

**Independent Review
of Aviation Fatigue Rules for Operators and Pilots
(Civil Aviation Order [CAO] 48.1 Instrument 2013)**

Final Report

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Further detail on the Independent Review Team and EAP members can be found at Annex A.

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Executive Summary

This Final Report presents to the Australian Civil Aviation Safety Authority (CASA) the findings of the Independent Review into aviation fatigue rules for operators and pilots (Civil Aviation Order [CAO] 48.1 Instrument 2013). The Review offers twenty-four recommendations for consideration by the CASA Board.

One of CASA's key objectives is to protect the aviation industry and travelling public from all intolerable risks associated with pilot fatigue. This is logical, and consistent with the principal of developing regulations designed to address known or likely safety risks. The scientific knowledge about fatigue and its effects on human reliability suggest a significant potential risk exposure that needs to be properly managed. There are difficulties isolating fatigue as a formal contributing factor to safety occurrences, and in linking flight crew fatigue, Flight Time Limitations (FTL) and safety events. Survey-based research with pilots in Australia and Europe confirms that fatigue is perceived as a threat to operational safety, and shows distinct differences in the nature and degree of fatigue experience and risk exposures across different sectors of the industry.

The current version of CAO 48.1 attempts to cater for the diverse nature of Australian aviation operations by proposing different rules for different groups of operations (set out in the Appendices). Within each of these groups however, there is still substantial diversity in the operations being conducted. Hence this approach may disadvantage some operators by imposing a rule set that is overly prescriptive and/or not suited to the varied characteristics of their operation. It is proposed that limited dispensations be allowed, where it can be shown that CASA considers specified fatigue mitigation to be appropriate relative to the risk exposure profile of an operation.

Detailed analyses revealed that the prescriptive limits in some areas of CAO 48.1 are conservative when compared with similar international jurisdictions. For example, although Appendix 2 operations are comparable with equivalent operations internationally, the prescribed Flight Duty Period (FDP) limits seem inconsistent with international peer regulations. Given the operational environment, safety record and relative safety culture maturity of the Australian aviation industry, it would seem reasonable to adopt Appendix 2 FDP limits more closely aligned with international averages from comparable operations and jurisdictions.

Aspects of the new regulations, including FDP limits, have been questioned as being unsupported by scientific principles or knowledge. This view misunderstands the limitations of fatigue science, and is based on a flawed expectation that research findings will be comprehensive, conclusive and categorical. In reality, the science as it relates to real-world operations is very rarely definitive or conclusive, because much of the available scientific evidence on fatigue has focused on single variables of interest, rather than on the multiple combinations and permutations of factors that impact on sleep, fatigue and recovery in operational environments.

An extensive review of previous industry feedback, and further consultation with stakeholders, identified a number of outstanding concerns with specific requirements of CAO 48.1.

Applying an FRMS regime designed primarily for large airline operators would impose relatively high compliance costs on other, less-well-resourced operators. The solution proposed is to create two risk-based tiers of FRMS requirements, enabling the highest level of FRMS requirements to be applied to proposed Part 121 passenger and cargo transport operations.

Stakeholder concerns about the prescriptive tone of CAO 48.1 Appendix 7, and related guidance material, could be addressed by reviewing the language used in these documents. Making clear distinctions between requirements and guidance notes would improve the capacity for risk-based flexibility, consistent with an "outcomes-based" approach to regulation.

Additional, specific guidance on Ultra-long-range (ULR) operations (including in-flight rest provisions and requirements) could be provided within CAO 48.1 guidance material.

Complications arise for operators required to switch between Appendices, particularly where they are using an FRMS but may still operate within an Appendix. This could be addressed by limiting the ability to switch between Appendices during a single FDP, and applying the most restrictive limits where multiple types of operations are carried out under different Appendices during a single FDP.

The prescriptive limits applying to aerial application operations within CAO 48.1 are significantly more restrictive than existing arrangements under CAO 48.0 with current exemptions. Given the relatively low risk to public safety from these operations, it is recommended that CASA considers removing Part 137 aerial application operations from CAO 48.1, or at least increasing the flexibility of included limits, to align with the current provisions of Subpart 137.Q. This would also align CASA with approaches taken by comparable jurisdictions abroad.

Opportunities exist to facilitate implementation of CAO 48.1 by operators, including:

- removing the requirement for operators to make allowance for lifestyle factors and circumstances of crew members that are outside operators' control;
- streamlining and aligning Fatigue Management and Non-Technical Skills (NTS) training program outcomes, by linking the content of NTS fatigue management training to content required for tier 2 and 3 operators;
- amending CAAP 48-1 to reflect a more realistic publishing requirement for flight crew rosters to a realistic period; and
- amending the current Appendix 2 four-hour FDP extension limit to one which better reflects international standards, similar for example to the EASA limits which consider sector numbers and time of day limitations.

The overall communication and consultation approach used to design, refine and advise industry about CAO 48.1 was found to meet CASA's obligations under the *Civil Aviation Act 1988* and to ultimately be effective. Opportunities for improvement are identified however, in the way industry is initially consulted on, and involved in fine-tuning proposed changes, the way feedback and industry submissions are managed, and regarding the consistency of advice and information provided by CASA.

Inconsistencies and shortcomings were noted in the way numerous documents associated with CAO 48.1 have been designed and distributed. Further confusion is associated with difficulty identifying and understanding the currently applicable version(s) of CAO 48.1, and the complexities faced by industry in locating the current suite of documents relevant to their own circumstances.

The Review Team considers it critical that CASA now develops a clear and coherent strategy to complete the implementation of CAO 48.1. Such a strategy would involve delaying transition dates until any changes resulting from this review are implemented, and final versions of CAO 48.1 and associated supporting documentation are ready. A staggered, risk-based industry transition to CAO 48.1 would alleviate resourcing pressures and better facilitate effective regulatory oversight and consistency in assessment of applications. Allowing operators greater autonomy to manage and improve their FRMS will also improve efficiency. It will be of critical importance that clear and comprehensive information is available to operators and flight operations inspectors on FRMS implementation and assessment processes.

List of Recommendations

The Independent Review Team makes the following recommendations:

Recommendation 1

That CASA collaborates with the Australian Transport Safety Bureau (ATSB) to develop an agreed definition of a 'fatigue-related safety occurrence', in order to generate and publish more definitive data on fatigue-related safety events in the Australian aviation industry..... 19

Recommendation 2

That where an operator chooses to conduct its operations under a specific Appendix, other than Appendix 1 (prescriptive limits) or Appendix 7 (FRMS), CASA amends Appendices 2 to 6 to provide operators some limited scope for flexibility with respect to compliance with the rules using a standardised approval process. This process will enable CASA to show that it considers fatigue mitigation to be appropriate relative to the risk exposure profile.21

Recommendation 3

That, notwithstanding any challenges the Australian operating environment may present, CASA adopts prescriptive FDP limits that are more closely aligned with international averages for similar types of operation.33

Recommendation 4

That CASA creates at least two risk-based tiers of FRMS requirements (to be reflected in FRMS application/assessment materials such as Form 817), with the highest level of FRMS requirements to be applied to Part 121 passenger and cargo transport operations.....37

Recommendation 5

That CASA reduces the level of prescription in CAO 48.1 Appendix 7 to align more closely with an outcomes-based regulatory philosophy.....38

Recommendation 6

That CASA modifies the tone and language used in CAO 48.1 and all supporting documentation to clearly distinguish between legal requirements and guidelines on acceptable means of compliance.39

Recommendation 7

That CASA considers limiting an operator's ability to switch between Appendices during a single FDP. Where multiple types of operations that would fall under different Appendices are required to be undertaken during a single FDP, the more restrictive limits should apply.40

Recommendation 8

That CASA considers removing Part 137 aerial application operations from CAO 48.1 due to the sector's lower relative risk exposures. If it is deemed necessary to include restrictions for aerial application operators in CAO 48.1 then CASA should consider increasing the flexibility of the relevant CAO 48.1 limits to align them with the current provisions of Subpart 137.Q.....41

Recommendation 9

That CASA removes the requirement for operators to make allowance for individual circumstances when assigning work, given the existing requirement for flight crew members to commence flight duty periods fit for duty, and notify the company if they consider themselves unfit for duty at any time.....42

Recommendation 10

That CASA amends CAAP SMS-3(1) to link the content of NTS fatigue management training to the content required for operators under CAO 48.1. This would streamline and align fatigue management and NTS training program outcomes.....42

Recommendation 11

That CASA amends CAAP 48-1 to reflect a more realistic publishing requirement for flight crew rosters. This could be achieved by reducing the guidance to a more realistic period, such as 7-10 days, noting that any other requirements included in current industrial agreements would still apply.43

Recommendation 12

That CASA amends the Appendix 2 four-hour FDP extension limit to one which better reflects international standards for similar operations. An extension to FDP in accordance with sector numbers and time of day limitations, similar to the EASA limits, would be a more appropriate method of balancing operational flexibility with fatigue mitigation.....43

Recommendation 13

That CASA implements a rigorous, 'error tolerant' process for formally logging, recording and responding to industry submissions in a systematic and transparent way.47

Recommendation 14

That for future complex, industry-wide regulatory change, CASA considers 'road-testing' the proposed changes in a collaborative 'desk-top' exercise with a representative sample of operators, to identify critical stumbling blocks, before formal implementation of the legislation and industry-wide roll-out.....47

Recommendation 15

That as part of the regulatory package development process, CASA develops in-house training, guidelines and communication protocols to ensure that CASA staff supporting the implementation of new regulations are all 'on the same page' when advising industry.48

Recommendation 16

That CASA establishes a single point of contact for industry seeking advice on FRMS, to ensure that accurate, timely, complete and consistent information is provided. To accomplish this, CASA should consider the creation of a centralised (perhaps 'virtual') cell of fatigue management and FRMS expertise to ensure standardisation of the evaluation of applications for FRMS and the subsequent calibration and standardisation of FRMS oversight.48

Recommendation 17

That CASA implements a process which utilises standard templates to produce documents that are clearly identifiable, and presented in a consistent, 'user-friendly' format. Such documents would then be more easily stored and managed, creating a logical trail for future reference.49

Recommendation 18

That CASA provides clearer guidance (on the website and elsewhere as necessary) on the current status of, and relationship between, all CAO 48.1 documentation.....49

Recommendation 19

That CASA allocates appropriate resources to the planning of a detailed, coordinated CAO 48.1 implementation strategy, as a matter of priority.....50

Recommendation 20

That CASA freezes CAO 48.1 transition dates for all elements of the aviation industry until recommended changes resulting from the current Review can be made to stabilise a final version of CAO 48.1 and all associated supporting documentation for implementation51

Recommendation 21

That CASA adopts a staggered approach to the implementation of and transition to CAO 48.1, with initial transition proceeding first for elements of the industry with the highest risk exposure51

Recommendation 22

That CASA initiates action to acquire and / or develop a significantly increased capability for FRMS evaluation and oversight. This action should be linked with the development of clear system / documentation outcomes, including timelines, and determining the particular skills required.....52

Recommendation 23

That CASA reviews the content and language used in CAO 48.1, Appendix 7, Section 7 to ensure that it allows operators sufficient autonomy to be able to manage and improve their FRMS efficiently53

Recommendation 24

That CASA provides clear and comprehensive information to operators and flight operations inspectors on the FRMS assessment process, including differences between requirements and guidelines at different levels of operational scale.53

List of Abbreviations

AC	Advisory Circular
AFAP	Australian Federation of Air Pilots
AIPA	Australian and International Pilots Association
AMOC	Alternate means of compliance
ANO	Air Navigation Order
AOC	Air Operator's Certificate
ASRS	Aviation Safety Reporting System (USA)
ATC	Air Traffic Control
ATSB	Australian Transport Safety Bureau
CAA NZ	Civil Aviation Authority of New Zealand
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CASA	Civil Aviation Safety Authority (Australia)
CASR	Civil Aviation Safety Regulations 1998
CD	Consultation Draft
CFR	Code of Federal Regulations (USA)
DAS	Director of Aviation Safety, CASA
EASA	European Aviation Safety Agency
EMS	Emergency Medical Services
FAA	Federal Aviation Administration (USA)
FCM	Flight Crew Member
FDP	Flight Duty Period
FM	Fatigue Management
FRM	Fatigue Risk Management
FRMP	Fatigue Risk Management Plan
FRMS	Fatigue Risk Management System
FTL	Flight Time Limitations
HF	Human Factors
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots' Associations
MTOW	Maximum take-off weight
NFRM	Notice of Final Rule Making

NPRM	Notice of Proposed Rule Making
NTS	Non-Technical Skills
NTSB	National Transportation Safety Board (USA)
RAAA	Regional Aviation Association of Australia
RIS	Regulation Impact Statement
RPT	Regular Public Transport
SARPs	Standards and Recommended Practices
SIE	Standard Industry Exemption
SMS	Safety Management System
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UK	United Kingdom
UK CAA	Civil Aviation Authority of the United Kingdom
ULR	Ultra long-range
UNSW	University of New South Wales
USA	United States of America
WOCL	Window of Circadian Low

1 Introduction

1.1 Establishment of the Independent Review

In August 2017, the Board of the Civil Aviation Safety Authority of Australia (CASA) commissioned a consortium led by Dédale Asia Pacific Pty Limited (Dédale) to conduct an Independent Review of proposed aviation fatigue rules for operators and pilots (Civil Aviation Order [CAO] 48.1 Instrument 2013; Civil Aviation Safety Authority, 2017a, 2017b). The purpose of the review was to provide guidance to CASA on how best to finalise and implement CAO 48.1, given ongoing industry concerns about the impact of the proposed rules on their operations and businesses, and on the broader Australian community.

The Independent Review Team consisted of five specialists in aviation human factors, fatigue, and organisational safety. Additionally, the Review Team recruited three internationally renowned aviation safety and human factors specialists to form an Expert Advisory Panel (EAP) for the project. Brief details on the Independent Review Team and EAP members are included at Annex A. The role of the EAP was to guide the strategic direction of the review, and support the Independent Review Team with specialist knowledge, including international best practice in fatigue risk management, safety management and aviation regulation. The EAP oversaw and critiqued key deliverables throughout the review, and provided critical input into this Final Report of the Independent Review Team.

