With membership to include representatives of the relevant civil and Defence industry sectors, CASA, Skills Service Organisations, training authorities and providers, and front-line employees, this forum be tasked with generating proposals for a coordinated approach to meeting national, rural and regional aircraft maintenance needs and to identifying areas of competitive advantage for establishing Australia as a significant exporter of specialist maintenance and maintenance training nationally and in the Asia-Pacific region.*

- **RECOMMENDATION 2:** That a priority task of the new Forum be to interface closely with the new Industry Reference Committee and Skills Service Organisation structures currently in the process of being established. One of its roles would be to facilitate a consultative process for the development of a workforce plan for the new expanded industry, including a review of current job classifications and training arrangements to facilitate mobility of skilled labour and portability of qualifications across the different sectors.
- **RECOMMENDATION 17:** That a National Aviation/Aerospace College (NAAC) be set up, drawing on the combined resources of the university and TAFE sectors, to take carriage of the training of Australia's aircraft maintenance engineers, to provide career paths to and from advanced aerospace manufacturing -and to provide a commercially attractive vehicle for an export industry in aircraft maintenance training and qualifications.

*That this College consist of nationally-networked local branches in each state and territory, including both civil and Defence aviation education and training providers, and gain recognition as Part 147 category Maintenance Training Organisation, a Registered Training Organisation and a nationally registered higher education provider. It will be necessary to ensure support from aerospace and aviation industry employers for a new model of shopfloor practical skills training and experience.*

## Appendix 1 Methodology

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### A1.1 Research aims and design

The project began by addressing a perceived decline in Australian aircraft maintenance industry capacity, prompted by linked concerns about offshoring, safety and workforce development. As the research developed, new understandings of the future of the maintenance industry, and its role in the wider aviation and aerospace industries, emerged.

### A1.2 Methods and outcomes

#### **RO 1. To project the supply of and demand for AMEs and LAMEs in the short, medium and longer term, and identify causal factors.**

This objective was addressed by finding answers to the following set of research questions:

**RQ 1:** *What is the most effective way to model L/AME supply and demand on a long term and ongoing basis? How can this approach help us establish as precisely as possible the dynamics of the L/AME labour market, and assess the likely shortfall (or oversupply) of skilled, qualified and licensed aircraft maintenance engineers at certain points in the future under certain scenarios?*

**The skill supply** was investigated by examining historical patterns of AME and LAME employment in Australia over the past 15 years and undertaking international comparisons, drawing out implications for future labour supply. This was done by:

- Interrogation of publicly available data (solving estimation difficulties resulting from the smallness of occupation) **to compile** trend data on patterns of entry into and exit from the occupation, including apprentice intake, completion and placement data supplied by Partner Organisations (POs), and compilation of available retention, attrition, replacement and mobility figures
- A secondary source literature review, supplemented by interviews in Turkey and Europe, to analyse employment and MRO trends in North America, Europe and Asia-Pacific
- Desk analysis of patterns of skilled migration intake
- A panel survey and interviews arranged through POs. These sources provided data on AME and LAME work histories (mobility and breadth of experience within the occupation), patterns of acquisition of qualifications, age when people leave, factors influencing intention to leave: remuneration, working conditions, career expectations, whether and why L/AMEs return, and patterns of transfer among defence, general and civilian aviation and patterns of transfer into allied occupations.

The factors affecting the **demand for AMEs and LAMEs** were investigated via:

- Broad trend projections of demand for air transportation to 2025 at global, Asia-Pacific, national, regional and general aviation levels
- Desk analysis, stakeholder workshops and industry group consultations facilitated by POs, continue to map air traffic projections and forecasts in all sectors (international, domestic, regional, general aviation (GA))
- Using the Civil Aviation Safety Authority (CASA) website, analysis of patterns of fleet composition and age, and rate of acquisition of new aircraft to estimate future patterns of demand for heavier and deep forms of maintenance, repair and overhaul

- Mapping of Australian MROs, contractors, original equipment manufacturers (OEMs) and aerospace manufacturers
- A survey of MRO operators
- Analysis of implications of workforce management policies – job design, work organisation, productivity management, outsourcing, offshoring; shift to safety systems approach.

The project was able to access a range of projections of present or future skilled labour requirements in the MRO industry on a global level. Chapter 10 provides a detailed account of how various credible international projections were compared and used jointly as the basis of a projection model for future Australian labour requirements.

Assessing the specific dynamics of the Australian labour market proved more difficult. The main source of Australian labour market data – the Australian Bureau of Statistics (ABS) *Labour Force* series – is of limited reliability in tracking the MRO labour force because of the small sample size of quarterly and annual data, and the last reliable count came from the 2011 Census. This count suggested that there were 14,489 AMEs and LAMEs in Australia in 2011, of whom 40% were in NSW and around 20% each in Queensland and Victoria (Table A1.1). Since that time, mainly resulting from the shift offshore from Avalon and the expansion of Qantas' Brisbane base maintenance operations, there is likely to have been some redistribution. Chapter 10 outlines in detail the sources, methodology and result of estimates of the maintenance workforce size.

Considerably more detailed modelling was possible for recruitment to the industry, thanks to the comprehensive statistics published at quarterly intervals through the VOCSTATS online database administered by the National Centre for Vocational Education Research (NCVER). While problems were encountered with the quality of these data (notably some apparent misclassification of apprentices to employing industries), they have provided an adequate basis for detailed modelling of current and future flows of new skilled workers into the occupation. By combining these with the demand figures from international sources, it was possible to model a range of credible scenarios comparing future demand for labour in Australia against alternative projections of demand over the next 10 years.

To supplement these publicly available data, we carried out a detailed panel survey of current and in some cases former employees in the industry in 2012. The achieved sample for this survey was 708. It was geographically representative (Table A1.1) but skewed to LAMEs (Table A1.2) in part because of the initial convenience sampling approach (reliance on four Partner Organisations – Australian Aerospace, AMROBA, ALAEA and AMWU) to undertake distribution mailouts). One purpose of this survey was to track movements within and out of the industry.

**Table A1.1 Panel survey responses by state/territory, compared with 2011 Census distribution of L/AMEs**

| State/Territory  | Survey Wave 1 , 2012 |         | Survey Wave 2, 2014 |         | Aust Census, 2011 |         |
|------------------|----------------------|---------|---------------------|---------|-------------------|---------|
|                  | Number               | Valid % | Number              | Valid % | Number            | Valid % |
| ACT              | 2                    | 0.3%    | 3                   | 1.1%    | 111               | 0.8%    |
| NSW              | 279                  | 40.4%   | 102                 | 38.8%   | 5697              | 39.3%   |
| NT               | 15                   | 2.2%    | 8                   | 3.0%    | 452               | 3.1%    |
| QLD              | 145                  | 21.1%   | 54                  | 20.5%   | 3498              | 24.1%   |
| SA               | 30                   | 4.3%    | 14                  | 5.3%    | 1028              | 7.1%    |
| TAS              | 5                    | 7.0%    | 3                   | 1.1%    | 44                | 0.3%    |
| VIC              | 160                  | 23.2%   | 56                  | 21.3%   | 2720              | 18.8%   |
| WA               | 53                   | 7.7%    | 23                  | 8.7%    | 939               | 6.5%    |
| Total valid      | 690                  | 100.0   | 263                 | 100.0   | 14489             | 100.0%  |
| Not specified/NZ | 19                   |         | 11                  |         |                   |         |
| <b>Total</b>     | 708                  |         | 274                 |         |                   |         |

Sources: Project LP110100335, Survey of Aircraft Maintenance Engineers, 2012 and 2014;  
Australian Bureau of Statistics, 2012

While the achieved sample size was insufficient to support confident extrapolation, the cases available for analysis were sufficient to provide at least an impression of the range of career paths commonly encountered within this industry. A follow-up round was conducted in late 2014, but sample attrition was in the region of 60%, making it difficult to perform any usefully reliable analyses of movements between the two years. Table A1.2 indicates that AMEs and LAMEs were 90% reliant on an employer for work. The 40% response rate from Wave 1 to Wave 2 may have been influenced by the apparent increase in transitional status between 2012 and 2014, with an increase from 0.3% to 12.3% in respondents seeking work, changing jobs or recently retrenched. Table A1.2 indicates that the main fall-off in response was from AMEs. Table A1.3 indicates that Qantas employees were over-represented in the survey responses: its actual share of civilian maintenance employment is likely to be closer to 36% than the 57% in this table. Employment with OEMs of aircraft and components, such as Boeing, appears to be under-represented.

