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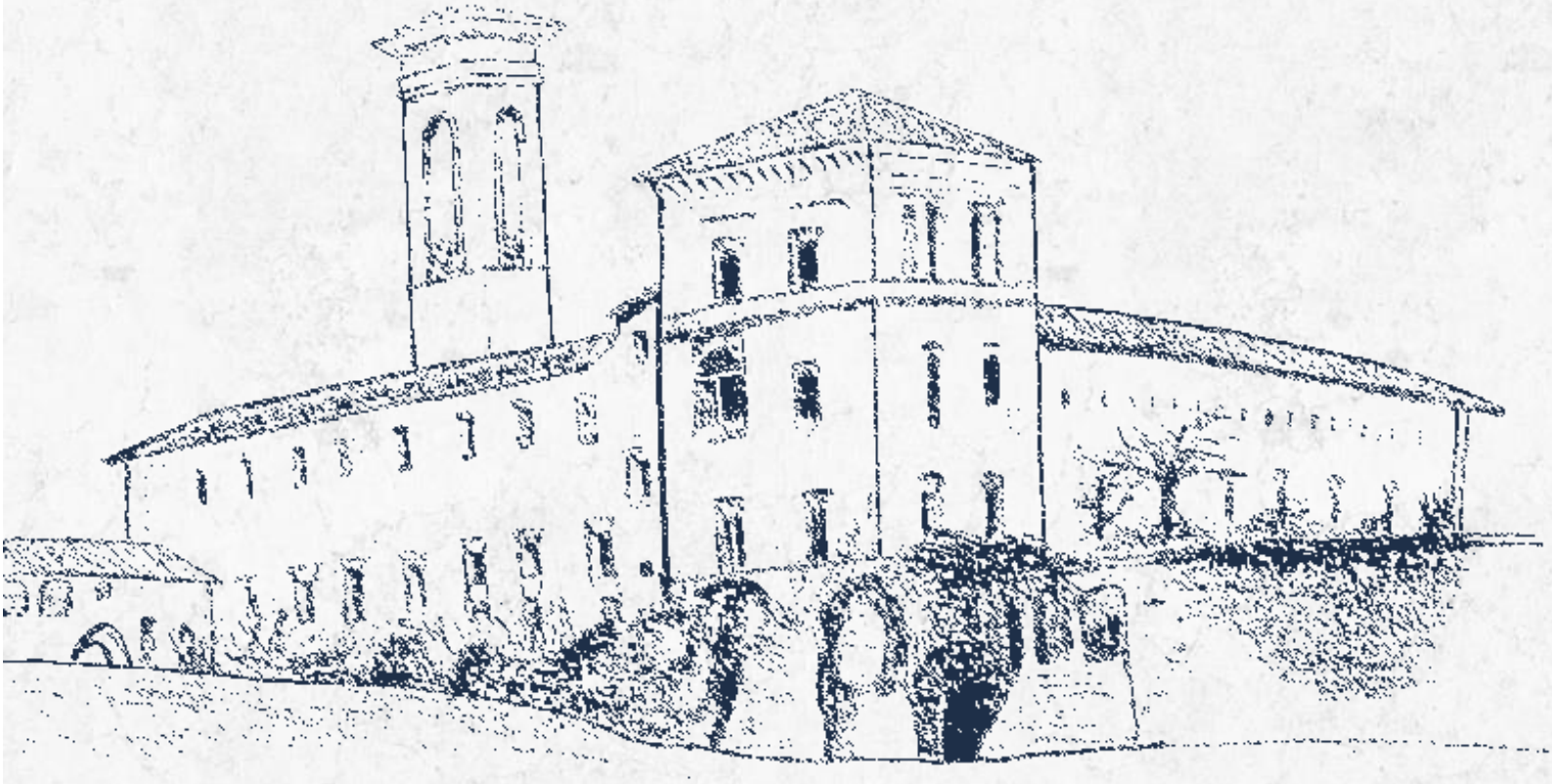

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Supply Chains and the Manufacture of Precarious Work: The Safety Implications of Outsourcing/ Offshoring Heavy Aircraft Maintenance

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Abstract. There is now a substantial body of global research pointing to the adverse occupational health and safety (OHS) effects of precarious work. Nonetheless there is still limited research into the link between supply chains and OHS and how these changes impact on non-precarious workers. This study of the outsourcing/off-shoring of heavy aircraft maintenance addresses this gap. Focusing on Australia it shows that the growth of maintenance supply chains has impacted on the OHS and other working conditions, not only of outsourced maintenance workers, but also of those continuing to work in-house for major airlines. In essence, cost pressures and competition have led to work intensification that has affected the latter and undermined their independence in terms of safety decision-making. The paper points to the importance of recognising inter-linkages between public and work safety and that the business practices encouraging precarious work affect all workers in an industry, not simply those deemed as precarious.

Keywords: *Precarious work, outsourcing/offshoring, aircraft maintenance, health and safety*

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Introduction

A substantial body of international research now points to the adverse occupational health and safety (OHS) outcomes associated with the growth of precarious and informal work. There has been less consideration of the mechanisms driving these changes, nor their wider public health and safety implications. One area that has attracted increased interest in this regard is national and global supply chains – essentially a sequential network of contractual arrangements increasingly used by large corporations to obtain goods and services in preference to in-house production. The global aviation industry is no exception to this trend. The bulk of heavy aircraft maintenance for airlines in North America, Europe, and Australasia is now performed, not in-house, but by specialist maintenance and repair organisations or MROs. Increasingly, these are located, not in the country where the airline is based, but off-shore, in countries in Asia and Central America, and the Baltic States, where wages are lower, other labour standards are less strict, and aviation regulators are often less interventionist.

Unlike many other industries, aviation (including safety aspects) is subject to international agreement based on the 1944 Chicago Convention, which set up the International Civil Aviation Organisation (ICAO). ICAO sets out procedures, binding on the 192 member states, which govern the certification of MROs by national aviation safety regulators. Further, there are bilateral agreements among regulators in different countries as well as a degree of regional oversight by such regulators as the US Federal Aviation Administration (FAA), and the European Aviation Safety Agency or (EASA), which maintain inspectors in a number of countries to monitor the effectiveness of national regulators and the safety performance of certified MROs. Nonetheless, aviation is not immune to the adverse safety effects linked to subcontracting and supply chains in other industries – particularly when layers of subcontracting escape regulatory oversight and inspection. Offshoring can be particularly problematic where regulatory regimes are weak and subject to potential corruption, or where there is little union presence and governance is poor.

This paper examines the implications of the trend to heavy aircraft maintenance outsourcing/offshoring. It uses examples from the major airlines based, or with a significant presence, in Australia and makes reference to the experience, particularly of the USA. It draws on documentary analysis together with extensive interviews conducted with industry, government and union representatives as well as a survey of aircraft maintenance engineers and maintenance employers. The paper

highlights the regulatory challenges posed by the outsourcing of maintenance and argues that, both in the home country and off-shore, the use of maintenance supply chains make work more precarious, including for groups that are both skilled and highly unionised. The 'whip-sawing' of successive heavy maintenance contracts between MROs in countries with different wage structures, regulatory and labour standards appears to promote employment insecurity everywhere. In addition, a 'race to the bottom' in cost-minimisation, in part based on sub-contracting, is putting pressure on working hours and safety standards, as well as wages. The study provides evidence suggesting that supply chains and the growth of precarious work not only weakens OHS, but potentially compromises public safety, and, by reducing the supply of maintenance apprentices in industrially-regulated nations such as Australia, has a tendency to exacerbate the emerging global shortfall of highly-skilled maintenance engineers.