The project Terms of Reference (Civil Aviation Safety Authority, 2017c) describe the objectives and scope of the project, and are addressed further in Section 1.3. For the purposes of the review, the term 'rules' was taken to mean the CAO 48.1 legislation, in force and in working draft, as well as supporting documents such as published CASA guidelines and forms, that is, the entire suite of documents related to CAO 48.1.

This document is the Final Report of the Independent Review. Three previous interim reports (unpublished working documents) were produced and provided to CASA in October, November and December 2017 (Dédale Asia Pacific, 2017a, 2017b, 2017c), to chronicle progressively the Review Team's activities, preliminary findings and recommendations. This Final Report contains the essential analyses and findings from the interim reports.

1.2 Background to the review

In May 2012 CASA published Notice of Proposed Rule Making (NPRM) 1202OS on Fatigue Management for Flight Crew Members (Civil Aviation Safety Authority, 2012). The NPRM proposed to update CAO Part 48 by introducing new Fatigue Risk Management rules for operators and pilots. The new rules were designed to better reflect modern flying conditions and advances in technology, and consider latest scientific understanding of fatigue as an influence on human performance. The NPRM explained the rationale for change, provided a synopsis of the change proposals, and invited feedback from industry stakeholders.

Following analysis and consideration of feedback in the second half of 2012, CASA issued a Notice of Final Rule Making (NFRM) on 8th April 2013 (Civil Aviation Safety Authority, 2013a). The NFRM included background on the regulatory policy proposed, outlined the consultation process undertaken, provided an analysis of the submissions made in response to NPRM 1202OS, and explained the changes and their anticipated impact. The final legislative changes were contained in Annex C to the NFRM, and associated advisory material was issued as Civil Aviation Advisory Publication (CAAP) 48-1 (Civil Aviation Safety Authority, 2013b). CAO 48.1 Instrument 2013 was to commence on 30th April 2013.

In response to ongoing industry feedback, CASA made further amendments to CAO 48.1, promulgating these as Consultation Draft CAO 48.1 Amendment Instrument 2015 (No.1) in August 2015 (Civil Aviation Safety Authority, 2015b). Twenty-six key changes were proposed and further industry feedback on these was invited. A second Consultation Draft was issued in March 2016 (Civil Aviation Safety Authority, 2016b), incorporating changes derived from new feedback (23 email discussions including attached documents) and consultation with industry. Once again, feedback was invited and received (27 email communications and documents).

Between May and July 2016 CASA conducted a series of 13 one-day industry workshops and nine staff briefing sessions in various locations around Australia in support of the anticipated transition to CAO 48.1 during 2017. A total of 268 industry members participated in the 2016 workshops, representing more than 160 organisations, ranging from very small to large airline operators (Civil Aviation Safety Authority, 2016c).

In July 2016 CASA issued an updated version of CAO 48.1 (Civil Aviation Safety Authority, 2016d), which included substantial changes to the original new instrument that had been issued in 2013, “principally to provide additional compliance options for balloon operators, for medical transport and emergency service operators, and for daylight aerial work operations, and flight training associated with aerial work.” (Civil Aviation Safety Authority, 2017e).

In late 2016 CASA and its Board determined that an independent review of CAO 48.1 should be undertaken. This decision was based in part on ongoing feedback from various sectors of the industry expressing concerns about the complexity of CAO 48.1, and difficulties encountered attempting to comply with it. The aim of the review was to provide CASA with an informed basis on which to complete the development and implementation of the new fatigue rules in the context of the current international and domestic regulatory environments.

In September 2017, after the review had commenced, CASA formalised a further extension to the implementation period for the amended fatigue rules. (A plan to extend the implementation period was originally announced in May 2017.) At that time (September 2017) CAO 48.1 was amended accordingly (see Civil Aviation Safety Authority, 2017a, 2017b, 2017d).

The review commenced in August 2017 and by December 2017 had delivered three Interim Reports, with the third report including preliminary findings and draft recommendations.

In December 2017, following the preliminary findings and recommendations of this review, CASA announced that the April 2018 deadline for submission of draft operations manual changes and FRMS applications no longer applied.

In February 2018 CASA confirmed that they had amended the CAO 48.1 Instrument 2013 accordingly and indicated that they will fully consider all recommendations of the review and seek industry feedback on the final report prior to establishing a final position and announcing a new transition deadline. Latest updates on transition dates are available from the CASA website: <https://www.casa.gov.au/standard-page/fatigue-management-rules-latest-news>

1.3 Review scope and objectives

The objective of the review was to provide an independent evaluation of the proposed Fatigue Risk Management rules, the processes underpinning their development and communication to industry, their scientific basis and validity, and the impact they will have on the Australian aviation industry. The Terms of Reference for the project are shown in Annex B.

CASA required that the review consider Director of Aviation Safety (DAS) Directive 01/2015 (Civil Aviation Safety Authority, 2016a), to evaluate the extent to which the new rules are “justified on the basis of safety risk and do not impose unnecessary costs or unnecessarily hinder participation in aviation and its capacity for growth”. Evidence was to be provided to

“determine whether the new rules are necessary, having regard to other current regulation including human factors training and safety management systems”.

Current fatigue science knowledge, principles and available best practice were to be used to evaluate the appropriateness of the new rules, with particular reference to the prescriptive limits outlined in the Appendices of CAO 48.1 Instrument 2013, and the proposed application of Fatigue Risk Management Systems (FRMS). It was noted from the outset of the project, however, that the Review Team expected that the available science would not be definitive regarding a variety of matters with respect to real-world operational safety.

Benchmarking against ICAO standards and recommended practices (SARPs) and the approaches of comparable jurisdictions (the UK, NZ, the EU, the US and Canada) was to be undertaken to evaluate (a) the extent to which the latest fatigue rules align with international fatigue-related risk management practice, and (b) the extent to which the CASA fatigue regulatory principles take account of the unique nature of the Australian operating environment. The review was required to test how well local regulation aligns with international standards and whether any identified differences can be justified through risks unique to Australian conditions.

CASA’s view is that all regulatory changes should be consistent with the principles in CASA’s regulatory philosophy and DAS Directive 1/2015. This review was therefore to consider the extent to which the fatigue risk rules are necessary to address known or likely risks, with particular regard to the safety of passengers, employees and other persons. The expectation that regulations should specify safety outcomes, where appropriate, was also to be examined.

Cost and business impact considerations for the Australian aviation industry were to form an important evaluation criterion for the review. Relevant guiding principles (from DAS Directive 1/2015) are that: ‘*Regulation must not impose unnecessary costs on industry, nor unnecessarily hinder growth or participation*’; and ‘*Regulation will address safety risks in the most cost-effective manner, proportionate to the risks involved*’ (Civil Aviation Safety Authority, 2016a). While highly subjective, and dependent on perspective(s) taken, the use of concepts such as ‘necessary’ (with no agreed definition or metrics) has nonetheless been included in the scope of this review.

Key references for the review included the legislative provisions of CAO 48 and CAO 48.1, as well as those relating to Safety Management Systems, Human Factors and NTS training. The review was also to include an examination of relevant scientific and industry literature, covering previous studies into fatigue and the management of fatigue-related risk in aviation. This included the collation and analysis of fatigue-related safety incidents and accidents (e.g., from safety occurrence and investigation reports resulting from air safety occurrence investigations conducted by the Australian Transport Safety Bureau (ATSB) and equivalent international transport accident investigation agencies). The aim of this analysis was to identify the extent to which elements of the new fatigue rules, and current requirements for applied human factors training, or Safety Management Systems, might have contributed to prevention of these events.

As a further benchmarking analysis, the review Terms of Reference asked for some comparison of CASA’s philosophy and approach to fatigue regulation against that of other Australian transport regulators (e.g., maritime, road and rail), and with that used in other safety critical industries such as oil and gas, mining, nuclear, and transport more globally.

The aim of the review was to provide findings and recommendations designed to ensure that “*a safe, effective and efficient set of Fatigue Risk Management rules is in place for Australian operators and pilots*”. Ultimately, the rules are expected to be consistent with good international practice, current scientific knowledge and tools, and be appropriate to the diverse operations being undertaken within the Australian aviation environment and context.

Finally, the review was to indicate the extent to which the rules are consistent with the Minister’s expectations, CASA’s regulatory philosophy, and to the degree possible, DAS Directive 1/2015.

1.4 Review approach and activities

The work of the Independent Review Team began in August 2017 and followed the eight phases agreed in the Project Plan (Table 1).

Table 1
Review Phases and Activities

Phase	Activities
Phase 1	Confirmation of the project plan, methodology, tasks and roles.
Phase 2	Development of a set of Evaluation Criteria against which the information gathered could be summarised and assessed. The Evaluation Criteria and their application are described in Section 1.5 below.
Phase 3	<p>A desktop review of relevant documents, and research into elements and aspects of CAO 48.1, including:</p> <ul style="list-style-type: none"> • Review of the fatigue science principles underpinning CAO 48.1 • Analysis of international Fatigue Risk Management and regulation, in comparison with CAO 48.1 • Review of fatigue related accidents and incidents, and analysis of potential fatigue / HF related preventative interventions • Research into FRM practice amongst other Australian Regulators, and across other high risk industries • Review and analysis of existing (i.e., already received by CASA) stakeholder feedback • Review of CASA processes for introducing CAO 48.1, including communication with industry. <p>Delivery of Interim Report 1.</p>
Phase 4	Identifying and summarising key issues emerging from the research and review activities carried out in Phase 3.
Phase 5	Consultation with selected industry stakeholders, to respond to their enduring concerns with the latest versions of CAO 48.1 and associated documentation, and with CASA's approach to communicating and implementing this major regulatory change. Interviews were conducted with 40 industry personnel representing five airlines, four other aviation operators, six industry bodies, and industry fatigue specialists ¹ .
Phase 6	Collating the findings from Phases 3, 4 and 5, desktop review, identification of key issues and stakeholder consultation. Delivery of Interim Report 2.
Phase 7	Developing and reporting of draft findings and recommendations. Delivery of Interim Report 3.
Phase 8	Reviewing feedback provided by the Expert Advisory Panel and CASA; Preparing a Draft Final Report for presentation to the CASA Board, considering and integrating further feedback, and finalising this report; Presentation of the Independent Review Team's Final Report.

¹ A list of organisations and individuals consulted during this phase of the project is included at Annex C.

In accordance with the project plan, the Review Team delivered three scheduled Interim Reports to CASA in October, November and December 2017. This Final Report draws together and summarises the most important research, analysis, findings and recommendations from those unpublished Interim Reports, with additional changes following feedback from the Review Team's Expert Advisory Panel and CASA.

The first Interim Report (Dédale Asia Pacific, 2017a) explained the project background, scope and objectives, and the approach and methodologies used. It also listed a set of *Evaluation Criteria* developed for use in the Review. The main section of the first Interim Report (Findings and Discussion, Section 4) summarised the preliminary findings and observations from the Review Team's initial desktop review and research activities.

The second Interim Report (Dédale Asia Pacific, 2017b) described the work undertaken to identify and summarise key issues emerging from the Review Team's initial research and review activities, and from face-to-face consultation with a range of industry stakeholders, conducted to acknowledge and respond to their enduring concerns with CAO 48.1, with associated documentation, and with CASA's approach to communicating and implementing this major regulatory change.

The third Interim Report (Dédale Asia Pacific, 2017c) provided CASA with preliminary findings and draft recommendations derived from the Independent Review Team's activities conducted between August and December 2017.

The Interim Reports, including the preliminary findings and draft recommendations were reviewed by the Review Team's Expert Advisory Panel and CASA, and written feedback was provided by all parties prior to and during January 2018. That feedback was analysed, and where considered relevant by the Independent Review Team, incorporated into the consolidated findings and recommendations presented in this Final Report.

1.5 Evaluation criteria

The Review Team determined it desirable to establish criteria against which aspects of the proposed fatigue regulations and supporting implementation approach could be evaluated with some degree of standardisation. A set of project *Evaluation Criteria* was developed for this purpose by referencing the following documents:

- DAS DIRECTIVE – 01/2015 Development and Application of Risk- Based and Cost-Effective Aviation Safety Regulations, which describes a set of Guiding Principles for the Development of Aviation Safety Regulations; and
- The project Terms of Reference (subsequently reproduced in the project contract), which established the scope and objectives for the project.

Information in these documents was reviewed and distilled into the 12 evaluation criteria shown in Table 2 below.

The Review Team's aim was to use these criteria as *reference points* when evaluating the philosophy and objectives underpinning CAO 48.1, the nature of specific proposed rules, and the implication of proposed changes for different parts of the aviation industry. It is also feasible to interpret feedback on CAO 48.1 in terms of these criteria, for example by classifying a concern as questioning the scientific basis of a proposed rule, or identifying a business / commercial impact that could be created under the revised legislation.

As discussed below in Section 2.6, application of the Evaluation Criteria and the DAS Directive to the Review Team's activities, findings and recommendations was not always feasible.

Table 2
Fatigue Review Evaluation Criteria

Safety driven

- Can the latest regulations be justified on safety assurance principles?
- Can the regulations be shown to be necessary to address known or potential safety risks?

Regulatory need

- Are the latest regulations necessary, having regard to existing regulations, including those on Safety Management Systems and HF / NTS?

Australian operating environment / context

- Do the latest regulations, where applicable, adequately consider the Australian context and operating environment?

International alignment

- Are the latest regulations consistent with international standards and those adopted by / proposed for comparable jurisdictions and circumstances (except where differences can be justified due to unique Australian operating conditions)?

Cost / commercial impact

- Do the latest regulations impose unnecessary cost on the industry, or unreasonably hinder growth and participation?
- Do the regulations address safety risks in a cost-effective manner, proportionate to the risks involved?

Scientifically sound

- Are the regulations consistent with the latest relevant research and evidence on sleep science, Fatigue Management, and FRMS?

Communication processes

- Have the latest regulations been written clearly and concisely?
- Has CASA's communication with industry been clear, timely and effective?

Regulatory processes

- Are the regulations scalable and proportionate to the type of operations being undertaken, and do they conform to the aircraft operations classification framework?

Governance

- Are the latest regulations consistent with CASA's stated regulatory philosophy and the principles of DAS Directive 1/2015?

1.6 Report structure

The findings and recommendations of the Independent Review Team are set out in the following four sections of this Final Report.