**Table A1.2 Wave 1 and Wave 2 survey respondents — Employment status**

| Employment status                     | Wave 1 2012 |         | Wave 2 2014 |         |
|---------------------------------------|-------------|---------|-------------|---------|
|                                       | Number      | Valid % | Number      | Valid % |
| Employee                              | 629         | 90.2%   | 219         | 81.4%   |
| Self employed (sole trader)           | 16          | 2.3%    | 5           | 1.9%    |
| Self employed (employing others)      | 9           | 1.3%    | 3           | 1.1%    |
| Retired                               | 38          | 5.5%    | 6           | 2.2%    |
| Seeking work/Changing jobs/Retrenched | 3           | 0.3%    | 33          | 12.3%   |
| Injury/ illness                       | 2           | 0.3%    | 3           | 1.1%    |
| Total                                 | 697         | 100.0%  | 269         | 100.0%  |
| Question not answered                 | 11          |         | 6           |         |
| <b>Total</b>                          | 708         |         | 274         |         |

Source: Project LP110100335, Survey of Aircraft Maintenance Engineers, 2012 and 2014

**Table A1.3 Employment location – Survey respondents Wave 1**

| Employer                                       | Number     | Valid%        |
|--|------------|---------------|
| Qantas   | 403        | 56.9%         |
| Airline operator Australian main route - other | 44         | 6.2%          |
| Airline operator – regional/freight            | 35         | 4.9%          |
| Airline operator - foreign                     | 9          | 1.3%          |
| GA/ Helicopter                                 | 63         | 8.9%          |
| Independent MRO                                | 59         | 8.3%          |
| Self employed/ Contractor                      | 7          | 1%            |
| Government/ Regulator                          | 23         | 3.2%          |
| Defence contractor/supplier                    | 12         | 1.7%          |
| OEM/ Distributor                               | 2          | 0.3%          |
| Education/ Training/ Research                  | 7          | 1%            |
| Not employed in aviation/nec                   | 5          | 2.1%          |
| Not answered/illegible                         | 28         | 3.5%          |
| <b>Total</b>                                   | <b>708</b> | <b>100.0%</b> |

Source: Project LP110100335, Survey of Aircraft Maintenance Engineers, 2012 and 2014

Table A1.4 sets out the range of career paths within the occupation. Chapter 3 has analysed in more detail patterns of career mobility within this range of occupations, and also mobility and destinations from and into other occupations indicated by Wave 1 respondents. Relative ease of re-entry following resignation or retrenchment appears likely, but may require relocation.

In seeking an accurate picture of MRO employers, the project team undertook a mapping exercise and a MRO survey, with the assistance of Partner Organisations. The starting point was a list of 700 potential businesses, but organisations lacking a website or phone number, and a heavy flow of RTS (return to sender) responses to the survey mailout, led to a revised estimate of this number to between 345 and 400. The survey, mailed in late 2013, received 73 responses, mainly from the GA sector. Of the respondents, 30% provided services to charter operators, 66% were engaged in component MRO and 11% were in tied contracts with OEMs to service aircraft or components.

The main specialisations were: structure/airframe (68%), engines (59%), mechanical components (47%) and instrumentation (24%). In terms of size, 62% had between one and nine employees or contractors, 19% were sole traders, 9% employed between 10 and 29 people and just over 10% had 30 or more employees or contractors. About 41% had remained much the same size in workforce numbers over the past four years, but 31% were smaller or much smaller, 16% were much smaller, and 45% believed that business turnover in the next five years would be higher (6% much higher), while 50% expressed confidence of viability in five years' time. On balance it appears the surveyed sector had contracted slightly over the period.



Table A1.4 Wave 1 and Wave 2 survey respondents – Broad aviation job classification by employment status, 2012 and 2014

| Broad Aviation Job Classification                    | Employment Status 2012 (n=708) |         |                            |       |                      | Employment Status 2014 (n=274) |         |                            |       |                      |
|--|--------------------------------|---------|----------------------------|-------|----------------------|--------------------------------|---------|----------------------------|-------|----------------------|
|  | Currently in paid work         | Retired | Not currently in paid work | Total | Effective % of Total | Currently in paid work         | Retired | Not currently in paid work | Total | Effective % of Total |
| Aviation Managers                                    | 27                             | 1       | 0                          | 28    | 4.0%                 | 9                              | 0       | 0                          | 9     | 3.4%                 |
| Aviation Professionals                               | 31                             | 3       | 2                          | 36    | 5.2%                 | 13                             | 0       | 0                          | 13    | 4.9%                 |
| Operations Manager                                   | 18                             | 3       | 2                          | 23    | 3.3%                 | 10                             | 2       | 1                          | 13    | 4.9%                 |
| Supervisor/Leading Hand                              | 34                             | 2       | 0                          | 36    | 5.2%                 | 20                             | 0       | 2                          | 22    | 8.2%                 |
| Licensed Aircraft Maintenance Engineer               | 380                            | 18      | 1                          | 399   | 57.2%                | 141                            | 16      | 3                          | 160   | 59.9%                |
| Aircraft Maintenance Engineer                        | 138                            | 8       | 0                          | 146   | 20.9%                | 11                             | 2       | 3                          | 14    | 5.2%                 |
| Apprentice   | 1                              | 0       | 0                          | 1     | 0.1%                 | 1                              | 0       | 0                          | 1     | 0.4%                 |
| Not applicable/Other employment                      | 8                              | 0       | 0                          | 8     | 1.1%                 | 8                              | 0       | 0                          | 8     | 3.0%                 |
| Blank/illegible/job not specified                    | 17                             | 3       | 0                          | 20    | 12.8%                | 0                              | 13      | 14                         | 27    | 10.1%                |
| Responses  | 654                            | 38      | 5                          | 697   | 100.0%               | 213                            | 33      | 21                         | 267   | 100.0%               |
| Did not answer question                              |                                |         |                            | 9     |                      |                                |         |                            | 7     |                      |
| Total survey respondents                             |                                |         |                            | 708   |                      |                                |         |                            | 274   |                      |
| Unreachable at Wave 1 workplace – Returned to sender |                                |         |                            |       |                      |                                |         |                            | 13    |                      |

Comments – Not applicable: Includes employed outside the industry, self-employed and jobs elsewhere in aviation e.g. pilot, ground staff. The 38 Retired respondents in Wave 1 included 6 volunteers working for example in restorations or air museums

## **RO 2. To investigate the links between offshoring and maintenance quality, including safety**

This objective was addressed by investigating answers to the following research questions:

**RQ 2:** *What issues of aviation safety, reliability and quality are raised by offshoring?*

The project examined whether there were any potential safety risks resulting from a possible failure to address workforce development issues and continued reliance on outsourced and offshore solutions.

**RQ 3:** *What evidence is there that maintenance-related safety incidents can be linked to skill deficiencies under various MRO organisational arrangements?*

The following sub-questions were explored:

- What is the extent of offshoring?
- What is the structure of the international MRO industry?
- What characteristics of offshore MROs have been associated with safety issues?
- What non-safety related consequences flow from deficient maintenance?

Answers to these questions were sought through:

- Review of the international literature on offshoring and safety, in order to identify:
- tendencies within offshore contract maintenance seen as likely to create risks in maintenance practice and outcomes, and approaches to managing them;
- differences of regulatory regimes and practices, and implications of approaches to auditing safety standards
- Interrogation of databases containing reports of safety outcomes associated with onshore and offshore maintenance: These databases contained summaries of maintenance-related incidents, allowing some exploration of links to training and skills
- Interviews with managers and union officials, to identify issues driving offshoring (Table A1.5)
- Working with POs, the conduct of interviews and stakeholder focus groups involving individuals (LAMEs, Regulators) who have overseen practices in overseas MROs or certified their outcomes, and consolidation of results (Table A1.5).

Analysis of responses to the open-ended questions in Waves 1 and 2 of the panel survey described above, in order to gain insight into employee concerns

We undertook a desk review of the academic and regulatory literatures, including the ICAO Convention, its Articles and Annexes, as well as the relevant CASA and European Aviation Safety Agency (EASA) regulations, and relevant training documents. The extensive “grey” literature on the aviation maintenance industry was reviewed – including several documentaries. We examined the statistical evidence about the safety of aviation in general, and outsourcing / offshoring in particular. We conducted ten focus groups with small business employers, skills council officials, defence maintenance personnel, training providers, LAMEs, and GA employers. We conducted 45 structured and semi-structured interviews with industry and regulatory experts, current and former CASA officials, training managers, employers, union officials and license holders.

In addition, we include here some data drawn from the Wave 1 survey of 708 licensed and unlicensed aircraft engineers undertaken in 2012/14 (Tables A1.1-3). The survey invited respondents to make any additional comments they wished about their industry. Of the 384

respondents who answered this question in Wave 1, 167 made negative comments about the current system of training and licensing; there was a similar proportion of responses in Wave 2. The interview and survey comments inform Chapters 3 to 9.

**Table A1.5 Interviews and focus groups conducted, 2011-2014**

| Categories   | Numbers   | Dates/Occasions Month/Year            |
|--|-----------|---------------------------------------|
| <b>INTERVIEWS</b>  | <b>45</b> |                                       |
| ALAEA Officials  | 7         | 0611;0711;2710;0412; 0312; 0313; 0814 |
| LAMEs (individual)   | 6         | 08(3); 09(2); 0514                    |
| Former HR Manager (large airline)  | 1         | 09                                    |
| Training Manager (large airline)   | 1         | 1109                                  |
| Former CASA Official   | 2         | 0312; 1213                            |
| Employer Organisation Representative   | 5         | 1109; 0711; 0711; 1013; 0814          |
| Training Manager (MRO)   | 1         | 0711                                  |
| Training Policy Official   | 1         | 1109                                  |
| RAAus Aircraft Mechanic  | 1         | 0611                                  |
| Air Engineer International Senior Officials (Secretary, President, Vice President) | 3         | 1011; 1011; 0411                      |
| Senior Maintenance Manager, Overseas MRO   | 1         | 1112;                                 |
| Training Provider Senior Managers  | 4         | 0611; 0313 (2 – ATS) 1013(KB)         |
| CASA Inspector   | 2         | 1113 (2)                              |
| GA employer  | 1         | 0811;                                 |
| Aircraft Component Repairer  | 2         | 0811;0811                             |
| Senior Maintenance Manager, Defence Contractor                                     | 3         | 0213; 0213; 0313                      |
| Senior Maintenance Manager, Major Airline  | 1         | 0914                                  |
| Former Quality Inspector, Major Airline  | 1         | 0414                                  |
| Trainer  | 2         | 050714;060714                         |
| <b>FOCUS GROUPS</b>  | <b>10</b> |                                       |
| GA Employers   | 1         | 070609                                |
| LAMEs – Major Airline,   | 1         | 0611                                  |
| LAMEs – Defence Contractor   | 1         | 0313                                  |
| Mixed (ex CASA; LAME; Employer)  |           | 0713                                  |
| Training Providers   | 3         | 1012; 1213(2)                         |
| Defence Maintenance Personnel  | 1         | 0313                                  |
| Skills Council Officials   | 1         | 0514                                  |
| Union Officials  | 2         | 09(ALAEA); 0711 (AMWU)                |

Two International Conferences of the Air Engineers International (AEI) – the international peak organization for national unions of aircraft maintenance engineers – were attended, in 2011 and 2013, and notes taken. This material has been excerpted for information about the implementation of the new licensing system and the way its protective role is being eroded through the combined effects of commercial pressure, political fashion and a decline in attention to the continuing risk factors.