Supply Chains, Precarious Work and Safety

Over the past three decades a substantial body of research has examined the occupational health and safety effects of global changes in work organisation, particularly the job insecurity associated with repeated waves of downsizing/restructuring in the private and public sector and the increased use of part-time, temporary and other contingent forms of work, like franchising and self-employed subcontractors.[1] Researchers have also turned their attention to the implications of these changes for work organisation and regulatory regimes governing OHS and other labour standards.[2] More recent studies have examined the underlying

[1] See for example M. Quinlan, C. Mayhew & P. Bohle, *The Global Expansion of Precarious Employment, Work Disorganisation and Occupational Health: A Review of Recent Research*, *International Journal of Health Services*, 2001, 31(2):335-414; M. Virtanen, M. Kivimäki, M. Joensuu, P. Virtanen, M. Elovainio & J. Vahtera, *Temporary employment and health: a review*, *International Journal of Epidemiology,* 2005, doi:10.1093/ije/dyi024; and M. Quinlan & P. Bohle, *Under pressure, out of control or home alone? Reviewing research and policy debates on the OHS effects of outsourcing and home-based work*, *International Journal of Health Services*, 2008, 38(3): 489-525.

[2] R. Johnstone, M. Quinlan & C. Mayhew Outsourcing Risk? *The regulation of OHS where contractors are employed*, *Comparative Labor Law and Policy Journal*, 2001, 22(2&3): 351-93.

drivers of these changes, including outsourcing/privatisation and supply chains and their implications for OHS.[3] While not new, elaborate supply chains are becoming a ubiquitous feature of the provision of goods and services globally. Supply chains are a sequential arrangement of contracts between different parties for the provision of goods (like clothing or food) or services (say a call centre for answering customer queries, transporting products or providing home-based support services). Typically, the supply chain is a pyramid subcontracting arrangement where a number of parties at the bottom provide the good or service through a series of intermediaries to the final buyer – commonly a large corporation, like a retailer. While research evidence is limited it appears that supply chains can have effects on OHS analogous to those commonly found with regard to pyramid subcontracting.[4]

There is also evidence that the outsourcing of tasks may also have adverse health and safety effects on the wider community. Examples of this include hygiene breakdowns in the supply of food-products and threats to other road users arising from competitive pressures/outsourcing in the road freight industry.[5] In aviation there is growing evidence that outsourcing can compromise both public (air travellers) and worker (flight and cabin crew) safety. In aviation as in other industries competitive pressures (especially the emergence of low-cost carriers) has led to a number of changes in business and work arrangements, including the leasing of aircraft, use of older aircraft and the outsourcing of maintenance activities to repair and maintenance providers in-country and increasingly offshore.

In the USA the safety implications of outsourcing/off-shoring heavy aircraft maintenance has been the subject of public debate for over 20 years. This debate coincided with changes to regulation that permitted the emergence of low-cost carriers relying on cost minimisation strategies

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[3] P. James, R. Johnstone, M. Quinlan, & D. Walters, D. *Regulating supply chains for safety and health, Industrial Law Journal*, 2007 36(2): 163-187.

[4] M. Quinlan, *Supply Chains and Networks*, Safework Australia, 2013, Canberra. http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/752/Supply-chains-networks-July-2011-Michael-Quinlan.pdf.

[5] C. Mayhew & M. Quinlan, *Economic pressure, multi-tiered subcontracting and occupational health and safety in the Australian long haul trucking industry*, *Employee Relations*, 2006, 28(3): 212-229 and M. Quinlan, R. Johnstone & C. Mayhew, *Trucking Tragedies: The Hidden Disaster of Mass Death in the Long Haul Road Transport Industry* in Eric Tucker ed. *Working Disasters*, 2006, Baywood, New York, 19-64.

including the outsourcing of maintenance, leasing of aircraft, use of older aircraft and lower wages paid to flight and cabin crew. Competition from low-cost carriers put cost pressure on older 'legacy' airlines so that by 2007 over 70% of heavy aircraft maintenance was being outsourced, with offshore maintenance firms accounting for 35% of heavy aircraft maintenance by 2006.[6] Safety concerns about outsourced maintenance were raised at the time of the shift (ie from the late 1980s) and by the 1990s evidence supporting these concerns began to emerge. Flaws in outsourced/offshored maintenance have been linked to six serious aircraft incidents in the USA, including three multiple fatality crashes - the best known being the crash of ValuJet Flight 592 killing all 110 aboard in 1996. ValuJet was a pioneer of the new budget airline model. Ignoring numerous minor issues in the year previous to the crash the airline had experienced two incidents with other planes sufficiently serious to warrant a formal investigation by the National Transportation Safety Board. Such investigations are reserved for the most serious incidents and a review of the airlines operations was being planned by the regulator, the FAA, at the time of the fatal crash. As has occurred in other industries, both the airline and the repair agency (Sabre Tech) ceased operations soon after the incident, meaning there was little scope for organisational learning. Nor did the incident have sufficient deterrent effect on other operators with subsequent incidents including a fatal crash involving Air Midwest Flight 5481 in 2003 (killing all 21 aboard) and a near miss incident involving US Airways Flight 518 in 2009 (due to an error in maintenance on the main cabin door).

A review of these incidents identified three contributory factors. First, there were economic and reward pressures, including cost-cutting relating to the conditions of maintenance staff, time pressures and the like. Second, there was a level of disorganisation, including gaps in staff training and safety systems as well as communication problems due to for example staff turnover. Third, regulatory failure comprised under-resourced or poorly targeted inspections of aircraft and airline safety systems as well as inadequate enforcement of breaches of laws, especially those of a systemic nature.[7] A follow-up paper examined the response of the US regulatory apparatus to evidence of shortcomings in regulatory

[6] M. Quinlan, I. Hampson, & S. Gregson, *Outsourcing and offshoring aircraft maintenance in the US: Implications for safety*, *Safety Science*, 2013, 57:283-292.

[7] M. Quinlan, I. Hampson, & S. Gregson, *Outsourcing and offshoring aircraft maintenance in the US: Implications for safety*, *Safety Science*, 2013, 57:283-292.

oversight. It noted the slow response of the Federal Aviation Administration to evidence of shortcomings in their oversight of maintenance outsourcing. Over far more than a decade these deficiencies were identified in a series of reports by the US Government Accountability Office, audits by the Office of Inspector General of the US Department of Transportation and hearings before US House of Representative and Senate Committees overviewing transport safety. It was not until 2012 that a number of decisive steps were taken to address the issue.[8]

Outsourcing and offshoring of heavy aircraft maintenance has been a global trend so the problems just identified were not confined to the USA. Similar safety concerns have been raised or identified in other countries, including Brazil and Australia. In Australia, a study found that incident reports of the Australian Transport Safety Bureau (the equivalent of the NTSB in the USA) were not adequate to identify issues related to outsourced/offshored maintenance. However, responses in a survey of aircraft maintenance engineers (both those working in-house and in repair organisations) identified problems that were entirely consistent with the US experience and where similar causal factors – economic pressures, disorganisation and regulatory failure – seemed to play a pivotal role (Gregson et al 2015).[9] A study which surveyed maintenance workers in Brazil reached similar findings.[10] Given the global nature of the industry this is hardly surprising.

Despite the well-documented (and readily accessible) US experience it is by no means clear that the issue has received sufficient attention by other regulators or that the implications of current trends in regulation relating to the licensing of aircraft maintenance engineers or outsourced maintenance more generally have received adequate consideration. In order to explore this point the next section provides a brief critical overview of the global regulation of aviation safety, particularly pertaining to aircraft maintenance.

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[8] M. Quinlan, I. Hampson & S. Gregson, *Slow to learn: regulatory oversight of outsourced aircraft maintenance in the USA*, *Policy and Practice in Health and Safety*, 2014, 12(1):71-90

[9] S. Gregson, I. Hampson, A. Junor, D. Fraser, M. Quinlan & A. Williamson, *Supply chains, maintenance and safety in the Australian airline industry*, *Journal of Industrial Relations*, 2015, 57(4):604-623.

[10] M. Cardoso Machado, M. Gomes Eller, A. L. Soto Urbina, & F. Macau, *A qualitative study of outsourced aeronautical maintenance: The case of Brazilian organizations*, *Journal of Air Transport Management*, 2016, 55:176-184

Regulation of Aviation Safety – Adequate or Fracturing?