- Section 2** contains discussion, findings and three recommendations about CASA's rationale for developing CAO 48.1, and on the strategic approach taken by CASA to implement the new regulations.
- Section 3** reports findings and nine recommendations related to outstanding industry concerns with specific requirements of CAO 48.1. The issues detailed here are the more substantial ones raised in written submissions to CASA or in interviews with the Independent Review Team. Some industry feedback not systematically processed by CASA was not analysed and may contain further concerns not yet addressed.
- Section 4** lists findings and six related recommendations made about the way CASA consulted and communicated with industry during the design, development and implementation of CAO 48.1.
- Section 5** reports findings on and addresses, through six related recommendations, industry concerns about potential barriers to the successful implementation of CAO 48.1.

2 Findings and recommendations on CASA's objectives

This section provides discussion on issues associated with CASA's rationale for developing CAO 48.1, and on the strategic approach taken by CASA to implement the new regulations. Findings and recommendations are provided for each major issue.

2.1 Prevention of fatigue-related safety occurrences

CASA's rationale for the introduction of CAO 48.1 was documented in NPRM 1202OS:

"The emergent science on fatigue management within the last decade has shown that there is a need for regulatory bodies in transport industries, and operators, to become more aware of human performance limitations and to organise work practices so that the resultant operational safety risk is kept within acceptable boundaries. This issue is highlighted further as aircraft become more sophisticated and may fly for longer periods together with a growing trend towards shift work."

(Civil Aviation Safety Authority, 2012)

CASA's booklet "Fatigue – The rules have changed" (2016) explained further that:

"The previous flight crew fatigue regulations had been in place for more than 50 years without significant review. Over those years, the industry has changed significantly. Flying in the era of Constellations was very different to today's global ultra-long-haul operations, with rapid transit of multiple time zones (up to eight time zones in 24 hours). Advances in technology, and scientific understanding of human performance limitations, and of sleep, meant the old regulations were out of step with contemporary practice and knowledge. They did not properly address transient and cumulative fatigue, operator and individual responsibilities, the impact of circadian rhythms, and crossing of multiple time zones."

(Civil Aviation Safety Authority, 2016f)

The same document goes on to discuss the link between fatigue and aviation safety occurrences (Civil Aviation Safety Authority, 2016f, p. 12):

"What about fatigue-related accidents and incidents?"

Evidence shows that fatigue is a safety issue or contributing factor in a number of Australian aviation accidents and near misses. The Australian Transport Safety Bureau (ATSB) has identified 12 accidents and 64 near misses over the last 10 years in which fatigue was considered relevant. There were two deaths as a result of these accidents."

Reference is made to 12 international aviation accidents in which fatigue was implicated.

The Independent Review Team's consultation with industry identified an ongoing theme of concern put forward by operators that data on fatigue-related safety occurrences does not justify the changes being made under CAO 48.1. One view was that the old rule set together with a Safety Management System and operational experience have provided adequate fatigue risk mitigation, with no evidence of systemic fatigue issues whilst operating under those rules.

The Independent Review Team's extensive analysis of database information on fatigue-related safety occurrences in Australia and comparable international jurisdictions confirmed that fatigue has been, and continues to be, an important risk factor within the aviation industry worldwide. This analysis considered around 1,600 incidents or accidents related to fatigue in aviation

operations, from a wide range of sources, including the Australian Transport Safety Bureau, the Transportation Safety Board of Canada, the US National Transportation Safety Board, and the confidential Aviation Safety Reporting System (USA).

Recent large survey-based research studies on pilot fatigue amongst Australian commercial pilots (Williamson & Friswell, 2017), and European pilots (Reader, Parand & Kirwan, 2016) indicate distinct differences in the nature and degree of fatigue experience and risk exposures perceived across disparate industry sectors / operation types, companies, pilot roles, and background and employment conditions. This suggests that generic approaches to fatigue regulation and training may be unsuccessful and potentially wasteful, by not focusing on and addressing the high-risk target groups and sectors. This view needs to be balanced with the cost-effective nature of general training to increase practical awareness of sleep and fatigue.

While two further interesting studies of operational fatigue involving Australian regional pilots (co-sponsored by CASA and the RAAA) and international pilots operating new ULR B787-900 routes (co-sponsored by QANTAS and AIPA) are currently underway, the results of those studies are yet to be finalised and so were not available for consideration by the Review Team.

Finding

CASA's objective of protecting the aviation industry from risks associated with pilot fatigue is logical, and consistent with the principal of developing regulations designed to address known or likely safety risks. As stated in the CAO 48.1 Regulation Impact Statement (Annex E to NPRM 1202OS; Civil Aviation Safety Authority, 2012): "while it is difficult to quantify the likely reduction in the fatigue related accident risk, indicative international evidence suggests that the proposed option will generate safety benefits."

The Review Team noted several difficulties in definitively linking fatigue as a formal contributing factor to safety occurrences. Analysis of fatigue-related safety events demonstrates that making a direct link between fatigue, Flight Time Limits and safety events is problematic, for reasons including the following:

- Fatigue is typically only one of a complex combination of factors that influences performance leading to a safety occurrence.
- The investigation of fatigue is not well standardised and can vary considerably depending on the background, expertise and focus of the safety investigator/s involved. Even if an investigator is predisposed to consider fatigue as a contributing factor, its influence is difficult to confirm and cannot be 'measured' reliably even if recent work / rest data for crew involved is available.
- Few safety events occur at the margins of prescribed Flight Time Limits (late in an FDP), so there is insufficient empirical data to determine whether different limits would or would not have influenced crew alertness levels and led to a different outcome.
- In many safety events, reported crew fatigue resulted from non-FDP factors such as limited sleep, associated with inadvertent domestic or psychosocial factors. This implies that education for crew members on fatigue prevention, recognition and management will continue to be important in the overall fatigue risk management strategy.

Recommendation 1

That CASA collaborates with the Australian Transport Safety Bureau (ATSB) to develop an agreed definition of a 'fatigue-related safety occurrence', in order to generate and publish more definitive data on fatigue-related safety events in the Australian aviation industry.

2.2 Risk-based approach

CAO 48.1 FRMS requirements would ideally be risk-based and data-driven. This point was made vociferously during the Review Team's industry consultation visits by operators who understand the need for an FRMS to meet those requirements. The need for risk-based and data-driven FRMS is also highly consistent with the tripartite ICAO/IATA/IFALPA position. However, in some cases, it is unclear what data-driven processes CASA Inspectors, and others who have reviewed FRMS submissions or components to date, are using (if any). Later findings and recommendations support increased transparency and scalability of FRMS in a form that is risk-based and data-driven in a form suitable for a type of operation.

2.3 Need for CAO 48.1

Some stakeholders have questioned the need for CAO 48.1 and FRMS as they believe that Fatigue Management is already covered by existing Safety Management System (SMS) and Human Factors / Non-Technical Skills training requirements.

The role of fatigue and other human factors in contributing to or preventing safety occurrences is understood at a theoretical level (see for example the Reason Model, Reason, 1990, 1991; Walker & Bills, 2008), but the exact relationship between these factors is difficult to discern in practice. As discussed in the CASA Biomathematical Fatigue Models Guidance Document:

“in aviation, the link between fatigue and safety is particularly difficult to establish because of the very low accident rate and the complexity of accident aetiology (Amalberti, 2001). In fact, multiple layers of operational defences (cockpit and ATC task automation, checklists, Crew Resource Management strategies, Standard Operating Procedures, etc.) reduce the probability of having an aviation accident attributable to a single cause (here a decrease in human performance due to fatigue; Gander et al., 2011). These operational defences or barriers are used by aircrew as protection strategies against the detrimental effects of fatigue (Dawson, Noy, Härmä, Åkerstedt & Belenky, 2011) as was observed in a simulator study of line crews conducted at a major airline (Petrilli, Roach, Dawson & Lamond, 2006). The use of these strategies could explain the non-linear relationship between safety-related indicators and fatigue-related indicators.”

(Civil Aviation Safety Authority, 2014b, p. 19)

Finding

The Independent Review Team supports the need for CAO 48.1. Scientific knowledge about fatigue and its effects on human reliability are strong enough to assert the existence of a significant risk exposure that needs to be properly managed. The absence of a precise and reliable quantitative model to describe the exact link between duty time and fatigue on the one hand, and fatigue and airborne risk on the other, should not be used as an excuse to underestimate the need to adapt Fatigue Risk Management approaches. On the contrary, these uncertainties must trigger a precautionary attitude and encourage routine regulatory attention to ongoing fatigue research, including aviation industry fatigue-related accident/incident analysis. Furthermore, Fatigue Risk Management is related to, but not always fully addressed by, SMS or other safety-related elements within an operation.

2.4 Australian operating environment / context

The Australian operating environment provides some unique challenges due to its size, topography, weather, and the diversity of the operations that are conducted. Ultra-Long Haul, Long Haul, Short Haul, Helicopter, Agricultural, Non-RPT (Regular Public Transport) fixed wing,

flight training and commercial ballooning operations are examples of this diversity. While most of the Australian population lives near the coast, there are often substantial distances between population centres, necessitating extended flying duties in some cases. There are also vast areas supported by agricultural and other operations that have considerations that are sometimes unique to Australia. Applying fatigue rules that are appropriate and scaled to these diverse operations is a complex task. Some aviation industry sectors perceive that CASA's proposed fatigue management changes are too generic (i.e., too 'one-size-fits-all'), and do not consider their unique operational environment and considerations adequately.

Finding

Although CASA has identified several different groups of operations, and classified these into subsets (Appendices) within the proposed CAO 48.1 rules, within each of these categories there is still substantial diversity in the operations being conducted. This may disadvantage some operators by imposing a rule set which is overly prescriptive, or not suited to the characteristics of their operation, even though their operations fall clearly into one of the nominated Appendices. Some requirements of "special operations", for example, including counter terrorism, may fall outside the prescribed limits of an Appendix, however there is currently no relief from this other than via an approved FRMS, which may not be always appropriate for some operators such as those who cannot foresee their mission demands. One example of this is a Police Air Wing that may be required on occasions to deal with critical public safety emergencies that fall outside the limits of their relevant Appendix. In such cases, it is believed that cautious flexibility could be provided by CASA under a standardised application and approval process.

Recommendation 2

That where an operator chooses to conduct its operations under a specific Appendix, other than Appendix 1 (prescriptive limits) or Appendix 7 (FRMS), CASA amends Appendices 2 to 6 to provide operators some limited scope for flexibility with respect to compliance with the rules, using a standardised approval process. This process will enable CASA to show that it considers fatigue mitigation to be appropriate relative to the risk exposure profile.

2.5 International alignment

CAO 48.1 incorporates a range of changes to prescriptive hours limits that are more conservative than the previous CAO 48.0 limits, particularly under existing standard industry exemptions (SIEs), which many operators have been utilising for some years.

While Australia has some unique operating challenges, comparison with other similar regulatory environments, including Canada, the EU, the UK, the USA and New Zealand is considered valid. Australia could be considered comparable to those jurisdictions in many areas, including:

- A strong aviation safety record, as acknowledged by the 2014 Australian Aviation Safety Review: "Australia has an excellent, high-capacity Regular Public Transport safety record and an advanced aviation regulatory system." (Australian Government, 2014);
- A largely predictable operational environment;
- A mature safety culture throughout the industry;
- Long-established SMS practices, including FRM;
- Generally positive operator attitudes towards continuous improvement of fatigue management; and
- A highly professional, well-trained pilot population, with good CRM / NTS understanding and awareness of fatigue self-management principles.

Analysis was thus undertaken to compare CASA's proposed prescriptive hours limits in CAO 48.1 and those existing under current SIEs with limits from other regulatory agencies. International aviation regulators included within the analysis were Transport Canada (TC), the European Aviation Safety Agency (EASA), the Civil Aviation Authority of the United Kingdom (UK CAA), and the US Federal Aviation Administration (FAA). While the Civil Aviation Authority of New Zealand (CAA NZ) has initiated public discussion on fatigue risk management options (Civil Aviation Authority New Zealand, 2016), their existing basic guidance material (Civil Aviation Authority New Zealand, 2006) was excluded from the comparison as it does not reflect current good practice.

While analysis across all Appendices was conducted, making direct comparisons with international limits proved problematic. Some regulators have chosen not to use flight time limitations as a means of regulating fatigue risk across some operations, or are yet to implement such rules, making direct comparison impossible. The CASA limits that were most useful for comparison with international figures were those from the proposed CAO 48.1 (Appendix 2), and the existing limits under SIEs. The analysis compared FDP limits based on hourly FDP sign-on segments throughout the day and night, for acclimatised, two-pilot crews. To enable an overall comparison with international practice, the FDP limits of the international regulators were averaged, and the CASA CAO 48.1 and SIE limits were measured against this average.

As shown in Table 3 below, comparison of existing SIE and CAO 48.1 limits against international averages from corresponding jurisdictions across FDP start times shows that although there are similarities, the SIE limits are generally more liberal than the international averages, whereas the CAO 48.1 limits are generally more conservative than international averages.

Table 3
Comparison of SIEs and CAO 48.1 with international averages

FDP Start Time	Comparison of SIEs with international averages	Comparison of CAO 48.1 with international averages
0000 - 0600	SIE limits are 1 hour or more longer than international averages for 1-4 sectors generally.	CAO 48.1 limits are 1 hour or more shorter than international averages for 5-7 sectors generally.
0700 - 1500	SIE limits are generally slightly longer than international averages for 1-4 sectors.	CAO 48.1 limits are generally similar to the international averages.
1500 - 2300	SIE limits are generally similar to international averages.	CAO 48.1 limits are largely over 1 hour less than international averages for most duties, regardless of the number of sectors.
2300 - 2359	SIE limits are at or over 1 hour more than the international average for up to 4 sectors per day.	The CAO 48.1 limits are generally less than the international average and over 1 hour less during higher multi-sector duties.

It should be noted that the comparisons made here and in the following tables incorporate previous UK CAP 371 limits (Civil Aviation Authority United Kingdom, 2004), which have recently been superseded by EASA FTL regulations (Civil Aviation Authority United Kingdom, 2015). They were included to provide additional useful comparative data. Further separate analyses, omitting these data, showed very similar results overall.