While many people with experience in aircraft maintenance offshoring were willing, indeed eager to talk “off the record”, far fewer were willing to give recorded interviews that conformed

to university Research Ethics Protocols. These people, however, contributed to our stock of general if unattributable “industry intelligence” that has partly informed this Report.

Patterns in safety-related accidents and incidents were identified, and then an attempt was made to establish the contribution, respectively, of offshore maintenance and of maintenance in general. Chapter 4 begins with a detailed inferential analysis of the accident statistics over the full period since the end of World War II, based on data from the international privately run Aviation Safety Network. These data were then triangulated with other reputable figures from international sources including the ICAO, IATA and most recently, the Air Safety Institute within the Aircraft Owners and Pilots Association in the US, and with the detailed annual statistics published for Australia by the Australian Transport Safety Bureau (ATSB). All these data sources are based on official crash reports and other incidents reported to National safety authorities, though their findings differ to some extent owing to differences in the segment of the fleet covered by each, and in some cases on the methods of analysis used.

Because of the relatively small number of serious accidents which occur in main route commercial aviation, statistical analysis by itself is not able to answer all the relevant questions. To fill the gaps in the picture, we developed a conceptual model based on the extensive international scholarly literature in the area of aviation and more generally of occupational safety, which was able to provide us with at least an impressionistic picture of the threats to passenger and aircrew safety that actually or potentially exist. Chapter 5 sets out this model and its sources in more detail.

In the case of the international statistics, the figures were disaggregated by country, but in all cases referred to the country of registration rather than that in which the accident had occurred or the maintenance had been carried out. As a result, we were only able to rely on qualitative sources and a number of specific accident investigations carried out by the US National Transportation Safety Board in past decades, which have been the subject of earlier published research by members of the project team. The international sources were generally more informative on the number of accidents in which errors and oversights in maintenance were the primary or contributory factor behind the accident. We have summarised the data from these sources and matched them to the accident statistics published by the ATSB to reach an estimate of the contribution of maintenance failures. While the estimates vary widely from source to source, they were sufficient once again to identify the key areas in which continuing vigilance is required.

### **RO 3. To investigate AME/LAME access to skills / qualifications development and possible links to (a) safety and (b) LAME retention**

This investigation was carried out initially by seeking answers to the following research questions:

- RQ4.** *How can training and licensing, workplace skill development and recognition best contribute to L/AME workforce retention in Australia? What is the role of heavy maintenance as a skills incubator?*
- RQ5.** *How possible is it to transfer into aircraft maintenance from allied trades? What role does recognition of comparable/similar skills in allied trades and defence maintenance play in preventing transfer in to the occupation?*

A starting point for exploring these questions came from:

- Desk research and field trips to RTOs/MTOs and efforts to study a European and an Australian MRO facility

- Analysis of training materials including the revised Australian Aeroskills, its European and US counterparts training package, as well as the ICAO Training Manual
- Comparison of qualification structures, skills recognition and work processes of L/AMEs in defence, civil aviation and allied trades to ascertain the extent to which qualifications overlap, and modules are common

As the research progressed, a further crucially important question emerged:

**RQ5a.** *What is the industry impact of changes to CASR processes for regulating continuing airworthiness maintenance organisations, MROs, the licensing of maintenance engineers, and maintenance training organisations? To what extent has harmonisation with the EASA system been achieved?*

In workshops and focus group discussions (Table A1.5) using the expertise of POs,

- Training package(s) were mapped to identify the uniqueness of aviation, areas of overlap and potential transfer paths; the sort of bridging training that would be necessary
- Different perceptions were explored as to the effectiveness of apprenticeship and training methods in producing engineers with the skills required to compete internationally
- Views were collected as to the availability of parts of the training system to some MROs/operators, for example in GA (this latter question was also explored as part of a survey of MRO operators).

It was noted that the process of regulatory reform is still under way, and the project may have picked up teething problems that will be resolved. Nevertheless, adverse impacts were identified from the uncertainties generated by the change process, its incompleteness in the GA sector, and lost years of opportunity to build a strong maintenance training presence in the Asia-Pacific region.

As noted under RQ1, the absence of reliable ongoing statistics on the Australian MRO labour market made it difficult to reach any statistically based conclusion on the dynamics of the market as a whole over this transition period. However, it was possible in Chapter 10 to produce confident estimates of the performance of the training sector, primarily in terms of output and capacity, but also shed some indirect light on quality issues, mainly through movements in the level of wastage. Once again, qualitative evidence based on the knowledge of industry insiders proved more helpful for analysing the effectiveness of the current training system and its interaction with aviation safety regulation.

#### **RO 4. To investigate the potential for a sustainable MRO and aeroskills training industry in Australia, and to estimate its costs and benefits, by reference to overseas practice and taking account of Australian policy conditions**

Again, as the research progressed, the final research question took on a range of increasingly specific forms:

**RQ 6a:** *What policy approaches, by operators and government, might influence the future demand for skilled and qualified labour in aircraft maintenance in Australia?*

**RQ6b:** *How can the relationship between future L/AME supply and demand be modelled, using scenarios based on these variable policy options?*

**RQ 6c:** *What are the potential benefits of an active government approach to workforce planning? What are the costs of government intervention and support and what are the costs of not doing so?*

The questions were addressed through:

- Desk analysis using scenario modelling
- Meta-analysis of overseas cost/benefit studies
- Consultation with industry experts and interest groups; advanced manufacturing site inspections; participation in aviation and manufacturing forums at industry and regional level; workshops in order to develop proposals for an enhanced role for Australian MROs in the various aviation sectors

The potential for an export industry in aviation maintenance training was estimated on the basis of ICAO projections for training needs and shortfalls over the next 20 years, with particular reference to the Asia-Pacific region where we envisage most of the demand arising for an Australian product.

A mapping was undertaken, state by state and region by region, of the “nesting” of aircraft maintenance within both the aviation industry and the aerospace industry, with growing intersections between civilian and defence maintenance contractors. Global and local supply chains and models of integration were identified, including links with Tier 1 advanced manufacturers, resulting in maps of the relationships amongst over 900 Australian air operators, third party maintenance providers, aviation business services, aircraft and component manufacturers and training and professional service providers.

Emerging requirements in the regional and GA sectors were identified, along with the role of the Airport Master Planning process. Case studies of multiplier and spillover effects of aircraft maintenance and manufacturing hubs were identified, along with estimates of the economic contribution of the GA sector, with evidence of rates of return where tax incentives and infrastructure are have been offered.

Without attempting to put a dollar value on them, **the costs of not intervening to stimulate the maintenance industry**, were identified, such as loss of potential and actual employment opportunities, of potential revenue from maintaining other countries’ aircraft and exporting maintenance training; risks to national technical capacity, very important in defence; potential safety and reliability issues; and the risks to regional and rural infrastructure. Potential specialisations were identified, building on existing initiatives.

## Appendix 2 Required Hours of Training and Experience under International and Australian Regulatory Structures

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This appendix describes the methodology used to compare international standards of aircraft maintenance training and licensing, and Australian training practice in respect of knowledge, skills and experience. Whilst this exercise cannot be done exhaustively it can be shown that there is a strong case that Australia provides fewer training hours in some areas than its international comparators. It follows that a more sustained study is needed to establish this claim in detail, as well as to suggest alternative approaches to the issues identified in Chapter 9. Where the analysis relies on a funding guide based on the Aeroskills Training Package MEA11, the comments refer to that Training Package, now superseded. Where possible the analysis refers to the 2015 Training Package, released in February 2015.<sup>1</sup>

International reference points for numbers of training hours, and training content, are found in the International Civil Aviation Organisation (ICAO) Training Manual,<sup>2</sup> and the European Aviation Safety Agency (EASA) Basic Regulations Parts 66 and 147. Unfortunately, while EASA does clearly specify the total number of hours to be allocated to category training (as well as the mix of theory and practice) it does so only at the level of the qualification underlying the particular licence, and not the more detailed level of the individual module.<sup>3</sup> The ICAO Training Manual, however, does provide recommendations of training hours for individual modules, some of which it refers to as “ICAO Chapters”. The usefulness for comparative purposes of the hours figure attached to each chapter, and to each chapter component, is compromised because of how the manual lists the total number of hours deemed necessary to learn each module as if it were being taught on its own, whereas the modules are often combined for teaching purposes. While this consideration compromises the utility of the analysis that follows, the exercise is worth undertaking, whilst taking account of the “inflated” ICAO hourly estimates. Although these do not correspond exactly to the EASA structure, they are near enough for our present limited purposes. To track correspondence more precisely, a finer level of detail is needed, but this is beyond the scope of this study — a further reason for a comprehensive look at Australia’s compliance with international standards.]