This section explores how supply chains in aircraft maintenance create vulnerabilities that have arguably gone beyond the capacity of the existing international regulatory system to remedy. The international regulatory system that arose at the end of WW2 always had limitations arising from tensions between safety regulatory systems within nation states and the need for a transnational authority that could enforce standards, which the former might resist for domestic policy reasons.[11] These weaknesses became more evident following deregulation of the aviation industry, beginning with the US in 1978. Intensified competitive pressures drove prices down making passenger transport more widely accessible than it had ever been, and sparked the latter's rapid expansion. Airlines sought competitive advantage through a number of strategies. Among these was outsourcing and offshoring of heavy aircraft maintenance.

During heavy aircraft maintenance, which takes place on a typical airliner approximately every five to seven years, the interior is removed and the plane stripped back to the hull, which is inspected for cracks and corrosion. Certain large airliners, like the B747 (now being phased out in Australia), require approximately 75000 person hours, or up to 3 months, for what is called a 'D' check. This work is a natural contender for offshoring to countries with lower wages, although a mix of labour is required. Much of the work is not especially skilled, although it does require careful adherence to procedures. Moreover, there is a possibility that poorly executed work may lead to catastrophe, sometimes months or even years after the faulty work was performed. The work of inspection and repair, however, is highly skilled, and many offshoring airlines have sent their own inspectors to make sure maintenance tasks are done properly. However, such decisions are made by the airlines and the offshoring process makes it far more challenging for regulators based in the airline's home-base to maintain effective regulatory oversight.

[11] J. Huang, *Aviation Safety, ICAO and Obligations Erga Omnes*, *Chinese Journal of International Law*, 2009, 8(1): 63-79.

Table 1. Main Operators of Wide-bodied and Large Aircraft (over 100,000kg MTOW), by Maintenance Strategy, Australia, 2015

Operator	Aircraft	Comment
Airline A (International & domestic main route RPT)	Airbus A380-842	20-year lease on hangar at LAX for layover maintenance; Australian staff? Maintenance off-shored: Base maintenance contract with Lufthansa Technik Philippines to 2023
	Airbus A330-202/203 Airbus A330-303	Heavy maintenance conducted in new Brisbane facility since 2010
	Boeing B767-338/381F	Heavy maintenance upgrading work on the fleet 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, following heavy reliance on a labour hire company
Airline A's Low-cost carrier subsidiary	Airbus A330 -202	Currently maintained in Singapore
	Boeing B787-8	Order for 14 larger 787-9, delayed option for 50 now proceeding; impact on heavy maintenance yet unknown — elements of full-scale D-checks likely to be redistributed over shorter maintenance cycles and full checks likely to be at longer intervals
Airline B (International & domestic main route RPT)	Airbus A330-243	Withdrawn from large on-shore outsourced operator (which collapsed with heavy job losses)
	Boeing B777-3ZGER	2008–2013 contract with a Singapore airline's engineering facility for B777heavy maintenance; use of an Australian-based subsidiary located in Australia

MTOW= Maximum takeoff weight
RPT – Regular Passenger Transport
SIA Singapore international Airlines Engineering Company

Source: I. Hampson, D. Fraser, M. Quinlan, A. Junor & S. Gregson, *The Future of Aircraft Maintenance in Australia: Workforce Capability, Aviation Safety and Industry Development. Final Report*, 2015 Australian Research Council Linkage Grant (LP110100335).

We are not making claims about the reliability of particular off-shore MROs, and we recognise the role of specialist MROs, for example in engine-overhaul, avionics trouble-shooting or aircraft painting. We recognise the rise, both of large civilian/defence maintenance contractors and of support arrangements between air operators and original equipment manufacturers. Nevertheless, we are arguing there is a real potential for the erosion of safety and working conditions, given current airline policy trends and international regulatory gaps. Empirically, the

analysis potentially applies to the maintenance of a specific range of aircraft. In Australia, in 2015, there were 85 wide-bodied aircraft in the over 100,000 kg MTOW (maximum take-off weight) range, mainly A330s, A380s, a small number of B777s and B787s coming on stream, with B747s being phased out. With the exception of the A330, the heavy maintenance of these aircraft was undertaken offshore (Table 1). There were 275 aircraft in the 50,001 to 100,000 MTOW range, such as the A320, B737, B717 and Embraer 190. These were maintained by a mixture of in-house, locally-outsourced and offshored arrangements (Table 2). The offshore MROs were subsidiaries of reputable offshore airlines, but they themselves tended to undertake further subcontracting of work to establishments in lower-waged countries. The issue is the potential for effective regulatory oversight of the aircraft on the Australian national register, and the impact of fragmented labour relations on job stability and on the working conditions that we argue provide the best assurance of safety.

Table 2. Main Operators of Large Narrow-bodied Aircraft (MTOW 50,001kg – to 100,000 kg MTOW) by Maintenance Strategy, Australia, 2015

Operator	Aircraft (numbers in CASA Register July 2015)	Maintenance
Airline A International and national main route RPT and freight subsidiary	67 Boeing 737NG (600–900)	Heavy maintenance project in house, Brisbane
	4 Boeing 737 Classic (300 to 500)	Maintained in-house Sydney
(Airline A's Low-cost carrier subsidiary)	53 Airbus A320	Maintained in-house at Newcastle NSW from 2015
	Offshore subsidiary airlines 6 Airbus A321	All aircraft currently maintained offshore Maintained offshore
(Airline B (International & domestic main route)	2 Airbus A320	Maintained offshore
	80 Boeing 737NG (600–900) 18 Embraer	Heavy maintenance performed mostly in NZ
(Low-cost carrier B)	14 Airbus A320	Base maintenance Melbourne; line maintenance Melbourne, Sydney, Brisbane by Australian subsidiary of large UK Defence contractor

MTOW= Maximum takeoff weight. Source: UNSW 2015

We now turn to regulation governing the safety of offshored maintenance, but which may be falling short of that goal. The centrepiece of the international regulatory system, which expanded following the end of WW2, is the International Civil Aviation Organisation (ICAO), set up as an arm of the United Nations, under the 1944 Chicago Convention. This Convention now has 192 signatories, which are bound (under its Article 37) to keep their regulations uniform with the Standards and Recommended Procedures (SARPs) specified in its various Annexes. Of these, Annex One, which specifies training standards, and licensing scope and privileges of aircraft maintenance workers, and Annexes Eight and Six, covering airworthiness and safe operations of aircraft, are particularly important for our subject – aircraft maintenance safety. The longstanding problem is that these Articles and Annexes are not always consistent. Annex Eight, for example, is very clear that the 'state of registry' – that is, the country in which a plane is registered – has overall responsibility for the safety of 'its' planes, even, or

perhaps especially, when they are being maintained overseas. However, the extent this right can be exercised (for example, through surprise inspections of maintenance facilities), without violating the fundamental principle of national sovereignty, is questionable. Article 33 allows a state of registry to accept the oversight of another state provided its practices '… are *equal to or above the minimum standards* which may be established from time to time pursuant to this Convention'.[12] The difficulty for the state of registry pertains to their knowledge as to whether the 'offshore' state's practices meet international standards. Means of verification are limited which means the regulator may, or even feel obliged to, accept the safety oversight practices of another country, even though means of verification are scant.[13]

When airlines were deeply embedded in their national context, and not subject to intense cost pressures, nation states were less concerned about verification. The growth of third party MROs, however, increased concerns over the safety of offshored maintenance, and by the mid-1990s, it became evident to the ICAO that some states were not observing the standards which were supposed to underpin the system, nor were they declaring 'differences' between their own systems and the ICAO standards, as required under Article 38. Accordingly, in 1998, the ICAO established the Universal Safety Oversight Audit Program (USOAP), with the aim of ensuring that states were meeting their obligations to ICAO.[14] Under the USOAP, teams of ICAO auditors visited national regulators by prior arrangement, examined their regulatory capacity, and issued ratings on their extent of compliance with ICAO SARPs. Since under Article 33, states can reject certificates issued by non- or weakly- compliant states, these audits were of quite some significance, potentially triggering a state to deny entry to its airspace to an airline from a non-compliant country, or denying access to its airspace to a plane maintained in a non-compliant state.