Table 4 which follows (pages 23-25) provides a more detailed examination of the comparative analysis of CAO 48.1 against counterpart international regulators. The international average is highlighted in yellow. Where the CASA limits differ by *one hour or more* from the average international limit, that difference has been colour coded according to whether the CASA limit was higher (shown in green) or lower (shown in blue) than the averaged international limit.

Table 4
CAO 48.1 International Comparisons
(for Two Pilot Acclimatised FDPs)

Legend

>= 1 Hour higher than average
>= 1 Hour lower than average

Local Report Time		Sectors									
		1	2	3	4	5	6	7+	8 or 8+	9	10
0000-0359	SIE	12	12	11	11	10	10	9	SIE = Standard Industry Exemption		
	48.1	10	10	9	9	8	8	8			
	UK	11	10.25	9.5	9	9	9	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	Transport Canada - Canada Gazette 1	TC CG1	9	9	9	9	9	9	9	TC is for average sector length >50 minutes	
	FAA	9	9	9	9	9	9	9			
	(International Average)	Average	10.0	9.8	9.5	9.3	9.1	9.0	9.0		
0400-0459	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	8	8	8			
	UK	11	10.25	9.5	9	9	9	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	TC CG1	10	10	10	10	9	9	9			
	FAA	10	10	10	10	9	9	9			
	(International Average)	Average	10.5	10.3	10.0	9.8	9.1	9.0	9.0		
0500-0559	SIE	13	13	12	12	11	11	10			
	48.1	11	11	10	10	9	9	9			
	UK	11	10.25	9.5	9	9	9	9	9		
	EU	12-12.75*	12-12.75	11.5-12.25	11-11.75	10.5-11.25	10-10.75	9.5-10.25	9-9.75	9-9.25	9
	TC CG1	11	11	11	11	10	10	9			
	FAA	12	12	12	12	11.5	11	10.5			
	(International Average)	Average	11.6	11.4	11.1	10.8	10.3	10.1	9.6		
0600-0659	SIE	14	14	13	12	12	11	10			
	48.1	12	12	11	11	10	10	9.5			
	UK	13	12.15	11.5	10.75	10	9.5	9			
	EU	13	13	12.5	12	11.5	11	10.5	10	9.5	9
	TC CG1	12	12	12	12	11	11	10			
	FAA	13	13	12	12	11.5	11	10.5			
	(International Average)	Average	12.8	12.5	12.0	11.7	11.0	10.6	10.0		
0700-0759	SIE	14	14	13	12	12	11	10			
	48.1	13	13	12	12	11	11	10			
	UK	13	12.25	11.5	10.75	10	9.5	9			
	EU	13	13	12.5	12	11.5	11	10.5	10	9.5	9
	TC CG1	13	13	13	13	12	12	11			
	FAA	14	14	13	13	12.5	12	11.5			
	(International Average)	Average	13.3	13.1	12.5	12.2	11.5	11.1	10.5		
0800-1059	SIE	14	14	13	12	12	11	10			
	48.1	14	14	13	13	12	11	11			
	UK	14	13.25	12.5	11.75	11	10.5	10	9.5		
	EU	13	13	12.5	12	11.5	11	10.5	10	9.5	9
	TC CG1	13	13	13	13	12	12	11			
	FAA	14	14	13	13	12.5	12	11.5			
	(International Average)	Average	13.5	13.3	12.8	12.4	11.8	11.4	10.8		

Table 4 (continued)

1100-1159	SIE	14	14	13	12	12	11	10			
	48.1	13	13	12	12	11	11	10			
	UK	14	13.25	12.5	11.75	11	10.5	10	9.5		
	EU	13	13	12.5	12	11.5	11	10.5	10	9.5	9
	TC CG1	13	13	13	13	12	12	11			
	FAA	14	14	13	13	12.5	12	11.5			
	(International Average) Average		13.5	13.3	12.8	12.4	11.8	11.4	10.8		

1200-1259	SIE	14	14	13	12	12	11	10			
	48.1	13	13	12	12	11	11	10			
	UK	14	13.25	12.5	11.75	11	10.5	10	9.5		
	EU	13	13	12.5	12	11.5	11	10.5	10	9.5	9
	TC CG1	13	13	13	13	12	12	11			
	FAA	13	13	13	13	12.5	12	11.5			
	(International Average) Average		13.3	13.1	12.8	12.4	11.8	11.4	10.8		

1300-1359	SIE	13	13	12	12	11	11	10			
	48.1	13	13	12	12	11	11	10			
	UK	13	12.25	11.5	10.75	10	9.5	9	9		
	EU	13-12.75	13-12.75	12.5-12.25	12-11.75	11.5-11.25	11-10.75	10.5-10.25	10-9.75	9.5-9.25	9
	TC CG1	12.5	12.5	12.5	12.5	11.5	11.5	10.5			
	FAA	12	12	12	12	11.5	11	10.5			
	(International Average) Average		12.6	12.4	12.1	11.8	11.1	10.7	10.1		

1400-1459	SIE	13	13	12	12	11	11	10			
	48.1	12	12	11	11	10	10	9			
	UK	13	12.25	11.5	10.75	10	9.5	9	9		
	EU	12.5-12.25	12.5-12.25	12-11.75	11.5-11.25	11-10.75	10.5-10.25	10-9.75	9.5-9.25	9	9
	TC CG1	12.5	12.5	12.5	12.5	11.5	11.5	10.5			
	FAA	12	12	12	12	11.5	11	10.5			
	(International Average) Average		12.5	12.3	12.0	11.7	11.0	10.6	10.2		

1500-1559	SIE	12	12	11	11	10	10	9			
	48.1	11	11	10	10	10	9	9			
	UK	13	12.25	11.5	10.75	10	9.5	9	9		
	EU	12-11.75	12-11.75	11.5-11.25	11-10.75	10.5-10.25	10-9.75	9.5-9.25	9	9	9
	TC CG1	12.5	12.5	12.5	12.5	11.5	11.5	10.5			
	FAA	12	12	12	12	11.5	11	10.5			
	(International Average) Average		12.3	12.2	11.8	11.5	10.8	10.5	9.8		

1600-1659	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	9	8	8			
	UK	13	12.25	11.5	10.75	10	9.5	9	9		
	EU	11.5-11.25	11.5-11.25	11-10.75	10.5-10.25	10-9.75	9.5-9.25	9	9	9	9
	TC CG1	12.5	12.5	12.5	12.5	11.5	11.5	10.5			
	FAA	12	12	12	12	11.5	11	10.5			
	(International Average) Average		12.2	12.0	11.7	11.4	10.7	10.3	9.8		

1700-1759	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	9	8	8			
	UK	13	12.25	11.5	10.75	10	9.5	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	TC CG1	12	12	12	12	11	11	10			
	FAA	12	12	11	11	10	9	9			
	(International Average) Average		12.0	11.8	11.3	10.9	10.1	9.6	9.3		

Table 4 (continued)

1800-2159	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	9	8	8			
	UK	12	11.25	10.5	9.75	9	9	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	TC CG1	12	12	12	12	11	11	10			
	FAA	12	12	11	11	10	9	9			
	(International Average)	Average	11.8	11.6	11.0	10.7	9.9	9.5	9.3		
2200-2259	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	9	8	8			
	UK	11	10.25	9.5	9	9	9	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	TC CG1	11	11	11	11	10	10	9			
	FAA	11	11	10	10	9	9	9			
	(International Average)	Average	11.0	10.8	10.3	10.0	9.4	9.3	9.0		
2300-2359	SIE	12	12	11	11	10	10	9			
	48.1	10	10	9	9	8	8	8			
	UK	11	10.25	9.5	9	9	9	9	9		
	EU	11	11	10.5	10	9.5	9	9	9	9	9
	TC CG1	10	10	10	10	9	9	9			
	FAA	10	10	10	9	9	9	9			
	(International Average)	Average	10.5	10.3	10.0	9.5	9.1	9.0	9.0		

Note 1: TC has proposed and gazetted new FTL which are in the process of implementation (TC CGI, used here). Existing TC Regs allow for 14 hours flight duty regardless of report time or whether or not acclimatised.

Note 2: FRM in NZ is currently the subject of review and public consultation. CAA NZ published guidance from 2006 (not used here) allows for 11 hours flight duty regardless of local report time.

Note 3: *EASA FTL's delineate some limits into 15 minute segments. The international average uses the median of this range.

As indicated above, the comparisons made in Table 4 show that the current SIEs allowed longer FDPs for duties that commenced back of the clock, or during the morning, but were similar for duties commencing in the afternoon. By contrast, CAO 48.1 Appendix 2 FDP limits are commonly shorter than international limits for duties commencing in the afternoon, night, or back of the clock, but are comparable for morning starts.

CAO 48.1 Appendix 2 FDP limits were also analysed and compared against other international regulations for augmented crew operations, and for Off Duty Periods (ODP). The results of these comparisons are detailed in Annex D to this report (Tables D-1 and D-2).

An overall summary of FDP (and in some cases flight time) limits, across the CAO 48.1 Appendices is shown in Table 5 below (pages 27-32). The table also includes the international comparison of two pilot, acclimatised, Appendix 2 FDP limits from Table 4 (discussed above), along with some illustrative examples of how Appendix 2 could be amended, should CASA choose to adopt limits that more closely reflect international averages.

The methodology used to determine these illustrative examples considered any CAO 48.1 Appendix 2 FDP limit which is one hour or more different to the international average determined via the analysis included in Table 4, for a given FDP start time. Where there was one hour or more difference, the Appendix 2 limits (both FDP and flight time), were increased or decreased by an hour so that they fell within an hour of the international average.

This process is not intended to be put forward as a definitive methodology for determining amendments to Appendix 2 limits, but simply illustrates a workable method for aligning those limits more closely with other comparable international FDP and/or FTL schemes.

2.6 Summary Comparisons ~ International Jurisdictions and ICAO SARPs

During an initial desktop research phase of the review, the Independent Review Team completed a summary component analysis of key FRMS requirements across a range of relevant international jurisdictions compared with ICAO standards and recommended practices (International Civil Aviation Organization, 2013, 2016).

The results of this FRMS component analysis across jurisdictions covered by EASA, UK CAA, CAA NZ, the FAA, Transport Canada, and CASA are shown in Table E-1, Annex E.

The results illustrate that, as with the FAA, CASA has virtually adopted content of the ICAO SARPs in their entirety. Not all regulators have elected to do this, with EASA and Transport Canada, for example, taking a much less stringent approach and modifying the requirements somewhat to better reflect operations within their jurisdictions. CAA NZ has yet to produce draft or proposed FRMS regulatory guidance.

Table 5
A Comparison of FDP Limits Between Appendices

Notes # FDP can only start at or after morning civil twilight
(30 mins before MCT until 30 mins after ECT for Appendix 5A)
(Figures in brackets denote flight time limits)
** Subject to FDP finishing no later than 0100 local time the following day
at the location at which the FDP commenced
\$ Subject to FDP finishing no later than 0100 local time the following day

=+ Denotes two pilot operation
* Denotes max FDP using split duty
N/A = Not authorised

Local Report Time	Sectors	1	2	3	4	5	6	7+			
0000-0359	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	Single Pilot Operation	
	Basic Limits	48.1 App 1	Limited	Limited	Limited	Limited	Limited	Limited	Limited		
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	10	9.8	9.5	9.3	9.1	9	9		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)		
	PTS - Single Pilot Ops	48.1 App 4	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+		10 (8)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10		10
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11		10#
Flying Training	48.1 App 6	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)			
0400-0459	Standard Industry Exemption	SIE	12	12	11	11	10	10	9		
	Basic Limits	48.1 App 1	Limited	Limited	Limited	Limited	Limited	Limited	Limited		
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	10.5	10.3	10	9.8	9.1	9	9		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	10 (8)	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	9 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)		
	PTS - Single Pilot Ops	48.1 App 4	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+		10 (8)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10		10
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11		10#
Flying Training	48.1 App 6	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)			

Sectors			1	2	3	4	5	6	7 +		
0500-0559	Standard Industry Exemption	SIE	13	13	12	12	11	11	10	Single Pilot Operation	
	Basic Limits	48.1 App 1	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)		
	PTS - Multi-pilots Ops	48.1 App 2	11 (9)	11 (8)	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	11.6	11.4	11.1	10.8	10.3	10.1	9.6		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	11 (9)	11 (8)	11(9)	10 (8)	10 (8)	10 (8)	9 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	11 (9)	11 (8)	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)		
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	12 (10)+	12 (10)+	12 (10)+	12 (10)+	12 (10)+	12 (10)+	12 (10)+		11(9)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	11	11	11	11	11	11	11		11
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	12	12	12	12	12	12	12		11#
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)			
0600-0659	Standard Industry Exemption	SIE	14	14	13	12	12	11	10		
	Basic Limits	48.1 App 1	9# (7)	9# (7)	9# (7)	9# (7)	9# (7)	9# (7)	9# (7)		
	PTS - Multi-pilots Ops	48.1 App 2	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	10 (8)	9.5 (8)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12.8	12.5	12	11.7	11	10.6	10		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	12 (9)	12 (9)	12 (9)	11 (9)	11 (8)	10 (8)	9.5 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	10 (8)	9 (8)		
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	13(10)+	13(10)+	12.5(10)+	12.5(10)+	12.5(10)+	12.5(10)+	12.5(10)+		11.5(9)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	11	11	11	11	11	11	11		11.5
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	13	13	12.5	12.5	12.5	12.5	12.5		11.5#
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)			
0700-0759	Standard Industry Exemption	SIE	14	14	13	12	12	11	10		
	Basic Limits	48.1 App 1	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
	PTS - Multi-pilots Ops	48.1 App 2	13 (10.5)	13 (10.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	13.3	13.1	12.5	12.2	11.5	11.1	10.5		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	13 (10.5)	13 (10.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	13 (10.5)	13 (10.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS - Single Pilot Ops	48.1 App 4	10 (8)	10 (8)	10 (8)	10 (8)	10 (8)	10 (8)	10 (8)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	14(11)+	14(11)+	13(11)+	13(11)+	13(11)+	13(11)+	13(11)+		12(10)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	12	12	12	12	12	12	12		12
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	14	14	13	13	13	13	13		12
Flying Training	48.1 App 6	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)			