The analysis that follows compares ICAO and EASA specified training hours with Australian funded hours. Aiding a comparison between ICAO training specifications and the Australian version of the EASA training requirements (as detailed in the CASRs) is the fact that both do specify components of modules, and their associated training hours, at a similar level of granularity. Also usefully, the Victorian Purchasing Guide<sup>4</sup> allocates the nominal hours by Unit of Competency, and these can be added up to arrive at a figure of funded hours per module. The result facilitates a comparison of the hours allocated to the EASA/CASR modules and the ICAO ones. The route by which the comparison is accomplished is detailed, as follows.

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<sup>1</sup> Manufacturing Skills Australia (MSA), 2011, 2015; State of Victoria, Department of Education and Early Childhood Development, 2013

<sup>2</sup> International Civil Aviation Organisation (ICAO), 2003.

<sup>3</sup> The Civil Aviation Safety Regulations (CASRs), although specifying *type* training hours precisely, do not specify numbers of training hours necessary for the attainment of the qualifications that underpin licences.

<sup>4</sup> State of Victoria, Department of Education and Early Childhood Development, 2013.

## A2.1 Do funded training hours in the Australian system match international standards?

The starting point is a comparison between EASA and Australia. EASA clearly specifies numbers of training hours necessary for particular types of licence – as well as the proportion of the training hours that are to be assigned to theory and “practical skills training” (to use ICAO terminology). They are represented in the Table A4.1, taken from the EASA Basic Regulation Part 147, 28 November, 2011 (p. L 315/160).

The Civil Aviation Safety Authority (CASA) does not list hours necessary for category (licence) training. But another reason why it is difficult to establish an “apples with apples” comparison between Australia and EASA is that the European figure includes what ICAO calls “practical skills training” (supervised practice and learning) done within training institutions (the EASA figure specifies the ratio) – whereas the Australian system conducts supervised practice and learning within training institutions, but also on the shop floor in apprenticeship arrangements. It is therefore more difficult to specify the total number of hours of “practical skills training”, and even more difficult to ensure practice accords with them.

These limitations aside, let us first compare EASA mandated hours (Table A3.1) with funded hours allocated to each qualification (Table A3.2). The Victorian Purchasing Guide<sup>5</sup> for the MEA11 Aeroskills Training Package<sup>6</sup> determines how many hours the Victorian government will allocate training providers to deliver particular qualifications and “units of competence”, and what funding rates per hour apply. This publication sets a benchmark for the funding practices of other States, although as mentioned above *few states deliver full funding to diploma level*. Table A3.2 has been prepared from that resource, and (when compared with the EASA chart above) it indicates that in terms of aggregate allowed funded training hours Australia and EASA are not far apart – if anything Australia exceeds the EASA requirements marginally, with the notable exception of the Certificate II in Aircraft Line Maintenance (which underpins the Category A licence).

**Table A2.1 Training hours required and proportion of training that is theoretical, EASA/ICAO, 2003**

| Basic Course | Duration (in hours) | Theoretical training ratio (%) |
|--------------|---------------------|--------------------------------|
| A1           | 800                 | 30 to 35                       |
| A2           | 650                 | 30 to 35                       |
| A3           | 800                 | 30 to 35                       |
| A4           | 800                 | 30 to 35                       |
| B1.1         | 2400                | 50 to 60                       |
| B1.2         | 2000                | 50 to 60                       |
| B1.3         | 2400                | 50 to 60                       |
| B1.4         | 2400                | 50 to 60                       |
| B2           | 2400                | 50 to 60                       |

<sup>5</sup> State of Victoria, Department of Education and Early Childhood Development (2013).

<sup>6</sup> Manufacturing Skills Australia, 2011.



**Table A2.2 Australian aircraft maintenance training qualifications - Nominal hours**

| Qualification | Qualification Title                         | AQF level | Nominal Hours |
|---------------|---|-----------|---------------|
| MEA20510      | Certificate II in Aircraft Line Maintenance | II        | 620           |
| MEA40707      | Certificate IV in Aeroskills (Mechanical)   | IV        | 1580, 1,750   |
| MEA40610      | Certificate IV in Aeroskills (Avionics)     | IV        | 1,600         |
| MEA50110      | Diploma of Aeroskills (Avionics)            | V         | 2,045         |
| MEA50211      | Diploma of Aeroskills (Mechanical)          | V         | 2,800-2,900   |

While EASA does clearly specify the total number of hours to be allocated to training (as well as the mix of theory and practice) it does so only at the level of the qualification, not the level of the individual module. To make some comparisons at the module level between numbers of Australian training hours and the hours specified by EASA, we turn to the ICAO Training Manual which specifies the content and training time (and learning level) of specific modules. The ICAO chapters, specified in the ICAO Training Manual, map only inexactly onto the EASA modules. This is visible in the following incomplete table (Table A3.3), which establishes that there is significant correspondence for the *theory* modules, although not for some of the others.

**Table A2.3 Mapping exercise seeking correspondence between EASA modules and ICAO Chapters**

| EASA Modules                                       | ICAO Chapters  |
|--|--|
| 1 Mathematics                                      | Ch. 4. Natural science and general principles of aircraft                        |
| 2 Physics  | Ch. 4. Natural science and general principles of aircraft                        |
| 3 Electrical fundamentals                          | Ch. 4. Natural science and general principles of aircraft                        |
| 4 Electronic fundamentals                          | Ch. 4. Natural science and general principles of aircraft                        |
| 5 Digital techniques electronic instrument systems | Ch. 7. Aircraft engineering and maintenance: Avionics: Electrical and Instrument |
| 6 Materials and hardware                           | Ch. 8. Aircraft engineering and maintenance: Avionics: AFCS/Navigation Radio     |
| 7 Maintenance practices                            | Ch. 10. Practical Maintenance Skills: Airframe                                   |
| 8 Basic aerodynamics                               |  |
| 9 Human factors                                    | Ch. 9. Human Performance and Limitations   |
| 10 Aviation legislation                            | Ch. 3 Civil Aviation Requirements, laws and regulations                          |
| 11 Aeroplane aerodynamics, structures and systems  | ETC  |

It is thus possible to examine, albeit roughly, the extent to which the numbers of hours stipulated by ICAO to achieve requisite levels of learning in specific chapters compare with roughly corresponding modules in the EASA syllabus (which is reproduced almost exactly in the CASRs). The material in EASA Modules 1, 2 and 3, for example, appears to be covered in Chapter 4 of the ICAO Training Manual, where it is allocated 445 formal training hours. An exploration of the Victorian Purchasing Guide reveals that 120 hours is allocated for this theory training. This point is established as follows.

The Victorian Purchasing Guide (p. 8) specifies that 120 nominal hours' funding can be claimed by RTOs for student achievement of MEA201B – a unit of the MEA011 Training Package (see the next section, where we discuss the very large claimed coverage of the Australian content of the unit of competence MEA201B). This competency is described as “covering” extensive content

from the CASR/EASA modules. In Table A3.4 below, the left column lists the theoretical content that MEA201B covers. Corresponding content at the “sub-chapter” level from the ICAO Training Manual Appendix 2 is aligned to it. Despite being organized slightly differently, it contains specifications of recommended training hours associated with each “sub chapter module”, and these can be summed for the whole module. For purposes of presentation, a truncated version of the table covering the EASA modules in comparison with the ICAO content is used.

The time specified by ICAO to cover the knowledge content of the key EASA theory modules 1, 2, 3 can thus be estimated to be in the order of 445 hours. The equivalent figure in Australia is 120 hours — significantly less.

**Note:** MEA148,<sup>7</sup> which now “covers” the EASA/CASR part 66 knowledge content for Mathematics and Physics, is a new Unit of Competence, and therefore there are as yet no guidelines in the Victorian Purchasing guide as to numbers of funded hours it will attract.

**Table A2.4 Hours comparisons, selected EASA/CASR modules**

| EASA/CASR Module              | ICAO Comparator Unit<br>(not exact)  | Hours ICAO<br>(Theory only) | Hours Australia (Total off<br>JT training – and some<br>On JT) |
|-------------------------------|--|-----------------------------|--|
| 1. Mathematics                | Chapter 4: Natural science and<br>general principles of aircraft:<br>4.3 Mathematics               | 75                          |  |
| 2. Physics                    | 4.4 Physics  | 70                          |  |
| 3. Electrical<br>Fundamentals | <b>Chapter 7:</b> Aircraft engineering<br>and maintenance: Avionics –<br>Electrical and Instrument | 300                         |  |
| Total hours                   |  | <b>445</b>                  | <b>120</b>   |

## A2.2 How much theory content is mandated in Training Packages?

This section explores the extent to which theory is stipulated in competency based Training Packages, which, in Australian Training System, guide assessment. Appendix 1 to MEA11 states that particular competencies should “cover” particular knowledge content for CASA licensing purposes. Thus under “Assessment Requirements” the Training Package says:

Underpinning skills and knowledge must fully cover the Civil Aviation Safety Regulation Part 66 licensing topics as listed by licence and unit of competency in Appendix 1 to this Training Package.