Subsequent ICAO monitoring identified "fundamental weaknesses in the safety programs of many States, resulting in significant differences in

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[12] ICAO, *International Civil Aviation Organisation, Convention on International Civil Aviation done At Chicago on the 7th Day of December, 1944*, http://www.icao.int/publications/Documents/ 7300_orig.pdf

[13] I. Hampson, D. Fraser, M. Quinlan, A. Junor, *The Uncertain Oversight of Offshored Aircraft Maintenance: The Case of Australia, Journal of Air Law and Commerce,* 2016 in press.

[14] J. Huang, *Aviation Safety, ICAO and Obligations Erga Omnes*, *Chinese Journal of International Law*, 2009, 8(1): 63-79.

safety standards around the globe".[15] This finding might have been expected to lead to more intensive safety oversight. However, audits actually became less frequent, possibly due to inadequate resourcing of the monitoring agency or the prevailing policy orthodoxy of deregulation/light touch regulation. USOAP 'evolved' towards a 'continuous monitoring' approach (CMA), which seeks to gather information on an ongoing basis precisely because of the gaps between audits.[16] Whether this was an 'upgrade' as suggested in ICAO documentation is a moot point. For some states, CMA consisted of the regulator answering lists of questions provided by ICAO or, as one critic put it, 'self-reporting'. For others, the old format of inspections and audits still applied. 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). This was hardly an impressive performance, and it may indicate that the ICAO-based system was experiencing some disintegration.

In fact, the international 'regulatory space' was becoming contested as alternative national and international agencies became more active. Approvals of the US aviation regulator, the FAA, began to play a greater role in the world system. Through its International Aviation Safety Assessment (IASA) program, FAA approves regulators, in accord with the ICAO principle that makes the state of registry responsible for the safety of 'its' planes, and Article Six, which allows a regulator 'to request consultations concerning the safety standards maintained by the other party'.[17] FAA also banned non-approved airlines from its airspace. FAA approvals were increasingly relied on by other countries and airlines. FAA also inspected and approved maintenance facilities.

From 2003, the new European Aviation Safety Agency (EASA) was set up to 'consolidate' aviation safety regulation across Europe. EASA's role was to approve national regulators as well as MROs, so that national airlines

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[15] ICAO, International Civil Aviation Organisation, *Safety Management Manual*, Doc 9859, Second Edition. 2008, Montreal: ICAO, p3-4-1.

[16] ICAO, *Evolving ICAO's Universal Safety Oversight Audit Program: The Continuous Monitoring Approach*, *ICAO Journal,* 2010, 04: 24-25; and ICAO, *The USOAP evolved: Realizing the promise of the continuous monitoring approach*, *ICAO Journal,* 2010, 05: 25-28.

[17] FAA, *Federal Aviation Authority, International Aviation Safety Assessment (IASA) Program*, no date, http://www.faa.gov/about/initiatives/iasa/media/FAA_Initiatives_IASA.pdf

could offshore their maintenance to other countries within Europe, and increasingly outside it. Eventually, EASA's approval powers extended to other countries, including some in Australia's region. Yet both EASA and FAA used ICAO standards as their reference point, whereas a private sector entrant to this regulatory space – an offshoot of the International Air Transport Association (IATA), essentially a representative body of airline employers, claimed to go above them. IATA Operational Safety Audits (IOSA) claimed to treat ICAO standards as minima, and its audits claimed to register standards of attainment that exceeded them.[18] Unlike ICAO, FAA and EASA, IOSA audits individual airlines. In doing so, IATA is seeking to position itself at the centre of safety regulation.[19]

The auditing process has arguably been weakened by changes in the methods of auditing – namely a shift from direct inspection to audits of process, and of 'safety management systems' (SMS). The most recent ICAO Annex (19) mandates the implementation of State Safety Programs (SSP) and SMSs at organisational and workplace level. However, any SMS is only effective to the extent that it represents real workplace processes. In other high hazard industries like mining the limitations of paper-based system auditing (often labelled 'paper compliance') have long been recognised with systems audits being accompanied by workplace inspections to ensure the processes described are actually being implemented.[20] Further, effective auditing depends on the skills of auditors, which Australia's recent Aviation Safety Regulation Review found was lacking among CASA auditors.[21] The ASRR suggested CASA might outsource much of its inspection work to independent private auditors, in accordance with the IATA proposals. However, the privatisation of inspection process like auditing has its own limitations, raising serious concerns in a number of industries including aviation.[22]

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[18] IATA, International Air Transport Association, *Safety Report,* 2014. Geneva: IATA.

[19] D. Hodgkinson, *IOSA: The Revolution in Airline Safety Audits*, *Air and Space Law*, 2005, 30(4-5): 302-329.

[20] Quinlan, M. *Ten Pathways to Death and Disaster: Learning from Fatal Incidents in Mines and Other High Hazard Workplaces,* 2014, Federation Press, Sydney.

[21] Truss, *Aviation Safety Regulation Review*, May, http://www.infrastructure.gov.au/aviation/asrr/files/ASRR_Report_May_2014.pdf.

[22] M. Quinlan, I. Hampson & S. Gregson, *Slow to learn: regulatory oversight of outsourced aircraft maintenance in the USA*, *Policy and Practice in Health and Safety*, 2014, 12(1):71-90.

The ASRR finding that many auditors and inspectors employed by Australia's safety regulator lacked the skills necessary to audit modern safety management systems was similar to findings of the most recent ICAO Audit of Australia in 2008.[23] Importantly, these skills are among those on which Australia relies to verify that the MROs to which Australian registered planes are offshored for their heavy maintenance are fit for purpose, in accord with its obligations under Annex Eight of the Chicago Convention. CASA has long had in place mechanisms to issue approvals to overseas MROs to perform heavy maintenance on Australian registered planes – first under Civil Aviation Regulation 30 (CAR 30) and lately, since the adoption of the EASA system, CASR part 145. These typically included initial inspections, with follow up inspections and, more lately audits, by representatives of the regulator. These, to be consistent with Annex Eight, must be regular. Our interviewees noticed and remarked upon the shift from direct inspection to 'paper based' audits of SMSs, both in the domestic sphere and overseas. It corresponds in time to the rapid escalation in offshoring heavy maintenance post-2012, and to the parallel move from CASA approval of offshore facilities based on direct inspection and/or auditing of SMS, to 'bilateral aviation safety agreements' (BASAs) according to which CASA accepts approvals of MROs in an offshore regulator's national space as equivalent to its own.[24] The processes by which approvals are issued, or withdrawn, are somewhat opaque and border on secretive. There are differences between approval authorities which hardly engenders confidence in the international regulatory system. As to secrecy, one example was FAA's near downgrading of Australia's safety regulatory system from Category One to Category Two. This move, which would have restricted Australian airlines' access to the US, only surfaced through a WikiLeak.[25] As to inconsistency, more recently, the FAA downgraded Thailand and restricted some of its airlines' access to the US after an ICAO Audit revealed 'serious safety concerns'. Yet Thailand passed an EASA audit,

[23] ICAO USOAP, International Civil Aviation Oversight Audit Program, *Final Report on the Safety Oversight of the Civil Aviation System of Australia*, 2008, International Civil Aviation Organisation.

[24] Hampson, I., D. Fraser, M. Quinlan, A. Junor, *The Uncertain Oversight of Offshored Aircraft Maintenance: The Case of Australia, Journal of Air Law and Commerce,* 2016 in press.

[25] B. Sandilands, *Wikileaks: Australia nearly lost its air safety rating*, *Plane Talking*, 31 August 2011.

and Thai airways serving European destinations were allowed to continue flying to Europe.[26]

In Australia's region, the crash of Indonesia AirAsia flight 8501, on 28 December 2014 into the Java Sea, with the loss of 162 passengers and crew, illustrates some of these issues. Shortly after take-off the pilot sought to climb above a storm. Permission was denied, and the plane entered the storm with weaknesses that were to prove fatal. For around 12 months the plane had been flying with an intermittent fault, due to a crack in a soldering joint, in a control unit that was part of what is known as a 'rudder limiter'. In fact, pilots had known about the fault, and there had been 23 computer alerts about it. Engineers too had known about it, because they had instructed the pilot how to turn the alarm off by resetting the flight control computer – a dangerous workaround that was not permitted in flight. On the particular day, the alarm went off four times, angering and confusing the pilot, who reset the flight control computer, turning off the autopilot. With the auto pilot off, the faulty rudder began to cause the plane to bank, and the pilots, due to poor training (the other main cause of the accident), were unable to prevent it falling into the sea.