Sectors			1	2	3	4	5	6	7 +		
0800-1059	Standard Industry Exemption	SIE	14	14	13	12	12	11	10	Single Pilot Operation	
	Basic Limits	48.1 App 1	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
	PTS - Multi-pilots Ops	48.1 App 2	14 (10)	14 (10)	13 (9.5)	13 (9.5)	12 (9)	11 (9)	11 (9)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	13.5	13.3	12.8	12.4	11.8	11.4	10.8		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	14 (10)	14 (10)	13 (9.5)	13 (9.5)	12 (9)	11 (9)	11 (9)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	14 (10)	14 (10)	13 (9.5)	13 (9.5)	12 (9)	11 (9)	11 (9)		
	PTS - Single Pilot Ops	48.1 App 4	11 (9)	11 (9)	11 (9)	11 (9)	11 (9)	11 (9)	11 (9)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	14(11)+	14(11)+	13(11)+	13(11)+	13(11)+	13(11)+	13(11)+		12(10)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	12	12	12	12	12	12	12		12
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	14	14	13	13	13	13	13		12
Flying Training	48.1 App 6	11 (7)	11 (7)	11 (7)	11 (7)	11 (7)	11 (7)	11 (7)			
1100-1159	Standard Industry Exemption	SIE	14	14	13	12	12	11	10		
	Basic Limits	48.1 App 1	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
	PTS - Multi-pilots Ops	48.1 App 2	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	13.5	13.3	12.8	12.4	11.8	11.4	10.8		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS - Single Pilot Ops	48.1 App 4	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	14(11)+	14(11)+	13(11)+	13(11)+	13(11)+	13(11)+	13(11)+		12(10)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	12	12	12	12	12	12	12		12
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	14	14	13	13	13	13	13		12
Flying Training	48.1 App 6	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)			
1200-1259	Standard Industry Exemption	SIE	14	14	13	12	12	11	10		
	Basic Limits	48.1 App 1	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
	PTS - Multi-pilots Ops	48.1 App 2	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	13.3	13.1	12.8	12.4	11.8	11.4	10.8		
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS Multi-pilot other than Complex Ops	48.1 App 3	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)		
	PTS - Single Pilot Ops	48.1 App 4	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)		
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*		
	Med Transport Ops & Emg Service Ops	48.1 App 4B	13(10)+	13(10)+	12(10)+	12(10)+	12(10)+	12(10)+	12(10)+		11(9)
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	11	11	11	11	11	11	11		11
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	13	13	12	12	12	12	12		11
Flying Training	48.1 App 6	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)			

Sectors			1	2	3	4	5	6	7 +	
1300-1359	Standard Industry Exemption	SIE	13	13	12	12	11	11	10	Single Pilot Operation 11(9) 11 11
	Basic Limits	48.1 App 1	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	
	PTS - Multi-pilots Ops	48.1 App 2	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12.6	12.4	12.1	11.8	11.1	10.7	10.1	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	13 (9.5)	13 (9.5)	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	
	PTS - Single Pilot Ops	48.1 App 4	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	10 (9)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	13(10)+	13(10)+	12(10)+	12(10)+	12(10)+	12(10)+	12(10)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	11	11	11	11	11	11	11	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	13	13	12	12	12	12	12	
Flying Training	48.1 App 6	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)	10 (7)		
1400-1459	Standard Industry Exemption	SIE	13	13	12	12	11	11	10	11(9) 11 11
	Basic Limits	48.1 App 1	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	
	PTS - Multi-pilots Ops	48.1 App 2	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	10 (8)	9 (8)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12.5	12.3	12	11.7	11	10.8	10.2	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	12 (9)	12 (9)	12 (9)	11 (9)	11 (8)	10 (8)	10 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	12	12	11	11	10	10	9	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	13(10)+	13(10)+	12(10)+	12(10)+	12(10)+	12(10)+	12(10)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	11	11	11	11	11	11	11	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	13	13	12	12	12	12	12	
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
1500-1559	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	10.5(8) 10.5 10.5
	Basic Limits	48.1 App 1	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	
	PTS - Multi-pilots Ops	48.1 App 2	11 (9)	11 (9)	10 (8)	10 (8)	10 (8)	9 (8)	9 (8)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12.3	12.2	11.8	11.5	10.8	10.5	9.8	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	12 (9)	12 (9)	11 (9)	11 (9)	10 (8)	10 (8)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	11 (9)	11 (9)	10 (8)	10 (8)	10 (8)	9 (8)	9 (8)	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	12(10)+	12(10)+	11.5(10)+	11.5(10)+	11.5(10)+	11.5(10)+	11.5(10)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	12	12	11.5	11.5	11.5	11.5	11.5	
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		

Sectors			1	2	3	4	5	6	7 +	
1600-1659	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	Single Pilot Operation 10 (8) 10 10#
	Basic Limits	48.1 App 1	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12.2	12	11.7	11.4	10.7	10.3	9.8	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	12 (10)	11 (9)	11 (9)	11 (9)	10 (9)	10 (9)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11	
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
1700-1759	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	10 (8) 10 10#
	Basic Limits	48.1 App 1	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	12	11.8	11.3	10.9	10.1	9.6	9.3	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	11 (9)	11 (9)	11 (9)	10 (9)	10 (9)	9 (8)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11	
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		
1800-2159	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	10 (8) 10 10#
	Basic Limits	48.1 App 1	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	8# (7)	
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	11.8	11.6	11	10.7	9.9	9.5	9.3	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	11 (9)	11 (9)	10 (9)	10 (9)	9 (8)	9 (8)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11	
Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)		

Sectors			1	2	3	4	5	6	7 +	
2200-2259	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	Single Pilot Operation
	Basic Limits	48.1 App 1	Limited	Limited	Limited	Limited	Limited	Limited	Limited	
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	11	10.8	10.3	10	9.4	9.3	9	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	11 (9)	10 (8)	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	8 (7)	8 (7)	
	PTS - Single Pilot Ops	48.1 App 4	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11	
	Flying Training	48.1 App 6	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	9 (7)	

2300-2359	Standard Industry Exemption	SIE	12	12	11	11	10	10	9	
	Basic Limits	48.1 App 1	Limited	Limited	Limited	Limited	Limited	Limited	Limited	
	PTS - Multi-pilots Ops	48.1 App 2	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)	
	FDP International Averages (Acclimatised 2 Pilot Crews)	Intl Average	10.5	10.3	10	9.5	9.1	9	9	
	Example of Alignment Changes to Appendix 2 FDP Limits	App 2 Update	10 (8)	10 (8)	10 (8)	9 (8)	9 (8)	9 (8)	9 (8)	
	PTS Multi-pilot other than Complex Ops	48.1 App 3	10 (8)	10 (8)	9 (8)	9 (8)	8 (7)	8 (7)	8 (7)	
	PTS - Single Pilot Ops	48.1 App 4	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	
	Balloon Ops	48.1 App 4A	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	6 or 10*	
	Med Transport Ops & Emg Service Ops	48.1 App 4B	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	11(9)+	
	Aerial Work Ops & Flt Trng Assoc with Aerial Works	48.1 App 5	10	10	10	10	10	10	10	
	Daylight Aerial Works Ops & Flt Trng Assoc with Aerial Works	48.1 App 5A	11	11	11	11	11	11	11	
	Flying Training	48.1 App 6	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	8 (7)	

Notes

1. Flight training (Appendix 6) is largely aligned with single pilot transport operations (Appendix 4), with generally 1-2 less hours of flight time allowed per FDP. This would seem appropriate given the likelihood of multiple students with associated briefings and debriefings within a given flight training FDP. The exception to this is flight training operations between 2300 and 0459, which are identical to single pilot ops.
2. Single pilot medical transport and emergency service operations (Appendix 4B) have single pilot limits which are 1-2 hours longer than single pilot transport or flight training operations. The basis for this disparity in what are arguably more complex and demanding ops (i.e., emergency service operations) is not immediately clear.
3. The reason for allowing single pilot medical transport operations to be 1-2 hours longer than single pilot transport ops is also not clear, given the similarity in pilot demands.
4. Single pilot aerial operation FDP limits (Appendix 5A) are similarly 1-2 hours longer than flight training or single pilot transport operations. The FDP limits for single pilot operations under Appendix 5A and Appendix 4B (medical transport and emergency service operations) are identical, however it is noted that there are no flight time limits under Appendix 5A - there are only FDP limits.
5. The basis for the disparity in the limits between single pilot transport operations and single pilot aerial operations (which are arguably far more demanding and risky), is not evident. If the underlying reason for the differences in these limits is purely public risk rather than fatigue science, then perhaps this needs to be explained in the CAO. If public risk is the underlying determinant, then why are flight training limits so low, given the relatively low level of public risk involved?
6. Under the requirements for switching between Appendices, conducting flight training during the same FDP for aerial operations does not affect the FDP limits, however this is not the case with the other Appendices. By switching between Appendices, a pilot could conceivably work a full FDP on flight training, and then conduct another 2-3 hours of 2 pilot transport operations or 2 pilot emergency medical operations. This may not be the intention, but it appears to be acceptable under the rule. If a FCM has not breached their acceptable fatigue limit after the full FDP of flight training, allowing them to continue with other flying, why is the limit so restrictive for flight training?

As expressed in the notes accompanying Table 5, the comparisons highlight a number of anomalies amongst the various single pilot operations covered in other CAO 48.1 Appendices. For example, single pilot operations under Appendix 4B (*Medical Transport and Emergency Services*) and Appendix 5A operations (*Aerial Operations*) have single pilot FDP limits which are 1-2 hours longer than Appendix 4 (*Single Pilot Transport Operations*), or Appendix 6 (*Flying Training*). Given that Aerial Operations, Emergency Services Operations, and possibly Medical Transport Operations, are likely to be frequently more complex and demanding than regular Single Pilot Transport Operations, the reason for the extra FDP allowance for these operations is unclear. The trade-off between fatigue science best practice and public risk in these operations, which creates these disparities, has not been adequately explained in CAO 48.1 or CAAP 48-1.

Switching between Appendices within FDP's (discussed further in Section 3.6 below), or between FDP's, can also be complicated at times, however it is recognised that operations under multiple Appendices may be necessary for some operators. Anomalies, which would limit a pilot conducting flight training to a certain FDP, but then allow them to carry on for perhaps three hours in air transport operations, generate questions about the fatigue science underpinning these FDP limits. Simplifying fatigue limits across multiple appendices, or allowing minor variations to FDP limits in exceptional circumstances, where fatigue risk is specifically mitigated, would provide greater transparency and ease of use.

Finding

The Review Team finds that the prescriptive limits in some areas of CAO 48.1 are conservative when compared to corresponding provisions in other international jurisdictions. Appendix 2 operations are comparable with other international operations, and not necessarily specific to Australia, so the FDP limits seem inconsistent with other 'science based' limits. Table 4 above illustrates the comparative limits and indicates where the conservatism is most prevalent.

There are also disparities in single-pilot FDP's across several appendices. The reason for these, which in some cases allow longer FDP limits for more complex operations, is unclear. Adding an explanatory note to CAAP 48-1 which outlines the relationship between operating risk, public risk, and fatigue management, and which provides some clarity for the reasons behind disparities between FDP limits in single pilot operations, across Appendices 4, 4B, 5A, and 6, would be beneficial for operators seeking to better understand the FDP limits.

Recommendation 3

That, notwithstanding any challenges the Australian operating environment may present, CASA adopts prescriptive FDP limits that are more closely aligned with international averages for similar types of operation.

2.7 Comparison with other industries and domains

As a further benchmarking analysis, the Review Team compared CASA's philosophy and approach to fatigue regulation with that of other Australian transport regulators (maritime, road and rail), and with that used in other safety critical industries including oil and gas, mining, nuclear, and transport more globally.

It was concluded that meaningful or informative comparisons cannot be made between the way aviation and other industries regulate (or choose not to regulate) hours of work and rest, and fatigue management. This is due to the very different nature of the work roles, demands and environments in these industries, and the diverse safety risk profiles involved. It is clear however that the aviation industry, across the board, is conservative when similar crew structures are compared side by side with what is permitted in the other industries examined.

2.8 Compliance with DAS Directive 01/2015

A number of stakeholders expressed concern to the Independent Review that, in their view, CAO 48.1 is not compliant with DAS Directive 01/2015 (Civil Aviation Safety Authority, 2016a). Specifically, they believe that CAO 48.1 does not meet the requirements for aviation regulations to be “necessary”, to be developed to address known or likely safety risks, and to address safety risks in the most cost-effective manner.

The Independent Review found that it was problematic, if not impossible, to formally evaluate CAO 48.1 against the principles of DAS Directive 01/2015, individually or in combination. The reasons for this include:

- Many of the criteria themselves are mutually exclusive. It is unlikely, for example, that safety risk exposures can always be addressed without some cost to the industry. While it may suit individual stakeholders to prioritise one of these criteria elements at the expense of others, the challenge is in fact to evaluate whether the *tension* between these ‘competing goals’ is reasonable.
- A rational analysis of the impact of CAO 48.1 against some DAS Guiding Principles was beyond the scope of the current review. For example, independently validating industry calculations on the financial impact of proposed rule changes on even one medium sized operator would have been too complex and time-consuming to undertake in the time available for the review. In any case this is likely to be unnecessary. It is readily determinable that implementing a Fatigue Risk Management System (FRMS) will in most cases prove to be a significantly lower-cost option for an operator than complying with prescriptive limits in an Appendix (or a combination of Appendices). As a second example, conducting a formal assessment of expected reduction in risk was not practical for the Independent Review, given the absence of even basic benchmarking data for most parts of the aviation industry.
- The criterion relating to regulatory change being ‘necessary’ is also problematic. The Review Team does not believe that ‘necessity’ in the context of fatigue regulation can be determined objectively, and considers that alternative terminology may have been desirable for the creation of more practical Evaluation Criteria.

As the Evaluation Criteria were partially based on DAS Directive 01/2015 principles, similar issues to those noted above also limited the capacity of the Review Team to relate some findings and recommendations to specific Evaluation Criteria.

Finding

The Review Team finds that determining whether a given industry regulation or rule is necessary can be a matter of subjective interpretation. However, there is enough evidence to consider fatigue as a significant potential flight safety risk factor, and the remaining uncertainties must trigger a precautionary attitude and encourage constant regulatory attention to new scientific research and safety data. It is believed that CASA, along with most other aviation regulators globally, have demonstrated that a reform of current flight crew fatigue management regulations to reflect contemporary knowledge on human sleep requirements and the factors that influence fatigue is logical and desirable. In specific cases the compliance with a requirement may impose a cost on the industry, or parts of it.