Where individuals are seeking the grant of an Aircraft Maintenance Engineer Licence ... in Categories A, B1 or B2 it must be demonstrated that *the knowledge requirements of the syllabus were fully covered in the underpinning knowledge* applicable to the units of competency relevant to the licence sought (emphasis added)<sup>8</sup>

In this Appendix there is a table for each A and B1 Licence, and for the B2 Licence (or the equivalent maintenance authorities) in which *syllabus modules and topics applicable to each licence are listed, along with the units of*

<sup>7</sup> Manufacturing Skills Australia (MSA), 2015.

<sup>8</sup> Manufacturing Skills Australia (MSA), 2011, p. 41

*competency that are expected to provide the required knowledge\_( emphasis added).*<sup>9</sup>

This table is modified below (Table A3.5) to show how different competency standards are required for different licences. However, here the discussion is confined to reproducing the first two modules, which identify the competency standards described as “fully covering” the knowledge requirements of the CASA/EASA syllabus. Also included in this table is part of Module 3 to establish that all the content of Modules 1, 2 and much of Module 3 is deemed to be “fully covered” by the competency standard MEA201B (at least for the B level licences). This must be a voluminous competency standard indeed! The full title of this competency standard is **MEA201B Remove and install miscellaneous aircraft electrical hardware/components**. Its elements are

- Remove aircraft electrical hardware
- Install aircraft electrical hardware

The theoretical knowledge of Modules 1-3 is “covered” in the “Required Skills and Knowledge” section of the Competency Standard by the following statement

- electrical fundamentals and related mathematical and physics principles.

Maintenance Category providers have expressed concern at this, arguing that the coverage does not provide any but the post elementary guidance for training programs. While it is true that the two and a half EASA/CASR modules are “covered”, the nature of the “coverage: is not such as to provide any but the most elementary guidance for training programs. Educators must draw from elsewhere to flesh out training knowledge content, and this will allow for the fragmentation of knowledge content.

Since the above was written, the MEA11 Training Package has been superseded by the new MEA Aeroskills Training Package – which is not referenced to a particular year. Appendices to this new Training Package contain much new work aimed at cross referencing the CASA Knowledge Syllabus to the competency standards. **MEA148 Apply mathematics and physics in aviation maintenance**, a new unit of competence, in its assessment guidelines, specifies the knowledge content necessary to be covered in more detail than did the corresponding competency standards (MEA201B) in MEA11. The content is specified at the level of content headings, and there is no question of the competency statements substituting for a curriculum document, since they were never designed to do so.

In November 2015, MSA advised that it is in the process of publishing a Companion Volume to the Aeroskills Training Package, providing advisory information based on discussions with CASA. It is designed as an “interface” between MEA Aeroskills qualifications and the additional CASA requirements that must be met for the granting of a licence. It provides a detailed alignment between the CASA licensing syllabus and various MEA Aeroskills Training Package units of competency. Topic lists mandate content for Common Units (21 pp.), Avionics (158 pp) and Mechanical (182 pp.) These lists, despite the use of terms like “mandatory” and “syllabus”, may clarify CASA requirements, but leave the RTO and educator with the responsibility of shaping a theoretically coherent curriculum and arguing for the hours required by a learner to acquire the theoretical understanding and practical experience implicit in the topic headings.

The ICAO Training Manual specifies in Chapter 9 that a large number of hours also be allocated to *skills training* (as distinct from knowledge training). Once again these are difficult to compare

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<sup>9</sup> Manufacturing Skills Australia (MSA), 2011, P. 89.

to Australian circumstances, but the following are indicative: Chapter 10, practical maintenance skills: Airframe = 1,825 hours; Chapter 11 Practical maintenance skills: Engine and Propeller = 1,000 hours; Chapter 12 Practical maintenance skills: Avionics – Electrical, instruments, autoflight and radio = 3,775. By contrast, the Australian training system deems that a portion of skills training and knowledge training takes place within the training institution (MTO) within the specified hours. Some skills training is also deemed to take place in the workplace, but it is difficult to apportion between this and the theory training.

**Table A2.5 Alignment between CASA licensing syllabus and Aeroskills units of competency**

| Syllabus Reference A1 Licence                     | Units of Competency Providing Full Coverage |             |               |
|---|---|-------------|---------------|
|   | A1.1  | B1.1 (Mech) | B2 (Avionics) |
| <b>Module 1 Mathematics</b>                       | MEA345A                                     | MEA201B     | MEA201B       |
| <b>Module 2 Physics</b>                           | MEA345A                                     | MEA201B     | MEA201B       |
| <b>Module 3 Electrical Fundamentals</b>           |   |             |               |
| 3.1 Electron Theory                               | MEA265A                                     | MEA201B     | MEA201B       |
| 3.2 Static Electricity and Conduction             | MEA265A                                     | MEA201B     | MEA201B       |
| 3.3 Electrical Terminology                        | MEA265A                                     | MEA201B     | MEA201B       |
| 3.4 Generation of Electricity                     | MEA265A                                     | MEA201B     | MEA201B       |
| 3.5 DC Sources of Electricity                     | MEA265A                                     | MEA201B     | MEA201B       |
| 3.6 DC Circuits                                   | Not required                                | MEA201B     | MEA201B       |
| 3.7 Resistance/Resistor                           | Not required                                | MEA201B     | MEA201B       |
| 3.8 Power   | Not required                                | MEA201B     | MEA201B       |
| 3.9 Capacitance/Capacitor                         | Not required                                | MEA201B     | MEA201B       |
| 3.10 Magnetism                                    | Not required                                | MEA201B     | MEA201B       |
| 3.11 Inductance/Inductor                          | Not required                                | MEA201B     | MEA201B       |
| 3.12 DC Motor/Generator Theory                    | Not required                                | MEA203C     | MEA203C       |
| 3.13 AC Theory                                    | MEA264A                                     | MEA203C     | MEA203C       |
| 3.14 Resistive, Capacitive and Inductive Circuits | Not required                                | MEA203C     | MEA203C       |
| 3.15 Transformers                                 | Not required                                | MEA203C     | MEA203C       |
| 3.16 Filters                                      | Not required                                | MEA203C     | MEA203C       |
| 3.17 AC Generators                                | Not required                                | MEA203C     | MEA203C       |
| 3.18 AC Motors                                    | Not required                                | MEA203C     | MEA203C       |

It is also necessary to revisit the issue of “practical experience”. The ICAO Training Manual recommends two years of experience (phase three) for each of the categories of Airframe, Engine and Avionics for base maintenance, and three years for line maintenance. EASA regulations specify numbers of years of experience slightly differently and in more detail. The EASA “Basic Regulation” (Annex III. 66.A.30) specifies (for Category A and B1.2 and B1.4) three years practical experience if the applicant has no previous technical training; two years if they have “relevant” technical training, and one year practical maintenance experience on “completion of a Part-147 approved basic training course” [Annex III. 66.A.30(a)1(iii)]. The VET system now has the task of supervising the documentation of what ICAO calls “practical maintenance experience”, while the opportunities to acquire that experience are rapidly vanishing.

## Appendix 3 Case Studies of Potential Aviation, MRO and Aerospace Clusters

The tables in Appendix 3 provide examples of aviation and aerospace business clusters within regions of different types and sizes, to which air operators and MROs have links. The numbers of organisations of each type are likely to be considerably understated, particularly in the case of manufacturing supply chains. They represent those that the researchers were able to identify from publicly accessible databases and websites. The examples of firms under each table were selected out of many that could have been chosen to indicate differences in the types of activities characteristic of each cluster.