Commentators at the time noticed that the plane had not been authorized to fly that particular route, drawing attention to the fact that Indonesia had the 'poorest safety oversight' of any ICAO member, and had an unenviable record of crashes. According to a media investigation, the Australian Department of Foreign Affairs and Trade (DFAT) had issued Australian travellers with advice not to fly on Indonesian internal airlines, because of safety concerns. This raised questions about the efficacy of Australia's aviation safety regulator, CASA, when it emerged that the unfortunate Air Asia plane had made 78 flights carrying Australian passengers between Perth and Denpasar. Further, Indonesia had failed an ICAO audit in 2007, with an average level of compliance of 30% - well below developed country standards. Little action appeared to have followed. In a media program, CASA's spokesperson acknowledged that CASA had no way of knowing that the aircraft had been flying with a serious defect for months. A former Indonesian official, close to the regulator, claimed that the primary problem lay with enforcement, not the regulation itself, and hinted at regulatory 'capture'. He said, - 'Because Air Asia knows the weakness of the Department of Transportation, it's not

[26] *Bangkok Post*, 8 & 14 December 2015

quite good in observing and making the close monitoring'.[27] Regulatory officials were vulnerable to corruption, he opined, because of the low wages paid to them and how inadequately trained pilots could bribe their way through assessment. FAA had long banned Indonesian airlines, including the national carrier, Garuda, from flying into US airspace. EASA allowed Garuda, but not the rest, into Europe. Yet CASA allowed Air Asia Indonesia to fly into Australia. CASA's spokesman said:

> The reason it is allowed to fly into Australia is that we have made our own assessments of the airline, of the Indonesian safety system, and we believe they are meeting the required international standards and… have been granted an air operators certificate – if some other part of the world thinks otherwise, well that's a matter for them
> The international system works on the regulator from the country of origin having the complete responsibility for the airline, so they have complete responsibility for the maintenance, the pilot training, reporting of defects,…
> The international system can't work if every regulator took responsibility for every single airline around the world.[28]

Several things emerge from this. On the strength of how the ICAO-based system is supposed to work, CASA was arguably entitled to believe that the Indonesian regulator was adequately regulating Indonesian airlines, because ICAO had not acted against Indonesia despite its evident low level of compliance in the 2014 audit. This would, however, be an odd argument in the face of the DFAT advisories to people not to fly on Indonesian airlines inside the country. It would be further undermined by the stance taken by other regulators, FAA and EASA, which had partially or wholly banned Indonesian airlines. Moreover, Article Six, the basis of the FAA's IASA, allows any national regulator to request information about safety standards, and, in any case, CASA could have inspected the planes (including their defect logs) when they were in Australia. In fact, according to the *Foreign Correspondent* report, CASA did intensify its unannounced, on-ground inspections of AirAsia aircraft following the December 2015 disaster. The episode also raises questions about CASA's approach to its regulatory responsibilities regarding the landing rights for foreign airlines. There is also the question of national interests. Geoffrey

[27] Foreign Correspondent, *False Economy*, screened 3 April 2016. http://iview.abc.net.au/programs/foreign-correspondent/NC1602H008S00.
[28] Foreign Correspondent, *False Economy*, screened 3 April 2016. http://iview.abc.net.au/programs/foreign-correspondent/NC1602H008S00

Thomas, an Australian expert in aviation regulation, observed that Australian airlines have to fly over Indonesia to get to Europe, and the Indonesian regime could retaliate by denying that right. This might explain CASA's 'hands off' approach to AirAsia, although it is clearly out of line with CASA's brief to protect safety, and not 'the industry'. Thomas asserts that AirAsia should not be allowed to fly into Australia, and claims that the airline should be banned unless it undertakes an IOSA audit – to which it has agreed. The final thing to emerge is that private sector IOSA audits of airlines are here being put above public sector ICAO ones of national regulators, in terms of their protective role.

Concluding this section, a number of key points can be made. While the international regulatory regime based on ICAO might seem to place aviation in a stronger position to deal with the safety challenges posed by global supply chains/outsourcing, there is evidence this is not proving to be the case. Indeed, the regime itself appears to be weakening in the context of limited enforcement and tensions between the framework and national and business interests in a competitive environment. It cannot be assumed that a country that claims to meet international standards, and has not been censured for failing to do so, does indeed meet those standards. For example, Indonesia failed ICAO safety audits but there was no uniform/global regulatory response to this. While some national and transnational regulators (EASA and FAA) imposed sanctions to protect their own airspace, CASA did not. Further, the emergence of competing standards regimes, uncritical acceptance of system approaches, the privatisation of some inspection/audit activities and problems connected with moving towards uniform licensing of maintenance workers across a number of jurisdictions have given rise to additional concerns.[29] Finally, these approaches to regulation, to the extent that they apply to the regulation of maintenance, are also problematic, because conditions at the lower end of the supply chain can provide low reference points for comparison in negotiations over wages and conditions.

[29] I. Hampson, D. Fraser, M. Quinlan, A. Junor, *The Uncertain Oversight of Offshored Aircraft Maintenance: The Case of Australia, Journal of Air Law and Commerce,* 2016 in press.

Creating Vulnerability: The Working and Employment Conditions of Aircraft Maintenance Workers

Beyond those considerations already raised there are also wider issues at play in connection to changes in work organisation. The shift to outsourcing of maintenance raises important questions about the adequacy of regulation and labour standards in countries where maintenance is being relocated. There are also questions about the effect of these changes on the working conditions, health, safety and wellbeing of aircraft maintenance engineers, both those in MROs and in-house workers in countries like the USA and Australia, and those in the poor/middle income countries where outsourcing is increasingly taking place. Under international regulation those undertaking critical aircraft maintenance activities are required to be trained and licensed. In Australia the skill-sets of these workers and the fact that they were unionised gave them considerable bargaining power to protect their role and working conditions in the past.[30] However, this position has been undermined by a number of changes. One is that cost pressures on their activities, especially in the context where work is being outsourced, threatens not only their jobs but also impacts on their activities, in relation to turnaround times and other pressures. Before discussing working patterns in Australia the working conditions of outsourced and offshored workers in other countries will be briefly considered.

As far as we are aware there have been no detailed studies of employment and working conditions of aircraft maintenance workers that compare those working in MROs with those directly engaged by airlines. In 2012, we attempted to obtain such data for Australia through the survey whose results are outlined in the next section. Our findings, drawn from the regional airline and general aviation sector as well as from the main route airlines that have so far been the focus of this study, require further validation. They provide some support for the fragmentary evidence that exists from other studies of the effects on job security and working conditions of subcontracting/outsourcing in other industries. However, the situation is not simple. MROs vary in the degree of job insecurity and in their reputation regarding standards and reliability. Further, the trend to

[30] S. Gregson, M. Quinlan & I. Hampson, *Professionalism or Inter-Union Solidarity? Organising Licensed Aircraft Maintenance Engineers, 1955-1975*, *Labour History*, 2016, 110 (May):35-56.

outsourcing has not been irreversible, with maintenance occasionally being returned in-house.