The Review Team also noted a tendency in both written industry submissions on CAO 48.1 and in consultation interviews for concerned stakeholders to ‘cherry-pick’ from the DAS Directive Guiding Principles in support of their preferred position.

2.9 Basis for regulations in scientific principles and knowledge

As noted by CASA in support of the changes included in CAO 48.1: “The International Civil Aviation Organization (ICAO) requires that the State of the Operator establish regulations for the purpose of managing fatigue. These regulations shall be based upon scientific principles and knowledge, with the aim of ensuring that flight members are performing at an adequate level of alertness.” (Civil Aviation Safety Authority, 2015c). There is thus a reasonable expectation from industry that regulatory change in a specialised area such as fatigue will be ‘scientifically sound’, that is, consistent with the latest research and evidence from the domain of sleep science on fatigue causation, prevention and management.

There was a view strongly expressed by some parts of the industry that the science related to sleep, fatigue and FRMS in general must be comprehensive, conclusive and categorical. Those holding such views also indicated that if the scientific basis for CAO 48.1 could not fulfil all these criteria then it should be concluded that the proposed changes should not be considered “necessary”, “effective in reducing risk” or “cost effective”. The underlying presumption of such a view is that the available science is both clear and definitive. The alternative provided is that if the science is not conclusive then related regulation must not be “necessary”.

Finding

The reality is that fatigue science is very rarely definitive or conclusive, but this does not negate the need for sleep and fatigue factors to be managed. The reason for this is that the clear majority of available scientific evidence focuses on single variables of interest. Examples include the effect of time of the 24-hour day on sleep and fatigue, the effect of scheduled duty duration, or the number of sectors to be flown per duty day as an indicator of workload. In the real world, however, an individual’s fatigue is multi-determined – the outcome of many variables interacting in complex ways over extended periods of time. These interacting factors include, for example, early morning starts, worked multiple days in a row, with long duty days and multiple sectors per day, without useful opportunities to nap.

The available science is not sufficiently sophisticated to enable deep insights into such real-world combinations for a specific operator or populations of individual crew, however the science is very important, to help us understand critical fatigue factors in general terms. The present level of scientific knowledge cannot independently prescribe absolute limits for a single fatigue variable, however, because the multiple combinations and permutations of factors that impact on sleep, fatigue, recovery, etc., have not yet been studied in sufficient depth, and this position is unlikely to change in the near future. Moreover, even if precise scientific knowledge on the genesis of fatigue were available, it would still be necessary to definitively link specific levels of fatigue with induced flight safety risks. Hence it is certainly unrealistic to expect that the current level of scientific knowledge can prescribe specific limits in variables such as duty hours, rest periods or duty extensions. Any rules that sit inside regulation should be informed by science, but empirical real-world risk management (informed by data and learning), will also be necessary for the foreseeable future.

ICAO Doc 9966 (International Civil Aviation Organization, 2016, p. 4.3), suggests that specific rules will be based in science, but moderated by local fatigue-risk factors:

“Taking into consideration the associated risks, the State has to draw informed boundaries, designed to maintain an acceptable level of safety performance in the majority of situations across an industry sector. For example, research on the fatigue hazards associated with pilots on short-haul operations in a particular region may identify common fatigue-related hazards such as frequent early starts and high workload associated with multiple stops.”

(ICAO Doc 9966, Manual for the Oversight of Fatigue Management Approaches)

3 Industry concerns with CAO 48.1 requirements

3.1 Cost impact of CAO 48.1 compliance

Regional and small airline operators have expressed considerable concern regarding the cost and complexity of compliance with CAO 48.1. These concerns relate to cost increases to cover additional labour and allowances, IT changes, additional training, modifications to some current operations, and hiring consultants to assist with fatigue management planning. Some operators believe that the cost of compliance would make it impractical to operate their existing schedules.

In many cases, it can be expected that achievement of accreditation under Appendix 7 could allow for a relative reduction in costs compared to operating under another Appendix. However, this does assume more flexibility will be given for operators deemed capable to operate an FRMS under Appendix 7, and the exact process to achieve accreditation may be subject to further change.

The requirements for an FRMS under Appendix 7 are not directly scalable to the size of the operation. This means that smaller operators who may have a diverse operation and therefore choose to implement an FRMS as the best way to manage their fatigue risk, are obliged to implement the same requirements as major carriers. This has major implications for resources and cost.

Another source of complexity required for all operators applying for FRMS approval relates to CASA Form 817. The large number of items in Form 817 requiring detailed responses that are structured and intended to apply to a very large commercial RPT operator provide significant workload for other industry sectors (e.g., small aerial work or ballooning operators).

Some smaller operators also stated that the cost quoted by CASA for evaluation and approval of an operator's FRMS does not seem appropriate or scalable for various sizes of organisation.

Finding

The concern expressed by some elements of the Australian aviation industry about the cost of compliance with CAO 48.1 is palpable and, in some cases, appears to be justified. CASA's plans to transition most elements of the aviation industry to CAO 48.1 simultaneously may have led to the development of a system that was designed primarily to suit large RPT operators being imposed on other, less-well-resourced, elements of the aviation industry. While CASA has created a range of Appendices to cater for different types of aviation operations, some other elements of transition to CAO 48.1 appear not to be 'scalable' (able to be changed in size or scale) to meet the needs of different types and sizes of operation. This is evident in the complexity of CASA Form 817, which may be appropriate for large RPT operators, but is overly complex for smaller operations (see 3.2 below for further discussion on this issue).

3.2 Scalability of regulations to type of operation

The primary source of guidance for aviation safety regulators engaged in developing FRMS legislation is ICAO Doc 9966, originally entitled '*Fatigue Risk Management Systems: Manual for Regulators*' (International Civil Aviation Organization, 2011), subsequently updated to the current '*Manual for the Oversight of Fatigue Management Approaches*' (International Civil Aviation Organization, 2016) for the second edition in 2016.

In principle, the Doc 9966 Manual indicates that the detailed structure of an FRMS, and the specific ways in which it links to an operator's SMS, will vary due to a range of factors including organisation size, type and complexity of operation, the relative maturity of both the FRMS and the SMS, and the relative importance of fatigue risks.

However, the comprehensive information provided in Doc 9966 is strongly oriented toward large-scale RPT operations. The primary focus of the Manual includes considerations appropriate for long-haul and ULR passenger operations as well as long-haul cargo operations, rather than other industry sectors such as emergency medical services, aerial work operations, hot air ballooning operations and small charter businesses.

This large-scale RPT focus also extends to most of the information provided within CAO 48.1 Appendix 7, which specifies details relating to the development and operation of an FRMS, and related guidance and support materials. This may impose unnecessary complexity and compliance cost burden on smaller-scale non-RPT aviation operators.

Findings

The Review Team finds that the requirements of CAO 48.1 Appendix 7 are oriented strongly towards larger RPT operators and therefore have significant 'economy of scale' implications for smaller non-RPT operators, who may nonetheless have much to gain in potential safety benefits from implementing an FRMS as the best means of managing their fatigue-related risks. There is significant overlap between SMS and FRMS elements and processes, and requiring two separate programs which are then integrated, involves unnecessary duplication and resource requirements, especially for small operators.

Different types of operations may reasonably be associated with different target levels in safety performance, in relation to fatigue induced risk management. From a risk-based point of view there is merit in determining the needs for fatigue risk management among the high-consequence sectors of the industry. However, if the complexity and resources required for implementing and managing FRMS in large-scale international operations are driven down to become mandatory requirements for all industry segments for which FRMS is suitable, then FRMS may unintentionally become a distraction and possibly even a risk consideration for smaller operators without the scaling down of requirements.

It is recommended that the criteria proposed to distinguish CASR Part 121 'large aeroplane' operators (more than 9 passenger seats / MTOW exceeding 8,618 kg) could be applied to determine eligibility for Tier 1 and Tier 2 FRMS requirements, with Tier 1 requirements to apply to any CASR Part 121 passenger or cargo transport operator. For further details see: <https://www.casa.gov.au/standard-page/casr-part-121-commercial-air-transport-operations-aeroplanes>

Recommendation 4

That CASA creates at least two risk-based tiers of FRMS requirements (to be reflected in FRMS application/assessment materials such as Form 817), with the highest level of FRMS requirements to be applied to Part 121 passenger and cargo transport operations.

3.3 Prescriptive tone of CAO 48.1

DAS Directive 01/2015 (Civil Aviation Safety Authority, 2016a) indicates particular priorities in the way regulation is developed: *"Where it is appropriate to do so, aviation safety regulations are to be drafted to specify safety outcomes. Where known or likely safety risks cannot be addressed effectively utilising an outcomes-based approach (in whole or part), more prescriptive requirements will be specified"*.

(DAS Directive 01/2015)

Numerous operators at various levels of the industry have expressed concern at the prescriptive content of CAO 48.1, including some elements of Appendix 7, and related guidance documentation, which they believe to be inconsistent with an 'outcomes-based' approach to

regulation. One large RPT operator made the point that if Appendix 7 does not allow mature operators to be flexible in their approach to identifying and managing risk, it fails in its intended purpose.

Finding

While CAO 48.1 Appendix 7 is closely aligned with ICAO requirements (International Civil Aviation Organisation, 2013, 2016) the Review Team concurs that Appendix 7 presents as a highly prescriptive approach to the specification of requirements. Given that many operators are already required to manage fatigue-related risk under their safety management system (SMS), using an outcomes-based risk management approach, the high level of prescription appears unwarranted. The overarching goal of each FRMS is to mitigate the risk to flight safety imposed by fatigue. To have overly prescriptive rules for such a wide range of activities within Australian aviation operations could be both counterproductive, and unnecessary.

Recommendation 5

That CASA reduces the level of prescription in CAO 48.1 Appendix 7 to align more closely with an outcomes-based regulatory philosophy.

3.4 Consistency and appropriateness of language in support documentation

Some operators identified a related concern about the use of overly prescriptive language in 'guidance' material provided to industry and to CASA staff, including FOI's. For example, there is a widely-held belief that terms being used in CAAP 48-1 such as 'must', 'shall' and 'is required to' are likely to become *de facto* requirements, regardless of the size, scale, complexity or risk exposures of the operator.

Stakeholders also expressed the belief that CAAP 48-1 and CASA Form 817 include several requirements that are over and above those specified in CAO 48.1. The concern is that in the absence of a Manual of Standards for CAO 48.1, the CAAP and Form 817 will become the *de facto* standard, with the potential that operators will be held to different standards by different CASA offices and personnel.

As a general principle, it is also considered problematic for a regulator to create a requirement for anything that is not verifiable. For example, there is reference in CAO 48.1 to 'sleep opportunity' defined as: "a period of time during an off-duty period when an FCM: (a) is not meeting the reasonable requirements of bodily functioning such as eating, drinking, toileting, washing and dressing; and (b) has access to suitable sleeping accommodation without, under normal circumstances, being interrupted by any requirement of the AOC holder. There are then requirements related to this, such as the following example from CAO 48.1 Appendix 1:

"1 Sleep opportunity before an FDP

1.1 An FCM must not be assigned or commence an FDP commencing away from home base unless, within the 10 hours immediately before commencing the FDP, he or she has at least 8 consecutive hours' sleep opportunity."

(Civil Aviation Safety Authority, 2017a)

Sleep may not be available for reasons other than those noted, including because of parenting responsibilities or engaging in hobbies. Also, measuring and especially verifying when actual sleep opportunity occurred is, for all intents and purposes, not possible. This is true in the case of audit, safety investigation, or for any other reason. Furthermore, what might be a theoretical

sleep opportunity on one day could be very different on a subsequent day, due to factors such as traffic during a commute or a breakdown, which makes attempting to regulate such a concept effectively impossible. Off-duty periods, on the other hand, can be recorded and verified, and it is such metrics that can reasonably be factored in to regulation. Sleep opportunity periods could be included as a guideline but are not a verifiable requirement.

In another example, CAO 48.1 specifies requirements for sleeping accommodation that are very subjective and therefore open to interpretation. Descriptors such as 'a bed is comfortable' or 'low occurrence of random noise' are impossible to measure objectively and therefore to objectively audit or enforce.

Finding

Some of the language used throughout CAO 48.1, including Appendix 7, and associated guidance documentation (e.g., an operator 'must', 'shall' and 'is required to'), blurs the line between legal requirements and what might be acceptable alternate means of compliance (AMOC) for an operator. This applies to the CAO 48.1 Instrument and associated supporting documentation, including the CAAP 48-01 (Civil Aviation Safety Authority, 2017d), which is intended to provide guidance to operators, and the CASA FRMS Handbook (Civil Aviation Safety Authority, 2013c), which is intended to provide guidance for CASA officers. This is likely to create unnecessary confusion, complexity, and potentially conflict, in CAO 48.1 implementation and audit processes.

Regulatory requirements should be clearly stated using imperative terms such as 'must', 'shall' and 'required'. Where it is appropriate to repeat regulatory requirements in supporting documentation (e.g. Form 817), imperative terms can again be used. However, guidance material contained in supporting documents must be clearly distinguished from requirements, and indicated as such by the use of non-imperative terms. The Review Team also finds the wording used in parts of CAO 48.1 and CAAP 48-1 subjective and therefore ambiguous and unhelpful in establishing standards.

Recommendation 6

That CASA modifies the tone and language used in CAO 48.1 and all supporting documentation to clearly distinguish between legal requirements and guidelines on acceptable means of compliance.

3.5 ULR operations

The prescriptive limits in Appendix 2 do not cater for Ultra long-range (ULR) operations, meaning that ULR operators must conduct these operations from within an approved FRMS. However, Appendix 7 has no specific detail about ULR operations, particularly with respect to in-flight rest provisions or requirements. There are currently significant variations on crew rest facilities amongst aircraft types deployed on ULR operations and minimum standards of rest facilities for these operations are not currently detailed in CAO 48.1.