**Table A3.1 Aviation/aerospace cluster — Western and South-Western Sydney**

| Main Business Activity | Total | Capability                                | Number | AOC | Part 42 CAMO | Part 145 AMO | Part 147 MTO    | S21M | Design Approver |
|------------------------|-------|---|--------|-----|--------------|--------------|-----------------|------|-----------------|
| GA Class A Operator    | 5     | In-house MRO                              | 4      | 4   |              |              |                 |      |                 |
|                        |       | Also MRO service to other operators       | 1      | 1   |              |              |                 |      |                 |
| GA Class B Operator    | 1     | In-house MRO                              | 1      |     |              |              |                 |      |                 |
| Defence contractor     | 10    | MRO (former Qantas Defence Services)      | 1      |     |              |              |                 |      | 1               |
|                        |       | TLS for OEM                               | 1      |     |              |              |                 |      |                 |
|                        |       | Manufacture of specialist components      | 2      |     |              |              |                 |      |                 |
|                        |       | Sourcing of parts                         | 2      |     |              |              |                 |      |                 |
|                        |       | Design of integrated systems – simulation | 4      |     |              |              |                 |      |                 |
| 3rd Party MRO          | 15    | Whole aircraft/airframe MRO               | 6      |     | 1            | 3            | 2 Type          |      | 1               |
|                        |       | Component MRO                             | 4      |     |              | 3            | 2 Type          |      |                 |
|                        |       | TLS for OEM                               | 1      |     |              | 1            |                 |      |                 |
|                        |       | Component supply and servicing            | 4      | 1   |              | 1            |                 |      |                 |
| GA-specific MRO        | 21    | Generalist Aircraft/airframe MRO          | 7      |     |              | 1            |                 |      |                 |
|                        |       | Component MRO                             | 13     | 0   |              | 2            |                 |      |                 |
|                        |       | TLS for OEM                               | 1      |     |              |              |                 |      |                 |
| OEM                    | 5     | Also AMO                                  | 2      | 0   |              | 2            | 1 Type          |      |                 |
|                        |       | TLS                                       | 3      |     |              |              |                 |      |                 |
| Education/Training     | 6     | Maintenance Training Organisation         | 1      |     |              |              | 1 Cat           |      |                 |
|                        |       | Commercial flight training                | 3      |     |              |              | 1 Type          |      |                 |
|                        |       | GA flight training                        | 2      | 2   |              |              |                 |      |                 |
| Aviation Services      | 8     | Component supply/logistics                | 5      |     |              |              |                 |      |                 |
|                        |       | Aircraft sales/leasing                    | 3      |     |              |              |                 |      |                 |
| Manufacture            | 21    | Component manufacturer/installer          | 5      |     |              | 1            |                 |      |                 |
|                        |       | Tier 1/2 supply chain                     | 12     |     |              |              |                 |      |                 |
|                        |       | Manufacture of tools, materials           | 4      |     |              |              |                 |      |                 |
| Professional Services  | 10    | Design, modification approval, testing    | 8      |     |              |              |                 |      | 3               |
|                        |       | Audit                                     | 2      |     |              |              |                 |      |                 |
| Total                  | 102   |   | 102    | 8   | 1            | 14           | 1 Cat<br>6 Type |      | 5               |

## **Western and Southwestern Sydney - Examples**

**Airbus/EADS Australian Aerospace**, a helicopter assembly company located in Brisbane and a Defence maintenance contractor with sites in Adelaide and Sydney. Now part of the Airbus Group, its Defence contracting work in Western and Southwestern Sydney includes deep maintenance life-extension structural support for the AP-3C Orion and through-life-support for C-130J Hercules transports. At other sites, the company provides support for the RAAF's Airbus A330-based Multi-Role Tanker-Transport (MRTT) aircraft and F/A18 (Classic) Hornet fighters (Airbus Group Asia Pacific, 2015).

**Bilyara** is an aviation consulting firm at Bankstown, that developed from HDH, with divisions providing engine overhaul, engine and engine component inspection and repair, scheduled engine maintenance and fault diagnosis, and other whole-aircraft deep maintenance projects involving inspections, overhauls and modifications. Another division provides sales and support of high- tech radar, navigation and aerial mapping equipment; complex project management and subcontracting; and advanced technology design, development and maintenance (Bilyara Aviation Services, 2015).

**Quickstep Holdings** Bankstown is an advanced manufacturer of carbon fibre composites for defence, aerospace and automotive industries, and has developed an out-of-autoclave Resin Spray Technology. Partners: Northrop Grumman and Airbus/EADS. With a Federal Government Development Grant, in 2014 it signed a 14 year agreement with Marand, furthering links with BAE Systems (UK), and Lockheed Martin (Fort Worth). Its technology is being used by ORPE Technologiya to develop a satellite heat shield and US-based Vector Composites to manufacture composite parts in-house. In January 2015, a technology transfer agreement with Thales opened a process plant in Munich. Nadcap accreditation allows pursuit of contracts with Airbus, Boeing and other manufacturers requiring this accreditation throughout their supply chain (Quickstep Technologies, Newsletters and Quarterly Reports 31/1/2014; 1/4/2014; 15/07/2014; 2/10/2014; 27/1/2015; 26/2/2015).

**The Safran** Group including Sagem Australasia Pty Ltd and Turbomeca, is a Defence/Civilian provider of afterservice and a Centre of Excellence for optronics, avionics, electronics and critical software. Has as EASA and FAA Part 145 approval for work on engines via a joint company with GE - CFM, and LEAP, performing deep maintenance for Pacific region of Arrius and Arriel turboshaft engines (Safran, 2015)..

**Northrop Grumman's Integrated Defence Services** (acquired in 2014 from Qantas Defence Services) operates from Richmond RAAF Base performing depot-level maintenance, repair and modification of C-130H Hercules aircraft including structural and mechanical components; and at Villawood providing maintenance, repair and overhaul of Rolls Royce T56 and Adour gas turbine engines (Northrop Grumman, 2015).

**Table A3.2 Aviation/aerospace cluster — Queensland – Regional/rural**

| Main Business Activity                | Total      | Capability   | Number     | AOC       | Part 42 CAMO | Part 145 AMO | Part 147 MTO | S21M Design Approver |
|---------------------------------------|------------|--|------------|-----------|--------------|--------------|--------------|----------------------|
| Regional Airline/<br>RPT Air Operator | 2          | In-house maintenance                                       | 2          | 2         | 2            | 1            |              |                      |
| GA Class A Operator                   | 23         | In-house maintenance, may also supply maintenance services | 23         | 23        | 1            | 1            |              |                      |
| GA Class B Operator                   | 1          | In-house maintenance                                       | 1          |           |              |              |              |                      |
| Defence Contractor                    | 3          | Parts sourcing   | 1          |           |              |              |              |                      |
|                                       |            | Design/manufacture of systems/components                   | 2          |           |              |              |              |                      |
| 3rd Party MRO                         | 14         | Tied contract  | 1          |           |              | 1            |              |                      |
|                                       |            | Aircraft MRO (nose-to-tail, refurbishment)                 | 6          |           |              | 2            |              | 1                    |
|                                       |            | Component MRO  | 6          |           |              | 4            |              | 1                    |
|                                       |            | TLS for OEM  | 1          |           |              | 1            |              | 1                    |
| GA-specific MRO                       | 59         | Aircraft MRO (generalist)                                  | 33         | 4         | 1            | 1            |              |                      |
|                                       |            | Component MRO (may also source, install parts)             | 26         | 2         |              | 6            |              |                      |
| Education/Training                    | 3          | MTO  | 1          |           | 1            |              |              |                      |
|                                       |            | Intro aviation skills training                             | 1          | 0         | 0            | 0            | 0            | 0                    |
|                                       |            | Flight training  | 1          | 0         | 0            | 0            | 0            | 0                    |
| Manufacturing and Engineering         | 12         | Component manufacture                                      | 6          | 0         | 0            | 2            | 0            | 0                    |
|                                       |            | Small aircraft manufacture                                 | 2          | 0         | 0            | 0            | 0            | 0                    |
|                                       |            | Tier1/2 Supplier   | 2          | 0         | 0            | 1            | 0            | 0                    |
|                                       |            | Tool manufacturer  | 2          | 0         | 0            | 0            | 0            | 0                    |
| Aviation Business Services            | 18         | Parts sourcing   | 10         | 0         | 0            | 0            | 0            | 0                    |
|                                       |            | Aircraft sales, ownership broking, airfield management     | 8          | 0         | 0            | 0            | 0            | 0                    |
| Professional Services                 | 6          | Modification design/ approval, testing, audit              | 6          | 0         | 0            | 0            | 0            | 4                    |
| <b>Total</b>                          | <b>141</b> |  | <b>141</b> | <b>31</b> | <b>5</b>     | <b>20</b>    | <b>0</b>     | <b>7</b>             |

## **Regional/rural Queensland - Examples**

**Milspec Services Pty Ltd**, a subsidiary of a Texas firm, specialises in total logistical support for the ANZ Defence Forces and is a CASA approved distributor of aircraft parts and an Australian Government Defence approved supplier. It provides technical and engineering support for all types of Defence aircraft and other vehicles, including spares procurement, inventory management, and repair and overhaul programs (Milspec Services, 2015)

**Aircraft Composites Australia** at Caloundra, is a GA MRO with CASA Part 145, CAR 30, one-off production and APMA approval to work on composite, composite to metal and sheet metal repairs (Aircraft Composites Australia, 2015.).

**Helibiz** at North Queensland's Airlie Beach is a GA MRO organisation with CASA approval to conduct service and maintenance on most helicopters and fixed wing aircraft, has tie-in to large Robinson inventory, does remote servicing, and has authorisation to do R22 and R44 rebuilds and overhauls, other aircraft modifications and upgrades and avionics installation (Helibiz, 2015.).

**The Australasian Aviation Group – Cairns (AAG-C)** was formed in 2006, as a one-stop shop for owners, operators, pilots and maintainers of both fixed and rotary wing aircraft. It includes two regional airlines (West Wing and Hinterland) and several GA operators. Cert II Aviation (not maintenance) training is provided at the Cairns Aviation Skills Center, and there is a branch of Brisbane-based Part 147 MTO Aviation Australia. In addition to air operators with MRO capability, the Group includes a branch of Hawker Pacific and the main hangar of its subsidiary Australian Avionics. Among five other MROs are two which pitch to Indonesian, PNG and South Pacific GA markets and a GA MRO with Australian Part 145 approval (Far North Queensland). There is also a branch of PTB (an engine MRO) and Five Rings (a S31 M authorized design approver). The aviation industry is seen to contribute to Cairns' tourist appeal and also to benefit from it. There may be some vulnerability as mining passes its peak, but AAG-C continues to affirm the strength of its international, national and regional markets. But a stabilizing presence is Hawker Pacific and its subsidiary **Australian Avionics**, which provides services to regional centres throughout Australia and internationally. Its Cairns workshop can handle highly sophisticated equipment, its extensive inventory includes new and overhauled equipment and it operates a large AOG rental/exchange pool (Australasian Aviation Group, Cairns (AAG-C) (2015).