On the one hand offshore MROs specialising for example in avionics or off-wing engine overhaul may perform high quality work, with relatively well-paid labour, deriving their cost advantage from specialisation. Among them are OEMs (original equipment manufacturers) who have captured maintenance work by rolling it into TLS (through-life-support) contracts. On the other hand off-shore MROs performing the routine aspects of D checks and heavy maintenance derive cost advantages from, *inter alia*, low paid, weakly organised workers, and loose enforcement of regulatory standards, including OHS. Currency differentials, for example those between Australia and New Zealand, also play a role. Part of the cost advantages of these MROs comes from their tight adherence to the letter of the tasks and time frames specified in the contracts governing such work, with less scope for being remunerated for rectifying unexpected problems identified in the course of repair work. Similarly, as in other industries, cost savings are derived from tighter time-scheduling of work (including undertaking a higher proportion of repairs at night), using lower ratios of highly skilled workers, at least in offshore facilities (though regulations set minimums in this regard) and lower pay and conditions (especially when outsourcing is offshored to countries with far lower average wage levels, little union presence, weak and poorly enforced labour standards, and in some cases political regimes that actively repress worker organisation (in China and Thailand for example).[31] For example, offshore maintenance providers in countries such as Brazil, the Philippines and China had much lower labour costs (from 10 to 50 per cent) than those pertaining in the USA, Australia, the UK and other rich countries.[32]

Even amongst rich countries with weaker union presence and decentralised IR regimes like the USA there is potential for considerable labour cost savings (a significant component of maintenance activities) from outsourcing of one type or other. Further, multi-tiered subcontracting (ie the further outsourcing of all or part of the work to another party) has the potential to further drive down costs and be

[31] M. Quinlan, I. Hampson & S. Gregson, *Slow to learn: regulatory oversight of outsourced aircraft maintenance in the USA*, *Policy and Practice in Health and Safety*, 2014, 12(1):71-90.

[32] M. McFadden & D. Worrels, *Global outsourcing of aircraft maintenance*, *Journal of Aviation Technology and Engineering*; 2012, 1(2):63-73.

conducive to critical gaps in safety communication as well as greater 'churning' in the workforce of repair stations. Evidence of this emerged in the NTSB investigation into the fatal crash of Air Midwest Flight 5481 in January 2003.[33] The NTSB investigation found that while maintenance work was contracted to one firm (RALLC) it was actually undertaken by another firm engaged by RALLC called Structural Modification and Repair Technicians (SMART). The investigation found short job tenure (often a matter of months), and consequent limited worksite experience, was typical amongst SMART mechanics at the maintenance site; training deficiencies with regard to new hires (and record keeping); and that RALLC's site manager worked a day shift and was not present at night to oversee maintenance when the work was actually being carried out – all factors that contribute to disorganisation and the likelihood of miscommunication or error.

It also critical to note that, as has been found in other industries, work intensification and cost cutting in outsourced work can then place pressures back on in-house workers due to the competitive pressures it places on the latter and fears of job loss.[34] The next section investigates work intensity and work extensification in the on-shore Australian MRO industry, in the context of increased off-shoring and declining local recruitment and apprentice intakes.

Work Patterns and Working Hours in Aircraft Maintenance — Safety Implications

An extensive body of research points to the adverse health effects of excessive working hours, especially when combined with shiftwork and increased work intensification.[35] These studies have justifiably focussed predominantly on the health detriments suffered by long-hours workers

[33] NTSB, National Transportation Safety Board. *Aircraft Accident Report: Loss of Pitch Control During Takeoff Air Midwest Flight 5481 Raytheon (Beechcraft) 1900D, N233YV Charlotte, North Carolina January 8 2003*. NTSB/AAR-04/01 PB2004-910401, 2004, National Transportation Safety Board, Washington, DC, 58-59.

[34] C. Mayhew & M. Quinlan, *Economic pressure, multi-tiered subcontracting and occupational health and safety in the Australian long haul trucking industry*, *Employee Relations*, 2006, 28(3): 212-229.

[35] See for example A. Dembe, J. Erickson, R. Delbos, & S. Banks, *The impact of overtime and long work hours on occupational injuries and illnesses: new evidence from the United States*, *Occupational and Environmental Medicine*, 2005, 62:588–597. doi: 10.1136/oem.2004.016667.

themselves, resulting from too few hours remaining for a healthy lifestyle, rest and recreation.[36] However, in a safety-critical industry like aircraft maintenance, the ill effects may well spread beyond the workplace to consumers and the general public if, for example, fatigued workers make mistakes that contribute to negative aviation incidents. We can surmise that fatigue may be exacerbated in the case of shiftwork, particularly nightwork.[37]

In aircraft maintenance, a combination of personal and industry pressures creates the circumstances where long working hours are normalised and where insufficient attention is paid to the risk factors generated by this trend. Campbell and van Wanrooy highlight the widespread ambivalence workers express about long working hours – that there are significant barriers to workers exercising free choice about their own optimal hours and that worker decisions to perform long hours are deeply affected by many factors, including household debt, family timetables, levels of work stress, fatigue and burnout etc., and workplace culture.[38] They argue that the term 'preference' may paper over a range of underlying reasons why workers do certain hours.[39]

Hours of work and shift patterns were among the aspects of the aircraft maintenance engineering work process we investigated through an Australia-wide survey conducted in 2012, as part of an Australia Research Council-funded Linkage Project studying the future of the aircraft maintenance industry in Australia.[40] Of 708 responses, 626 provided information on work patterns and working hours in aircraft maintenance jobs. 430 responses (68.7%) came from employees of main route and foreign airlines (of whom 380 were from major carrier Airline A). 33 respondents (5.3%) worked for regional airlines, 79 (12.6%) were from General Aviation, 58 (9.3%) were from independent MROs and the remaining 26 (4.1%) were from defence, education, contractors, or original equipment manufacturers. The responses provided evidence of

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[36] B. Pocock *The Work/Life Collision: What Work is Doing to Australians and What to Do about It*, 2003, Federation Press, Annandale.

[37] J. Reason, Achieving a safe culture: theory and practice, *Work & Stress*, 1998, 12(3):293-306.

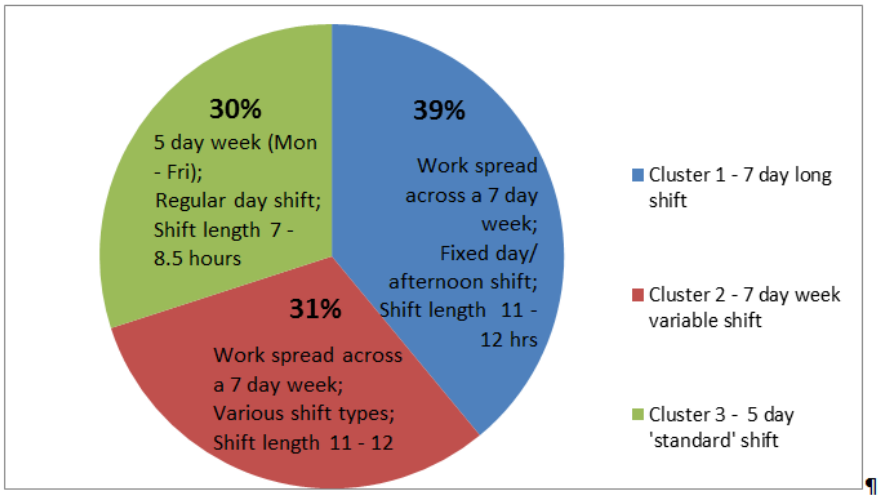
[38] I. Campbell & B. van Wanrooy, *Long working hours and working-time preferences: Between desirability and feasibility*, *Human Relations*, 2013, 66(8): 1131-1155.

[39] R. Drago, M. Wooden & M. Black, Long Work Hours: Volunteers and Conscripts, *British Journal of Industrial Relations*, 2009, 47(3): 571-600; and

[40] UNSW, *The Future of Aircraft Maintenance in Australia: Workforce Capability, Aviation Safety and Industry Development*. ARC Linkage Project 110100335.

working hours and shift patterns that suggested work extensification in the in-house sector. As 55% of respondents volunteered qualitative responses to a final open-ended question, it was possible to derive reasons for the long hours worked, including comments on the links between pay and 'forced choice' of hours, as well as to identify concerns about fatigue and safety.