Finding

With Australian RPT operators conducting, or about to conduct, flights of over 17 hours' duration, and with the prospect of even longer non-stop flights mooted publicly, one area where CASA could be more explicit is in providing guidance on the minimum standards of in-flight rest facilities for ULR operations. For example, stating that flights exceeding 12 hours require lie-flat bunk rest facilities (Class 1), or that a lie-flat bunk and access to a reclinable seat (Class 3) is required for each resting crew member for operations over 16 hours, could standardise ULR rest

facility requirements for the industry. Making a reclinable seat available to crew members as well as a lie-flat bunk on ULR flights, would alleviate the need for crew members to 'have to' use a limited space bunk for rest, beyond the time that they would generally be asleep during rest breaks. This may be of some use for operators new to ULR, or existing ULR operators who are significantly extending their flight durations from current operations.

While ULR fatigue management under Appendix 7 FRMS rules should be outcome-focussed, CASA could provide some guidance for ULR in-flight crew rest facilities. Such guidance could be incorporated into a revised CAAP or in other guidance material.

3.6 Switching between Appendices during a single FDP

Industry feedback indicates that the requirements of CAO 48.1 make it complex to switch crew between Appendices during a single duty period.

Where an FRMS is available, then ideally it should cover all available operations, eliminating the need for operators to switch to another Appendix during a single FDP. While CAO 48.1 allows operators to switch between Appendices, and there may be some operators who would benefit from this, it does add complexity to the issue of adequately addressing operational fatigue risks.

Finding

The Review Team finds that there are complications associated with switching between Appendices, particularly where operators choose to utilise an FRMS but still operate within an Appendix as well. Complications include both human (e.g., making rules clear for FCMs to comply with) and technical (e.g., customising rostering software to allow for maintenance of compliance to multiple rule sets simultaneously).

If Recommendation 2 is accepted, and some limited dispensations are allowed under specific circumstances, through a standardised approval process, then the complexities of switching between Appendices are likely to be simplified for some operators. Nonetheless, any allowances given by CASA to provide limited dispensations should be applied judiciously and it is likely that some operators will still decide or need to switch between Appendices. In that case, the following Recommendation remains a relevant consideration.

Recommendation 7

That CASA considers limiting an operator's ability to switch between Appendices during a single FDP. Where multiple types of operations that would fall under different Appendices are required to be undertaken during a single FDP, the more restrictive limits should apply.

To assist operators, and particularly those undertaking operations under multiple appendices, or one-off operations, the limits across Appendices 2-6 could be varied by application for flexibility, as discussed above in Section 2.4, where an individual organisation could demonstrate to CASA that a specific fatigue management plan (FMP) was in place to address fatigue risks associated with that variation. This would not be a blanket exemption, but rather a means of facilitating specific instances where FDP limit extensions were considered operationally necessary and demonstrably risk-based.

3.7 Aerial application operations

Industry feedback from the aerial application sector suggests that the proposed limits under Appendix 5 of CAO 48.1 are unduly restrictive and would incur significant additional cost to the many operators involved. Several other international regulators (including Transport Canada, CAA NZ, EASA and the FAA) recognise the unique operating environment and characteristics of this sector and have, to date, elected to exclude it from significant fatigue management regulatory requirements or reforms. The Australian aerial application sector (fixed wing) currently operates under the less-restrictive flight duty time and rest provisions of Subpart 137.Q of CASR Part 137, governing aerial application operations other than rotorcraft.

Finding

The Review Team finds that the prescriptive limits applying to aerial application operations within CAO 48.1 are more restrictive than existing arrangements under CAO 48.0 and current exemptions. Other comparable international regulators have recognised that public risk from these types of operations is relatively limited, and have elected to defer or remove restrictive fatigue management limits. Given the sector risk profile (Civil Aviation Safety Authority, 2014c) the Review Team believes that inclusion of aerial application operations within CAO 48.1 may not be warranted. Exclusion would be consistent with the findings of the 2014 Aviation Safety Regulation Review Panel (Australian Government, 2014) regarding adjusting the level of safety oversight so that it is proportional and appropriate to the scope and risk of sector operations.

Recommendation 8

That CASA considers removing Part 137 aerial application operations from CAO 48.1 due to the sector's lower relative risk exposures. If it is deemed necessary to include restrictions for aerial application operators in CAO 48.1, CASA should consider increasing the flexibility of the relevant CAO 48.1 limits to align them with the current provisions of Subpart 137.Q.

3.8 Individual circumstances of flight crew members

Feedback from industry indicated that current references within CAO 48.1 and CAAP 48-1 (for example CAAP sections 5.2.7 to 5.2.9) require operators to make provision for the individual circumstances of each FCM, concurrently reducing the responsibility on FCMs for managing their own rest and mitigating fatigue. Of particular concern were the requirements for an operator to take into account a FCM's home address and living arrangements, and to consider these in determining flight and duty limitations. An operator's FRMS or FMP will in most cases allow a FCM to remove themselves from duty should they be fatigued for any reason, without consequences, which should be sufficient to address the intent of the above provisions.

Finding

The Review Team finds that the requirement for operators to make allowance for individual circumstances of FCMs is inappropriate and impractical for several reasons. These include the fact that it is unreasonable to hold operators accountable for crew lifestyle factors and circumstances outside of their control and on which they are unable to collect or monitor any data. The need for flight crew members to present themselves for work fully fit for duty, and to notify the operator and remove themselves from duty at any time if they consider they are not fit, remains a critical component of any holistic fatigue management process.

Recommendation 9

That CASA removes the requirement for operators to make allowance for individual circumstances when assigning work, given the existing requirement for flight crew members to commence flight duty periods fit for duty, and to notify the company if they consider themselves unfit for duty at any time.

3.9 Fatigue Management training

While CAO 48.1 and its associated advisory publication (CAAP 48-1) outline quite clearly the topics that would be expected under tier 2 and 3 Fatigue Management training, the SMS guidance on Non-Technical Skills (NTS) training [CAAP SMS-3(1)], defers to individual operators to develop their own content for CASA approval. Apart from those operators who elect to use Appendix 1 basic limits, tier 2 and 3 operators will be required to conduct both initial and recurrent fatigue management training, which would likely meet the requirements for initial and recurrent NTS fatigue training.

Finding

The Review Team finds that there is an opportunity to better integrate the requirements for Fatigue Management training and NTS training for tier 2 and tier 3 operators.

Recommendation 10

That CASA amends CAAP SMS-3(1) to link the content of NTS fatigue management training to the content required for operators under CAO 48.1. This would streamline and align the fatigue management and NTS training program outcomes.

3.10 Publishing of rosters in advance

CAO 48.1 requires operators to publish rosters for flight crew members sufficiently in advance that the flight crew members can plan their rest to accommodate work requirements. However, CAAP 48-1 (Section 3.6.3) suggests that the minimum notification period for rosters should be between 14 and 30 days for augmented duties that involve multiple time zones, include multiple late-night operations, or include split rest duties. Feedback from industry suggests the 14-day minimum period suggested is not workable in many operations.

Finding

The Review Team finds that the 14-day minimum period between publishing of rosters and roster commencement provided in CAAP 48-1, is unrealistic for real world airline and non-airline, operations.

Recommendation 11

That CASA amends CAAP 48-1 to reflect a more realistic publishing requirement for flight crew rosters. This could be achieved by reducing the guidance to a more realistic period, such as 7-10 days, noting that any other requirements included in current industrial agreements would still apply.

3.11 Duty extension

Concern was expressed by several organisations about the four-hour limit to duty extension, once an assigned duty has commenced, irrespective of the original duty period. The operators concerned challenged the scientific basis and validity of this limit.

Finding

CAO 48.1 Appendix 2 (Section 7) allows for duty reassignment and an FDP extension, once an assigned FDP has commenced, of up to 4 hours, regardless of the original FDP duration. This could limit an extension of a short FDP of say 2 hours, to just 6 hours, which has minimal fatigue implications for fully rested FCMs. By contrast, other international regulators have a less restrictive approach. EASA for example will allow extensions based on the time of FDP commencement time and the number of sectors, up to a maximum of 14 hours for day duties of 1-2 sectors. They do impose restrictions on night duties or multiple sector duties, which may prevent any extension in some cases.

The FAA recognises the need for FDP extensions and explicitly states that “it is unreasonable to limit extensions on FDP’s that are less than what the certificate holder can legally schedule” (Federal Aviation Administration, 2013). This is a less conservative approach than used in EASA, especially when worst-case scenarios are considered.

Recommendation 12

That CASA amends the Appendix 2 four-hour FDP extension limit to one which better reflects international standards for similar operations. An extension to FDP in accordance with sector numbers and time of day limitations, similar to the EASA limits, would be a more appropriate method of balancing operational flexibility with fatigue mitigation.

4 Communication and consultation

4.1 Communication and consultation obligations

The 2012 NPRM on CAO 48.1 (Civil Aviation Safety Authority, 2012) refers to CASA's obligations under the Civil Aviation Act 1988 on consulting and communicating with industry:

"CASA is responsible under the Civil Aviation Act 1988, amongst other functions, for developing and promulgating appropriate, clear and concise aviation safety standards.

In the performance of this function and the exercise of its powers, CASA must, where appropriate, consult with government, commercial, industrial, consumer and other relevant bodies and organisations."

(Civil Aviation Act 1988 Paragraph 9(1)(c) and Section 16:
Australian Government, 2016).

DAS Directive 01/2015 restates this requirement as a Guiding Principle in the development of aviation safety regulations:

"CASA must consult appropriately with industry in an open and transparent manner ensuring that all communication is clear, timely and effective".

The expectation for CAO 48.1 was that "the consultation process will allow CASA to 'fine tune' the standards to ensure a positive safety outcome, whilst also being confident it meets the needs of industry within the legislative safety framework."

(NPRM 1202OS, Section 3.1.3)

Review of the subsequent consultation and feedback process to refine and finalise CAO 48.1 shows that industry pushback was far greater than anticipated, and that more than 'fine tuning' was required to satisfy the concerns of industry stakeholders before the new regulations could be finalised. The process of amending the proposed legislation to incorporate industry feedback not only delayed the implementation date, but created a considerable administrative burden to record, process and respond to a deluge of submissions from industry on the draft legislation and associated documentation. Comment on CASA's management of this unanticipated workload is made below under 'CASA response to feedback, and 'Document management'.

Finding

Regarding CASA's general approach to designing and initially communicating the new fatigue regulations, the Independent Review concluded that CASA acted in accordance with its charter under the *Civil Aviation Act 1988* by consulting with 'commercial, industrial, consumer and other relevant bodies and organisations' during the development of CAO 48.1. Both before and after NFRM was promulgated in April 2013 (Civil Aviation Safety Authority, 2013a), CASA undertook a variety of communication and consultation endeavours to support the industry's transition to the new fatigue rules. These activities included conducting workshops, working group discussions, targeted meetings, direct contact with particular operators and industry bodies, and publication of feedback summaries and numerous useful guidance documents (see, for example, Civil Aviation Safety Authority, 2014b, 2015c, 2015d, 2016c, 2016e, 2016f).

Early stakeholder feedback (including an online survey conducted after NPRM 1202OS) was critical of CASA's consultation processes. More recent feedback following the 2016 Industry Fatigue Workshops was mostly positive, suggesting ongoing consultation and communication strategies have been largely successful in repairing early communication failures and preparing

the industry for CAO 48.1 implementation. As a counter-point, however, the time it has taken CASA to complete the CAO 48.1 development and implementation is frustrating for many.

Some lingering concerns were expressed however during several Independent Review Team stakeholder consultation meetings with industry. Some operators expressed disappointment and concern that they had not been invited to participate in the initial industry consultation on the development of CAO 48.1, conducted through an Industry Consultation Workshop. A view was expressed that selection of participants for this workshop may have been biased towards industrial organisations rather than all operators / peak bodies.

The Review Team is aware that CASA formed the Aviation Safety Advisory Panel (ASAP) in mid-2017 to fulfil the role of “the primary advisory body through which CASA directs its engagement with industry and seeks input on current and future regulatory and associated policy approaches” (<https://www.casa.gov.au/rules-and-regulations/standard-page/aviation-safety-advisory-panel>). More specifically, the ASAP will:

“provide the CEO/Director of Aviation Safety (DAS) with informed, objective high-level advice from the aviation community on current, emerging and potential issues that have, or may have, significant implications for aviation safety and the way the Civil Aviation Safety Authority (CASA) performs its functions”, and operate as “the primary advisory body through which CASA will direct its engagement with industry and seek input on current and future regulatory and associated policy approaches”

(Civil Aviation Safety Authority, 2017f)

The ASAP has scope under its Terms of Reference to establish Technical Working Groups to advise CASA on specific issues or subjects within an industry sector. The Review suggests that it may be advantageous to establish a Technical Working Group on Fatigue Risk Management, with the objectives, *inter alia*, of developing a strategy and priorities for aviation fatigue research, and advising CASA on future data-driven policy development.

4.2 Communication strategy

In 2016 CASA ran a series of Fatigue Workshops to support industry transition to the new fatigue rules. This national ‘roadshow’, titled “*Fatigue Workshops: Putting the new rules into practice*”, reached 268 participants representing 163 organisations.

A survey of participants was conducted as part of the workshops, to measure current industry perceptions about the workshops themselves, and also about industry’s understanding about the rules, and their readiness to implement them. Feedback (from 73% of participants) was considerably more positive than that that obtained in response to the NPRM 2012. For example:

- The workshops increased participant knowledge of the new fatigue rules, from fair (45%) or good (25%) before the workshop, to 80% ‘good’ to ‘very good’ after the workshop.
- Most participants reported that Information and resources provided at the industry workshops were “good or very good” (88%) and useful (85%).
- Comments in response to open-ended questions (discussed further below) indicated that the workshops were informative, well-structured and well facilitated, and that participants appreciated the quality of resources provided.
- Almost all participants (96%) indicated that their organisation would attend similar CASA industry workshops in the future, and recommend this communication format to others.

Finding

As many participants in the workshops indicated in their survey responses, the roadshow strategy, at the right time and facilitated by people with the required subject matter expertise, would appear to be a useful template for future communication campaigns by CASA on regulatory change. It is critical, however, that any workshop / roadshow activity be carried out to support a formally documented process to deal systematically and transparently with feedback. For any issue formally submitted there would need to be documentation of the issue, with the submitter de-identified as required, and for public visibility of the treatment of each item (e.g. considered or not considered, and the reason(s) why it did or did not lead to any change) (See Section 4.3 below for further discussion on this issue).