**Flying Colours**, is an Australian-owned company at Townsville, providing painting refinishing of exterior, cabin interior and components for the civil RTP/airline, corporate jet and defence aircraft sectors. The company has worked on aircraft ranging from Iroquois and Chinook helicopters to Boeing 737-800s. Clients include Qantas, Cobham, Virgin, Alliance, BAE Systems, Boeing, the Army and the RAAF (Flying Colours, 2015).



Table A3.3 Aviation/aerospace cluster — South Australia - All

| Main Business Activity | Total | Capability   | Number | AOC | Part 42 CAMO | Part 145 AMO | Part 147 MTO    | S21M Design Approval |
|------------------------|-------|--|--------|-----|--------------|--------------|-----------------|----------------------|
| GA Class A Operator    | 3     | Uses tied maintenance contractor   | 1      | 1   | 1            | 1            |                 |                      |
|                        |       | In-house MRO   | 2      | 2   |              | 1            | 1 Type          |                      |
| GA Class B Operator    | 4     | In-house   | 4      |     |              |              |                 |                      |
| Defence contractor     | 9     | OEM/TLS  | 1      |     |              |              |                 |                      |
|                        |       | Component manufacture/ installation                                      | 2      |     |              |              |                 |                      |
|                        |       | Custom engineering design & manufacture – integrated systems, simulation | 6      |     |              | 1            | 1 Type          | 1                    |
| 3rd Party MRO          | 6     | Whole aircraft/ airframe MRO   | 1      |     |              | 1            |                 |                      |
|                        |       | Component MRO  | 2      |     |              | 1            |                 |                      |
|                        |       | TLS for OEM  | 2      |     |              | 1            |                 |                      |
|                        |       | Component supply/servicing   | 1      |     |              |              |                 |                      |
| GA MRO                 | 13    | Whole aircraft MRO   | 6      | 1   |              | 1            |                 |                      |
|                        |       | Component MRO (may also source specialist parts or perform NDT)          | 7      |     |              | 2            |                 |                      |
| OEM                    | 3     | Also AMO   | 2      |     |              |              | 1 Type          |                      |
|                        |       | Design, R&D, TLS   | 1      |     |              |              |                 |                      |
| Education/ Training    | 3     | MTO  | 1      |     |              |              | 1 Cat           |                      |
|                        |       | GA flight training   | 1      | 1   |              |              |                 |                      |
|                        |       | Commercial flight training   | 1      | 1   |              |              |                 |                      |
| Aviation Services      | 6     | Component supply/logistics   | 2      |     |              |              |                 |                      |
|                        |       | Aircraft sales/ leasing/ charter broker                                  | 2      |     |              |              |                 |                      |
|                        |       | Labour hire  | 2      |     |              |              |                 |                      |
| Manufacture            | 13    | Component manufacture  | 3      |     |              |              |                 |                      |
|                        |       | Tier 1/2 supply chain  | 7      |     |              |              |                 |                      |
|                        |       | Integrated systems /safety management software                           | 2      |     |              |              |                 |                      |
|                        |       | Manufacture of tools, processes, materials                               | 1      |     |              |              |                 |                      |
| Professional Services  | 4     | Design, modification approval, testing                                   | 4      |     |              |              |                 | 3                    |
| Total                  | 64    |  | 64     | 6   | 1            | 9            | 1 Cat<br>3 Type | 4                    |

## **South Australia - Examples**

**Aerovalley Holdings** has capability extending from design and APMA-approved component modification, to avionics systems installation and repair (Aerovalley Holdings, 2015).

**BAE Systems** — This UK-based Defence contractor, over its 50 year history in Australia, has acquired a range of aerospace, electronic and logistics operations. It is also an OEM of regional and defence training aircraft, and a source of technology transfer in integrated systems avionics, night vision, 3D metal parts printing and composites. It recently moved into civilian maintenance contracting, with a five year agreement to provide TigerAir Tiger Air with overnight base maintenance of its A320 fleet at Melbourne International Airport and line maintenance in 3 states. Its MRO capability is a spin-off from its Defence systems support experience maintaining over 200 ADF aircraft over the past two decades. It has CASA 145 accreditation for line maintenance up to and including A-checks for A319/A320/A321. Its capabilities include aircraft modifications and integration, and AMO work across third-party platforms (BAE Systems, 2015a).

**Broens** manufacture ground support equipment for over 20 Defence forces globally; their main national contribution however lies in manufacturing innovation. Their capability for large scale, high volume production of precision machined components and assemblies is based on metrology and robotics, such as the use of live turret CNC lathes, intelligent conveyors and in-process gauging (Broens, 2015).

**Cobham** is a global Defence and civilian contractor employing 1400 people in Australia and working across charter, Fixed Base Operation, commercial aviation, helicopters and special missions. It provides all crew and engineering support and services for QantasLink's Jet operations in Australia, and operates freight services for Australian Air Express. Its engineering specialisations include the operation, maintenance and modification of jet, turbo-prop and rotary-wing aircraft and partnership with OEMs in sourcing parts. Has design approvals for modifications of aircraft structures, systems, power plants, and electrical and instrument systems; specialises in the design, installation and integration of high-tech avionic and mission system solutions into complex air platforms, eg for aircraft search and rescue (SAR) and surveillance. Has airworthiness authority clearances for ground test (e.g. electromagnetic capability) and flight test programs. (Cobham Pty Ltd, 2015).

**Levett Engineering** is a precision manufacturer of machined components supplying Defence, Aerospace (including BAE Systems), and the medical, electronics and commercial engineering sectors. With an advanced manufacturing focus it has high level inspection capacity and fabrication and materials treatment facilities to commercial and military standards, embracing parts assembly and component and assembly painting and powder coating. It and has capabilities in management of projects and of local and global supply chain (Levett Engineering, 2015).

**TAE** is a fully Australian owned provider of gas-turbine engine MRO services, as well as aerospace engineering, advanced manufacturing, avionics, fuel and electrical component maintenance, aircraft wheels & brakes and materials sales, with a large parts inventory, engine rental pool and asset base of tooling and test equipment. Headquartered in Adelaide, it has workshops in four states. It services regional airlines, business jet and aerial agricultural aircraft sectors as well as Australian and Southeast Asian Defence Forces. As well as having CASA, FAA and EASA Part 145 and CASA Part 21M modification design approvals, TAE is a recognised Defence AMO with capability to work on engines for the F/A-18 Hornet and Super Hornet, and is the designated Asia Pacific regional provider of MRO and upgrade for the Pratt & Whitney F135 engine for the F-35 JSF. Through a relationship with OEM Honeywell, it has diversified into work on army tanks (TAE, 2015).

**Table A3.4 Aviation/aerospace cluster – Melbourne and environs (includes Avalon)**

| Main Business Activity          | Total | Capability  | Number | AOC | Part 42 CAMO | Part 145 AMO | Part 147 MTO | S21M Design Approval |
|---------------------------------|-------|---|--------|-----|--------------|--------------|--------------|----------------------|
| Qantas (International/Domestic) | 1     | In-house/outsourced/off-shored maintenance            | 1      | 1   | 1            | 1            | 1 Type       |                      |
| Jetstar                         | 1     |   | 1      | 1   | 1            | 1            |              |                      |
| Other airlines                  | 2     | In-house/outsourced/off-shored maintenance            | 2      | 2   | 2            | 1            | 1 Type       |                      |
| Regional RPT Operator           | 1     | In-house maintenance                                  | 1      | 1   |              |              |              |                      |
| GA Class A Operators            | 10    | In-house or outsourced                                | 9      | 9   |              |              |              |                      |
|                                 |       | Also provides MRO service to other operators          | 1      | 1   |              |              |              |                      |
| GA Class B Operators            | 2     | In-house maintenance                                  | 2      |     |              |              |              |                      |
| Defence Contractor              | 13    | Component manufacturer/installer                      | 2      |     |              |              |              |                      |
|                                 |       | Parts sourcing  | 3      |     |              |              |              |                      |
|                                 |       | Training/ simulation                                  | 2      |     |              |              |              |                      |
|                                 |       | Engineering design/testing                            | 1      |     |              |              |              |                      |
|                                 |       | Integrated systems; custom manufacture                | 5      |     |              |              |              |                      |
| 3rd Party MRO                   | 13    | Tied contractor to regional airline                   | 1      | 1   | 1            | 1            |              |                      |
|                                 |       | Whole aircraft MRO                                    | 1      |     |              | 1            |              |                      |
|                                 |       | Component MRO   | 8      |     | 3            | 5            |              |                      |
|                                 |       | TLS for OEM   | 1      |     | 1            |              |              |                      |
|                                 |       | Component installation / maintenance                  | 2      |     | 1            |              |              |                      |
| GA MROs                         | 32    | Generalist aircraft MRO                               | 16     | 3   |              | 2            |              |                      |
|                                 |       | Component MRO   | 15     |     |              |              |              |                      |
|                                 |       | Parts sourcing  | 1      |     |              |              |              |                      |
| OEM                             | 4     | Also an AMO   | 1      |     |              | 1            |              |                      |
|                                 |       | Provides TLS  | 1      |     |              |              |              |                      |
|                                 |       | Parts, equipment sourcing                             | 2      |     |              | 1            |              |                      |
| Education/Training*             | 13    | Maintenance training organisation                     | 1      |     |              |              |              |                      |
|                                 |       | Commercial flight training                            | 6      |     |              |              |              |                      |
|                                 |       | GA flight training/ flying instructor rating training | 6      |     |              |              |              |                      |
| Aviation Services               | 25    | Component, tool supply/logistics                      | 13     |     |              |              |              |                      |
|                                 |       | Aircraft sales/ leasing                               | 10     | 1   |              |              |              |                      |
|                                 |       | Labour hire   | 2      |     |              |              |              |                      |
| Manufacture                     | 33    | Component manufacture/ installation                   | 13     |     |              |              |              | 5                    |
|                                 |       | Tier1/2 supply chain, incl. composites                | 15     |     |              | 1            |              |                      |
|                                 |       | Manufacture of tools, creation of processes           | 5      |     |              |              |              |                      |
| Professional Services           | 20    | Design, modification, approval, testing               | 14     |     |              |              |              |                      |
|                                 |       | Regulation, audit                                     | 4      |     |              |              |              |                      |
|                                 |       | Aerospace training, R&D                               | 2      |     |              |              |              |                      |
| Total                           | 170   |   | 170    | 20  | 10           | 15           | 2 Type       | 5                    |