Figure 1 Three main work patterns – aircraft maintenance survey respondents, Australia, 2012 (n=575)



Source: Source: Survey of aircraft maintenance workers, Australia, 2012

Three characteristic work patterns emerged from a cluster analysis, identifying dominant combinations of three factors: the number and spread of days per work cycle; work schedules (rotating or regular shiftwork rosters) and hours per shift (Figure 1). The most common pattern (39% of the sample) was one in which respondents typically worked a 7 day week (62% of the cluster), a rotating day/afternoon shift (96% of the cluster), and a shift length of 11 - 12 hours (69% of the cluster). The second cluster (31% of the sample) was based on a 7 day week (77% of the cluster), with 57% working an average shift length of 11 - 12 hours, but with a variety of shift types: including rotating shifts other than day/afternoon (52%) and a regular day shift. The third cluster (30% of the sample) worked a 5 day week Monday to Friday (100%), a regular day shift (62%), and a shift length of 7 - 8.5 hours (92%). This cluster of respondents had a work pattern that was closest to the Australian ideal-

type norm, and it can be surmised that this was the safest of the three clusters, with the least risk of fatigue.

The spread of work across a 7 day week meant that 70% of respondents did not have the regular two-day weekends that Australians associate with the 'standard' working week. Their work cycles were combined with long-hours days, a shift length of 11 to 12 hours being the norm. When translated to hours per week, it emerged that compared with the Australian 'standard' full-time week of 35 – 39 hours (depending on industry), aircraft maintenance workers had a working week that was longer than the standard. The mean number of hours worked in the survey week was 43.85 hours, slightly more than the usual mean (42.3 hours) and considerably longer than that preferred (40.67 hours). Indeed 25% of respondents worked more than 48 hours in the reference week.

Table 3 indicates that only a 35% minority usually worked a 'standard' full time week of 35 – 39 hours. For convenience, we can define as a 'stretched' full-time week the 40 – 44 hours usually worked by 31% of the respondents. A further 30% worked either long (45 – 49) hours or very long (50 or over) hours. Part time hours were worked by only 3.5%, mainly in the independent MRO sector.

Table 3. Hours Usually Worked per Week – Aircraft Maintenance Industry Respondents, 2012

Hours per week	**Number**	**Per cent**
Part time (34 hours or less)	20	3.5
Full time - standard (35 - 39 hours)	205	35.4
Full time – 'stretched' (40 - 44 hours)	181	31.3
Long hours (45 - 49 hours)	111	19.2
Very long hours (50 hours or more)	62	10.7
Total	579	100.0

Source: Source: Survey of aircraft maintenance workers, Australia, 2012

The high incidence of 'stretched', 'long hours' and 'very long hours' was in part a function of the incidence of overtime in the industry. Table 4 indicates this incidence. To analyse *overtime* patterns, the pay period was converted to weeks, obtaining 571 valid responses. Of these, 271 (47.5% of respondents) reported working overtime in the most recent pay period. Just over half (152 or 56% of the 271) had worked less than 5 hours of overtime. Of those working overtime, 56% had worked less than five hours, but 29% had worked five to under 10 overtime hours and 15% had worked ten or more hours of overtime. The mean number of overtime hours was 4.75, of which 3.65 were paid. Three-quarters of the 271 had

been paid for all their overtime hours worked, although payment was most common for those working fewer than 10 hours per week (80%). Among those working 10 or more hours of overtime, 34% were paid for only some of those hours and 27% were paid for none of the extra hours. The discrepancy between median overtime hours (4hrs) and median paid overtime hours (2 hrs) was significant (sig<0.0005, Wilcoxon ranked sign test). The inference is that where overtime was more likely to be paid, it was less likely to be excessive. This suggests that industrial regulation and its enforcement, for example by ensuring that additional hours are paid, is a potential means of curtailing excessive and risky unpaid overtime.

Table 4. Actual Hours of Overtime Worked in Most Recent Paid Week—Australian Aircraft Maintenance Industry Survey, 2012

Actual hours of overtime worked in most paid week	Number of respondents answering question		
	Number	% of respondents	% of those working overtime
No overtime	300	52.5%	
Worked overtime	271	47.5%	100%
Less than 5 hours	*152*	*26.6%*	*56.1%*
5 to 9.5 hours	*78*	*13.7%*	*28.8%*
10 or more hours	*41*	*7.2%*	*15.1%*
Total respondents	571	100.0	

Source: Source: Survey of aircraft maintenance workers, Australia, 2012

Significant sectoral differences were found in hours actually worked in the reference week (contingency coefficient 0.218, sig 0.036). About half of all Major Airline A and General Aviation respondents worked a standard (35-30 hour) or 'stretched' (40 to 44 hour) full-time week, but for those working additional hours, in Major Airline A more were in the 'long (45-49) hours' bracket than in the 'very long' hours, whereas in regional and General Aviation, an alarming 27% had worked 50 hours per week or more in the survey period (Table 5). Respondents working for regional airlines were the most likely to be working overtime (69%). In Major Airline A, 27% of respondents had worked no more than 5 hours overtime in the previous week while 14% had worked 5 to 9 hours. Those working in MROs were the least likely to work overtime (36%), perhaps because off-wing repairs and overhaul presented less intense

pressure to return aircraft to service. The poor conditions in regional airlines suggest labour shortages.

Overall, it would appear from a comparison of usual and preferred hours, and paid and unpaid overtime, that there was a high incidence of 'stretched' and long hours in aircraft maintenance industry, and that some of this additional work was involuntary, reflecting a labour shortage or labour over-utilisation, at a time of significant job losses in the industry. This situation, if prolonged, represented a potential fatigue and safety hazard. This hazard was likely to be compounded by the relatively high incidence of 11-12 hour days and variable shift patterns. Many of the 55% who provided responses to the open-ended question painted a sobering picture of hazards turning to endemic risk.

Even when long working hours were undertaken voluntarily, to what extent were these preferences forced by other conditions of the job? Many respondents commented on unsatisfactory pay levels in the industry and declining relativities with other trades, especially in light of the heavy weight of safety responsibility borne by them, the high cost of self-funded training and, as one put it, "for what we put up with" (10016, 10025, 10028, 10185, 10187, 10189, 10198, 10223, 10279, 10336, 10375, 10420, 10440, 10492, 10506, 10530, 10560, 10568, 10588, 10651, 10660, 10683). Some referred explicitly to the need to do overtime hours to earn sufficient pay (10045, 10125, 10329).[41]

Respondents referred to the increased safety risks involved in shift work, especially night shift, advising that management should not schedule complicated, heavy tasks late at night because coordination and thinking was more impaired at that time (10128, 10129, 10406).

> I have personally seen incidents occurring due [to lack of] situational awareness, communication breakdown and fatigue. The employer blaming the employee for incidents and employer not looking at their own policies and employment numbers for task requirements. The airlines preach 'safety first' but still carry on doing the opposite (10242).

Concerns were expressed that safety risks were being incurred because a lot of heavy and technical work was being performed between midnight and 6 am to allow maximum utilisation of the fleet (10121). One LAME detailed how more and more aircraft were serviced on night shift with the

[41] A five-digit reference number was assigned to each survey response to protect respondent anonymity.

same number of staff. "I hate going to work at the moment. Not because of the work, but [because of] the resources and the politics" (10152).
Some reported that greater attention should be paid to incidences of mental health and depression; fatigue, one wrote, was not permitted on a sick form (10121, 10189). As another put it:

> I feel that safety is not a big enough concern within the company. Fatigue is also a major issue, the amount of hours we are required to do to maintain serviceability is excessive (10450).

Engineering staff were leaving and not being replaced (10189), more work was expected and turnaround times were reduced (10443, 10485). A respondent wrote:

> My main area of concern in my career is the stress levels that have increased substantially due to reduced staff levels, inadequate time to carry out tasks thoroughly, and constant uncertainty in my future position through offshoring of maintenance, without adequate supervision by Australian qualified engineers (10349).

With an ageing workforce, work design was also important, wrote one 59-year old respondent. Recovery time from 12 hour shifts was significant (10194). Another wrote:

> 12 hour shifts have a massive impact on life outside work. While a lot of people will work many more hours per week for lower pay, 2 x 12 hour night shifts leaves you feeling like death warmed up and not being involved with the world for the best part of 3 days (10204).

LAMEs have developed a strong 'ideal worker' norm that posits them as the 'last line of defence' or 'guardian' against a catastrophic hull loss, insisting on high standards of work and passing on knowledge to the next generation (10012, 10024, 10070). A LAME 'creed', well known in the industry, commits those in the trade to refuse to sign out any aircraft on which they would not happily have their own family[42]. One wrote of 'the expertise, culture and determination to provide a first class product, on time, every time' (10018) and others of the 'pride' and professionalism involved in the reliability of their work, a reliability that was diminishing

[42] S. Gregson, M. Quinlan & I. Hampson, *Professionalism or Inter-Union Solidarity? Organising Licensed Aircraft Maintenance Engineers, 1955-1975*, *Labour History*, 2016, 110 (May):38

with increased use of outsourcing (10002, 10070, 10090, 10110, 10248). Undermining that commitment, however, was a recognition that correct procedures were often not followed during outsourced maintenance (10010), work was often 'deferred' to keep to flight schedules (10089) and problems existed that managers "turn a blind eye to" (10207). Our respondents felt a strong pressure to "do that bit extra" to fix the hundreds of defects that should have been done during routine maintenance performed elsewhere (10018, 10021, 10109). As one wrote:

> They always threaten us saying how expensive it is and how cheap it is, the work done overseas. But they don't see that the aircraft that undergo an overseas check has so many defects that we have to fix during the next maintenance check that we do, so then it takes longer for us to fix things that the overseas people should have fixed. We are always under pressure to meet unrealistic deadlines to match what overseas MROs do (10375).

Supervisory pressures were increasing because LAME to AME ratios were declining and, coupled with high levels of redundancies in the industry, staff levels were "stretched thin" (10213, 10555). Increased pressure created by the development of complex, highly competitive supply chains for maintenance work has only increased the sense of obligation many LAMEs feel to cover for the effects of 'disorganisation' that now characterises the industry. Because of increased competition and managerialism, there was no longer "an even playing field" (10005) and, as a result, many LAMEs felt declines in quality, training and safety standards, often reduced to 'ticking boxes', were inevitable (10007, 10009, 10012, 10014, 10034, 10036, 10110, 10242).

Discussion and Conclusion

There is now an extensive body of international research pointing to the adverse OHS effects of precarious work. However, a limitation with this categorical approach is that it fails to give sufficient recognition to the business practices and labour processes that give rise to precariousness/vulnerability or to consider whether these processes impact on the working conditions, health and wellbeing of all workers in an industry, not simply those in contingent work arrangements. We would argue it is more valuable to focus analysis on processes like outsourcing/subcontracting and to see the growth of precarious work as but one of a spectrum of changes to work arrangements that can have implications for OHS and also, in some cases at least, community health

and safety. There is a relatively small but nonetheless persuasive body of international research on the adverse health and safety effects of outsourcing/subcontracting and supply chains. This research also points to serious challenges these work arrangements pose for regulators. Our review of US, Australian and other evidence found that the experience in aviation, and more especially heavy aircraft maintenance, very much fits the experience of other industries in this regard and for essentially the same reasons namely the cost-pressures underpinning outsourcing, disorganisation and regulatory failure.

Global supply chains present a particular challenge because they shift work processes outside the jurisdiction of national regulators in countries which are the primary market for such products and services and there is no enforceable set of OHS and labour standards internationally (even those countries signing ILO conventions will essentially decide to what extent they are implemented). Aviation, along with several other industries (like maritime transport), is exceptional in having an international regulatory framework. However, as this paper has indicated the regime has serious gaps (worse in some countries than others) and has been unable to effectively accommodate to the changes in business and work practices following deregulation of airlines and the emergence of low-cost carriers.

With regard to the effects of these changes on working conditions and OHS, the paper noted that changes could be identified at three levels. First, the movement of maintenance work to countries with substantially lower labour costs, many with weak or non-existent union representation/collective bargaining, often with weak social protection and safety regulation (especially when enforcement was considered), and some ruled by endemically corrupt if not totalitarian political regimes. There is little if any systematic research on the OHS conditions of these workers. Second, by outsourcing maintenance, work has also been shifted either internally to MROs within richer countries or to MROs in other countries at similar or lower levels of economic, regulatory and political development. Third, the outsourcing of work has also impacted on the job security and work intensity of those in-house maintenance workers in countries like Australia.

The paper assessed evidence on the second and third aspects, using survey and qualitative data pertaining to Australia. The findings can be summarised as follows. First, long working hours were a feature of the industry and one with significant consequences for OHS. As the evidence was cross-sectional we were unable to conclude whether the shift to outsourcing had contributed to longer working hours across the sector as

a whole. Although this would seem a plausible scenario, and one worth exploring in aviation and other industries it would require longitudinal research methods. Having said this, the evidence indicates that while long hours were the norm, hours were comparatively lower in the more highly regulated Qantas sector and higher in the less unionised, less regulated other main Route regional and GA sectors.

Second, we found that long hours were endemic amongst aircraft maintenance workers in ways that were indicative of the over-utilisation of labour. Respondents found the combination of long hours and nightwork stressful, especially in the context of ongoing management claims about how much more costly was onshore maintenance and how much cheaper it would be to do it offshore. These threats – reinforced by knowledge that other work has been outsourced or offshored – means that workers holding nominally secure jobs rightly feel insecure and precarious and adapt their work practices accordingly. Those retaining their jobs were working harder and feeling more pressured at the same time as other maintenance workers were losing their jobs. We would suggest this is not an uncommon scenario in other industries where strategies such as restructuring/downsizing, outsourcing and the like are being pursued. Whether such an approach is sustainable and its implications for burnout, labour retention and future hiring in aircraft maintenance or more generally are questions warranting serious consideration. Fatigue is known to contribute to poor decision-making and this too may have important implications in terms of public as well as worker safety – an especially significant consideration in high hazard industries.

Third, if hours seem overly long in Australia, what are working hours at offshore MROs in countries where working conditions are less regulated? Are long hours becoming characteristic of aircraft maintenance work in Europe and North America? The study also raises larger questions. Do the employment regimes in these countries mean that workers in aircraft maintenance and more generally essentially experience the precarious work that was characteristic of rich countries prior to World War II?[43] Are we witnessing a convergence in work arrangements between poor and rich countries even affecting industries making use of workers with specialist technical skills?

Taking working hours as one body of evidence it can be hypothesised that outsourcing, and especially when it is offshored, is a mechanism that

[43] M. Quinlan, *The 'pre-invention' of precarious employment: The changing world of work in context*, *The Economic and Labour Relations Review*, 2012, 23(4):3-24.

drives down working conditions amongst non-outsourced and onshore workers, even groups like aircraft maintenance workers who were highly unionised and many with the additional apparent protection of needing to be licensed. As indicated earlier the regulatory protections, including licensing, have not prevented this shift. Indeed, some changes in regulatory regimes have arguably facilitated the process. Finally, this reinforces a more general point about precariousness and vulnerability. Rather, than being treated as a set of categories of work arrangement precariousness is better understood as something that can to some degree affect all categories of workers, encapsulating the loss of control over working-life. Research into the OHS and other effects of precarious and vulnerable work can be significantly advanced by viewing precarity in this broader way and relating its effects to underlying changes in business practices, regulation and work organisation like outsourcing/subcontracting and the use of elaborate global supply chains.

ADAPT International Network

ADAPT is a non-profit organisation founded in 2000 by Prof. Marco Biagi with the aim of promoting studies and research in the field of labour law and industrial relations from an international and comparative perspective. Our purpose is to encourage and implement a new approach to academic research, by establishing ongoing relationships with other universities and advanced studies institutes, and promoting academic and scientific exchange programmes with enterprises, institutions, foundations and associations. In collaboration with the Centre for International and Comparative Studies on Law, Economics, Environment and Work, (DEAL) the Marco Biagi Department of Economics, University of Modena and Reggio Emilia, ADAPT set up the International School of Higher Education in Labour and Industrial Relations, a centre of excellence which is accredited at an international level for research, study and postgraduate programmes in the area of industrial and labour relations. Further information at *www.adapt.it*.

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