(\*Not counting Kangan Batman, still listed on CASA website as a Part 147 Category training provider)

## **Victoria (Melbourne and environs) - Examples**

**Boeing Aerostructures Australia** is the Boeing Company's largest manufacturing footprint outside North America, employing 1200 at Fisherman's Bend and is Australia's only designer and manufacturer of structural composite components for commercial aircraft. Produces flight control surfaces for large commercial aircraft using components, developed through co-location of R&D, design, testing, fabrication and assembly activities. Core capabilities cover work in the areas of design, test, certification and manufacture. As a Tier 1 partner to the Boeing 787 Dreamliner program, Boeing Aerostructures Australia is the sole source supplier of 787 moveable trailing edges, comprising left and right hand inboard flaps, flaperons, outboard flaps and ailerons. The 787 Dreamliner contract is Australia's largest aerospace contract, valued at \$5 billion over 20 years. Boeing Aerostructures Australia is also the sole source of 737 ailerons, 747 moveable leading edges, and 777 cove lip doors, elevators and rudders. All production from Boeing Aerostructures Australia is exported to the United States of America (Boeing Aerostructures Australia, 2015).

**Boeing Australia Component Repairs (BACR)** at Tullamarine, incorporates the former Aerospace Technologies of Australia Limited (previously Government Aircraft Factories), Commonwealth Aircraft Corporation, and Hawker de Havilland. It is a large MRO employer with capabilities in composite, bonded and metal structures, servicing both civilian and Defence aircraft, and links to the other Boeing subsidiaries. BACR capabilities are said to include ready access to dedicated tooling, equipment and processes, such as stocks of advanced composite materials, autoclaves, non-destructive testing equipment, robotics (for example scanning hulls for flaws) and on-wing repair capability. It has the advantage of links with Boeing Research & Technology-Australia, the logistics and parts supplier, and Aviall and Boeing Defence Australia (Boeing Australia Component Repairs (BACR), 2015a, 2015b).

**Marand Engineering** – A privately owned Australian company with international clientele, supplying industry with high-quality precision tooling, machine tools and highly engineered automated production solutions. Experience in most key manufacturing industries including automotive, aerospace, defence, mining, aviation, rail, food processing, white goods and general manufacturing. High ratio of engineering and design staff and skilled, technical and production personnel, including tool-makers, machine tool fitters and precision machinists. Marand ongoing commitment to training and apprenticeships. Supplies precision airframe tooling on projects such as the Pilatus PC-9 turbo prop trainer, Boeing 737, 747, 757 and 777 rudder and aileron programs, 787 Flaperon and Aileron programs, Airbus A330/340 undercarriage doors and wing tip assemblies, British Aerospace Nulka electronic decoy (rocket) and McDonnell Douglas MD Explorer helicopter. In Defence, has fabricated and machined complex shaped aluminium, steel & invar lay-up mandrels and fixtures for the FA/18 E & F version Hornet fighter contract and has been a large contributor of CS&E (control surfaces and edges) tooling to the F35 JSF program globally (Marand Precision Engineering Pty Ltd, 2015).

**Rosebank Engineering Australia** —RUAG. A Swiss OEM, acquired Rosebank Engineering in Dec 2012, taking over its 154 employees and gaining an Australian base for its Asia-Pacific activities (previously Malaysia). Provides MRO for the RAAF. Acquisition provides platform for provision comprehensive life-cycle support out of Australia. RUAG provides MRO support to Swiss Defence Forces. Former name retained in Australia; called RUAG offshore (Rosebank Engineering Australia, n.d.).

**Table A3.5 Aviation/aerospace cluster — Western Australia – All**

| Main Business Activity                          | Total      | Capability  | Number     | AOC       | Part 42<br>CAMO | Part 145<br>AMO | Part 147<br>MTO | S21M<br>Design<br>Approver |
|---|------------|---|------------|-----------|-----------------|-----------------|-----------------|----------------------------|
| Network Aviation (Sunstate) & Network Turbine   | 3          | In-house/outsourced/off-shored MRO                  | 3          | 3         | 3               | 3               | 2 Type          |                            |
| Jetstar   | 1          | In-house/outsourced/off-shored MRO                  | 1          |           | 1               | 1               |                 |                            |
| Regional RPT Operators (incl Virgin subsidiary) | 2          | In-house/outsourced/off-shored MRO                  | 2          | 2         | 1               | 1               |                 |                            |
| GA Class A Operator                             | 15         | Uses tied maintenance contractor                    | 1          | 1         |                 |                 |                 |                            |
|   |            | In-house MRO  | 13         | 15        |                 |                 | 1 Type          | 1                          |
|   |            | Also provides MRO services to other operators       | 1          | 1         |                 |                 |                 |                            |
| GA Class B Operator                             | 8          | Buys MRO services                                   | 2          |           |                 |                 |                 |                            |
|   |            | In-house MRO  | 6          |           |                 |                 |                 |                            |
| Defence Contractor                              | 2          | Engineering design, testing                         | 1          |           |                 |                 |                 |                            |
|   |            | Integrated systems- logistics, design               | 1          | 1         |                 |                 |                 |                            |
| 3rd Party MRO                                   | 9          | Tied contractor to airline                          | 1          | 1         |                 | 1               | 1 Type          |                            |
|   |            | Whole aircraft/ airframe MRO                        | 1          |           |                 | 1               |                 |                            |
|   |            | Component MRO                                       | 7          |           |                 | 3               |                 | 3                          |
| GA MRO  | 33         | Historical restorations                             | 1          |           |                 |                 |                 |                            |
|   |            | Whole aircraft/airframe MRO                         | 20         | 2         | 1               | 1               | 1 Type          |                            |
|   |            | Component MRO                                       | 10         |           |                 | 1               |                 |                            |
|   |            | TLS for OEM   | 1          |           |                 |                 |                 |                            |
|   |            | Component supply/servicing                          | 1          |           |                 |                 |                 |                            |
| Education/Training                              | 4          | Commercial flight training                          | 3          | 2         |                 |                 |                 |                            |
|   |            | GA flight training                                  | 1          | 1         |                 |                 |                 |                            |
| Aviation Services                               | 14         | Component supply/logistics                          | 8          |           |                 |                 |                 |                            |
|   |            | Aircraft sales/ leasing/ charter broker             | 6          |           |                 |                 |                 |                            |
| Manufacture                                     | 7          | Component manufacture/installation                  | 3          |           |                 | 1               |                 |                            |
|   |            | Tier 1/2 supply chain                               | 4          |           |                 |                 |                 |                            |
| Professional Services                           | 4          | Design, modification approval, testing, calibration | 3          |           |                 |                 |                 | 1                          |
|   |            | Audit   | 1          |           |                 |                 |                 |                            |
| <b>Total</b>                                    | <b>101</b> |   | <b>101</b> | <b>29</b> | <b>6</b>        | <b>13</b>       | <b>5 Type</b>   | <b>5</b>                   |

## **Western Australia - Examples**

**Fugro Spatial Solutions** is a part of the Fugro NV group, with over 13,500 staff around the world. It operates a large fleet of aircraft equipped with state-of-the-art remote sensing technology, servicing natural resources management, urban planning, economic development, emergency response, environmental, and engineering activities throughout Australasia and internationally. It appears to purchase maintenance services from independent MROs (Fugro Aerospace Solutions, 2015).

**Aerospace NDI** - Aviation support company founded in Perth in 1994 by an ex-Defence pioneer of non destructive testing (NDT); now also overhauls aircraft wheels/brakes/undercarriages; manufactures NDT reference standards and aircraft components, performs electroplating and painting of aircraft parts. CASA Part 145 compliant (Aerospace NDI, Pty Ltd, 2015)

**Heliwest** offers charter and tourism, aerial, sling and medical work GA services across WA. It has an in-house engineering section with CASA Part 145 authorisation, and carries out MRO work on rotary and fixed wing single and multi-engine aircraft. It has a paint shop and staff licensed to work on airframe, engine, electrical, instrument, radar, sheet metal and composites. It stocks Robinson, Bell and Eurocopter parts and has a logistics service to source further parts (Heliwest Group, 2013).

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