4.3 CASA response to industry feedback

On the issue of industry feedback, NPRM 1202OS stated that “CASA is required to register each comment and submission received, but will not individually acknowledge a response unless specifically requested. However, the names of contributors will be published in the subsequent NFRM, except where CASA is specifically requested not to do so.” (NPRM 1202OS, p. 6.)

Comments received in response to the NPRM 1202OS issued on 1 May 2012 were formally analysed by CASA and published as Annex A to the NPRM – “*Consolidated Summary of Comments received, CASA’s Response and Disposition Actions to NPRM 1202OS*”. This document set out some 230 items summarising stakeholder feedback by topic area, suggested wording changes or definition clarifications, and general concerns about the impact of the proposed changes. These items are reported as a summary of the feedback, CASA’s responses address each issue raised, and ‘*Disposition Actions*’ to indicate whether amendments were made, or other action taken, or not taken, in response to the feedback.

The Independent Review found that this process adopted by CASA to manage and respond to industry feedback on NPRM 2012OS was initially structured and sound. Comments were logged and consolidated into discrete topics, and CASA’s views on each disposition documented (Annex A to NFRM, 2013). This process provided a transparent link between the comments provided and the changes made to CAO 48.1, and a tangible audit trail that allows CASA’s decisions to be independently validated. This is a good example of how formal feedback submission and consideration processes can be done well.

The rigour of this process did not continue on subsequent iterations of industry feedback. Further proposed changes were listed in Consultation Drafts in August 2015 and March 2016, but not documented systematically or linked individually to preceding feedback. Some feedback received in response to Consultation Draft 2 between April and May 2016 has been responded to by CASA in email correspondence, but it does not appear to have been acknowledged in all cases, and it is not clear what action, if any, was taken in response.

Several operators expressed similar concerns over the lack of communication and response to organisations that had taken the trouble to compile detailed submissions on consultation drafts of CAAP 48-1(2) and CAO 48.1 submitted in 2016. Another submission from industry indicated that the author had presented CASA with a proposal for a much easier and simplified flight and duty system on behalf of their industry sector, purportedly based on recognised international standards used worldwide. It was stated that no response was ever received from CASA.

Finding

Email and other industry submissions on CASA publications (NPRM, NFRM, CD’s etc.) were not always provided to the Review Team in an organised or helpful way. Different emails were saved under the same file name, making it difficult to track and trace these communications from

industry stakeholders. Attached documents were not re-saved with file names identifying the subject, date or author / organisation. Simple changes to the process for accepting and naming such documents would reduce the risk that emails are lost or duplicated, the content neglected, or an appropriate response not provided.

CASA's internal processes for dealing with multiple iterations of industry feedback did not always provide a transparent link between the comments submitted and the changes subsequently made to CAO 48.1. Initially, CASA managed and responded to industry feedback on NPRM 2012OS in a structured, comprehensive and transparent way. The outcome of industry submissions received by CASA on two CAO 48.1 Consultation Drafts (August 2015 and March 2016) was not transparent or traceable however, due to the absence of documentation showing how, or in fact whether, this feedback was considered, responded to and/or translated into subsequent amendments.

Even though the feedback management process may have been put on hold when the Independent Fatigue Review was commissioned, this intervention would not appear to absolve CASA of its responsibility to acknowledge submissions from industry and explain why a formal response may be delayed.

Recommendation 13

That CASA implements a rigorous, 'error tolerant' process for formally logging, recording and responding to industry submissions in a systematic and transparent way.

4.4 Regulation development process

In hindsight, the quantum of feedback on CAO 48.1 over multiple iterations of the legislation indicates shortcomings in the way the new fatigue rules were initially designed and tested with industry. Substantial changes were made in response to industry feedback on NPRM 1210OS, and two subsequent Consultation Drafts (Annex E to NFRM 1202OS, Regulation Impact Statement (RIS) – Review and Amendment of Flight Crew Fatigue Regulations, March 2013; and Annex B to CD1510OS – Proposed changes to CAO 48.1 Instrument 2013, undated). While these amendments, some cosmetic and some quite substantial, show flexibility on CASA's part, they also indicate that the proposed rules did not undergo sufficient 'beta testing' prior to publication of the NPRM.

Recommendation 14

That for future complex, industry-wide regulatory change, CASA considers 'road-testing' the proposed changes in a collaborative 'desk-top' exercise with a representative sample of operators, to identify critical stumbling blocks, before formal implementation of the legislation and industry-wide roll-out.

4.5 Consistency in communication with industry

Concern was expressed across various industry sectors about the potential for a lack of standardisation and substantial regional variability in the evaluation of applications and oversight of FRMS between regional CASA offices. Examples were cited of cases where operators in different locations had submitted virtually identical documentation for FRMS approval, with one application being accepted and one being rejected. Anecdotal evidence of regional variation in relation to other previous regulatory reform processes was also widely cited.

Regarding CAO 48.1, one operator reported considerable frustration as a result of inconsistent messages from CASA about their airline's suitability to implement an FRMS. While the operator was initially told that "there were only two airlines in Australia that were large enough and mature enough to have an FRMS", this advice was amended by 2016, when they were strongly encouraged towards adopting an FRMS. They are now on track to do this, but at some cost due to the earlier misdirection.

Other organisations expressed concern that CASA's education processes on FRMS needed "urgent improvement", as they believed there were currently some gross misunderstandings and misinterpretations of the intent of CAO 48.1 within various sectors of industry, including within CASA itself.

Recommendation 15

That as part of the regulatory package development process, CASA develops in-house training, guidelines and communication protocols to ensure that CASA staff supporting the implementation of new regulations are all 'on the same page' when advising industry.

A number of related concerns were reported about the quality and accessibility of information from CASA on implementing an FRMS. Some operators observed that the CAAP does not provide any guidance on the use of Appendix 7, creating a risk that operators who opt to implement an FRMS as per Appendix 7 may have elements of Appendix 2 or the CAAP also imposed upon them. It was also noted that there is no clear, single point of contact for FRMS related queries, increasing the risk of inconsistent or incomplete advice (as noted above).

As another example, one operator was advised by CASA that training would be required for their FRMS Manager, but CASA was unable, at the time, to provide further advice on what this training might involve.

One solution that could address many of the above issues is the creation of a centralised cell of fatigue management and FRMS expertise to ensure standardisation of the evaluation of applications for FRMS and the subsequent calibration and standardisation of FRMS oversight.

Finding

The Review Team finds that the threat of regional variation to the standardised evaluation and oversight of FRMS applications is evident and believes that centralisation of these processes would assist in standardising information content and harmonising FRMS evaluation and oversight processes to mitigate this threat.

Recommendation 16

That CASA establishes a single point of contact for industry seeking advice on FRMS, to ensure that accurate, timely, complete and consistent information is provided. To accomplish this, CASA should consider the creation of a centralised (perhaps 'virtual') cell of fatigue management and FRMS expertise to ensure standardisation of the evaluation of applications for FRMS and the subsequent calibration and standardisation of FRMS oversight.

4.6 Document management

Numerous CASA documents were examined as an integral part of the review. This process identified frequent anomalies associated with CASA's document design and management. Examples include:

- Key documents relating to the implementation of CAO 48.1 not being labelled in a way that makes them easily identified and recalled. While filenames such as "1202os.pdf" and "cd1510os-2-annexa.pdf" may be easily recognised by the authors, they are not as readily discerned by other readers amongst the plethora of documents now promulgated around the implementation of CAO 48.1. In an area of complex rules and regulations, improved document identification and usability would be helpful.
- Similar documents are not titled or annotated consistently, and sometimes lack helpful detail. For example, some documents exist independently and as an Appendix version, some Appendix documents do not indicate the primary document with which they are linked, some documents are not dated, some documents do not indicate the intended audience / purpose of the document, and some do not contain a table of contents. Standardisation of these features would greatly improve usability and reduce confusion.

Finding

CASA documents related to CAO 48.1 were found to have inconsistent formatting, and unclear / unhelpful labelling, making it difficult in some cases to understand their purpose and relationship to other documents.

Recommendation 17

That CASA implements a process which utilises standard templates to produce documents that are clearly identifiable, and presented in a consistent, 'user-friendly' format. Such documents would then be more easily stored and managed, creating a logical trail for future reference.

4.7 Applicable version of CAO 48.1

The identification of current or "in force" versions of CAO 48.1 and associated publications on the CASA website was found to lack clarity and create confusion. This is apparent from feedback received during recent industry consultation, where considerable confusion was reported over which document/s represented the currently applicable version/s of CAO 48.1. While the CASA website includes some explanation of this, it is not evident which documents / versions are currently applicable. Industry feedback also noted the problem of having to work with unincorporated amendments, and raised concerns about the complexity and difficulty of having to refer to multiple documents to attempt to fully comprehend the CAO 48.1 rule set. Ideally, the CASA website would provide a clear path for each defined sector rather than a single page of all documents that may or may not be relevant to some sectors.

Recommendation 18

That CASA provides clearer guidance (on the website and elsewhere as necessary) on the current status of, and relationship between all CAO 48.1 documentation.

5 CAO 48.1 implementation issues

5.1 CAO 48.1 implementation strategy

Given the various issues related to resources, knowledge, training, industry consultation, communication and implementation noted by industry during consultation, a sophisticated and highly coordinated implementation strategy for transition to CAO 48.1 is considered essential.

Finding

It is vital for CASA to plan and prepare for CAO 48.1 implementation effectively and get the roll-out strategy right. At a minimum, this is likely to include:

- the provision of more appropriate and more sufficient staff resources;
- the acquisition or development of greater Fatigue Management and FRMS knowledge and expertise within CASA;
- the provision of enhanced Fatigue Management and FRMS awareness training for both the industry and relevant CASA staff;
- the development of a strategy and processes for standardisation of the evaluation and oversight of FRMS applications and operations;
- improved internal and external stakeholder communications regarding all aspects of CAO 48.1 transition; and
- an evaluation process through which CASA can critically assess the outcomes and effectiveness of CAO 48.1 (including any adverse unintended consequences) at appropriate intervals post-implementation.

Recommendation 19

That CASA allocates appropriate resources to the planning of a detailed, coordinated CAO 48.1 implementation strategy, as a matter of priority.

5.2 Instability of CAO 48.1 content and transition dates

Concern was frequently expressed by industry about the lack of stability of CAO 48.1 and the effect that this would have on the long lead-time required for operators to transition. These factors create considerable cost and delay associated with spooling up for an FRMS (e.g., to engage and accurately task software developers, modify complex rostering systems, etc).

This issue is noteworthy given that CASA has been encouraging “early adopters” to transition to an FRMS, when the current provisions and requirements of CAO 48.1 may be subject to change. Specific concerns include any concessions provided to early adopters, along with any disadvantages that may be facing early adopters if CASA implements significant changes. (Any major changes have the potential to attract significant flow-on costs with software providers, etc.)

Concern was also widely expressed that the current industry transition dates are unrealistic given the timeframe of reporting for the Independent Review.

Finding

The Independent Review Team finds that the instability of the CAO 48.1 Instrument and associated documentation and the numerous changes to application and transition dates have provided considerable uncertainty and inconvenience for industry.

The current transition dates are not feasible and should be discarded, with future changes to transition dates frozen until the Instrument is stabilised and ready for implementation. The strategy of encouraging “early adopters” to transition to an FRMS should also be abandoned until the instrument and all associated documentation is stabilised.

Recommendation 20

That CASA freezes CAO 48.1 transition dates for all elements of the aviation industry until recommended changes resulting from the current Review can be made to stabilise a final version of CAO 48.1 and all associated supporting documentation for implementation.

Note: In February 2018 CASA formally amended CAO 48.1 to remove the April 2018 submission deadline or air operators and Part 141 certificate holders to submit draft operations manual changes or apply for a fatigue risk management system (FRMS) in preparation for transition. They announced that future submission and transition dates will be determined and announced following consideration of the findings and recommendations of the current review.

5.3 Staggered transition

With publication of the 2012 NPRM on Fatigue management for flight crew members (Civil Aviation Safety Authority, 2012) and the subsequent versions of CAO 48.1 (including Civil Aviation Safety Authority, 2013; 2017a; 2017b), CASA embarked on an ambitious plan to simultaneously transition most elements of the Australian aviation industry to new fatigue management regulations and rules. While many other aviation regulators around the world have embarked on similar “science-based” updates to fatigue management regulation in recent years, most other jurisdictions (including Canada, EASA, the FAA), have opted for some form of staggered implementation or transition to new fatigue rules.

Given CASA’s current limited capability in this area, exemplified by low fatigue management expertise and resource levels, and the broad diversity and characteristics of the Australian aviation industry, the present approach is very ambitious and is considered unlikely to be achieved efficiently. During industry consultation, suggestions were made that some form of staggered implementation may be advantageous to both the industry and CASA.

Finding

The Review Team finds that CASA’s plan to transition most elements of the Australian aviation industry to CAO 48.1 concurrently is highly ambitious and not workable, particularly given the low current fatigue management capability noted above. It is believed that adoption of a risk-based staggered transition across the industry will allow for a more orderly transition and more sustainable regulatory assessment and oversight.

Recommendation 21

That CASA adopts a staggered approach to the implementation of and transition to CAO 48.1, with initial transition proceeding first for elements of the industry with the highest risk exposure.

5.4 CASA Fatigue Management resources

Various elements of the Australian aviation industry expressed doubts about whether CASA currently has the available resources, expertise and capability to efficiently evaluate numerous simultaneous applications for FRMS, and following that to effectively oversee and mentor operators that opt to establish an FRMS.

Finding

The Independent Review Team has identified that CASA does not currently possess the capability required to effectively and concurrently evaluate and oversee a large number of operators transitioning to FRMS. This situation could be eased somewhat by introducing initiatives noted in this report, such as staggered implementation and reducing some of the Appendix 7 application requirements for smaller operators.

However, there are still resource shortfalls that need to be addressed by initiating action to acquire and/or develop additional fatigue management / FRMS resources. These resources could include additions to and/or the development of existing CASA staff with the objective of enhancing FRMS knowledge and capability. In addition, there is a need to invest in improving the package of templates and resources available for industry, CASA FRMS application reviewers and other critical stakeholders.

For example, as noted above, there is a need for at least two versions of the current Form 817, to allow smaller operators to build a system appropriate and relevant to their risk profile and operational circumstances. In addition, a standardised set of templates, procedures and communications/reports need to be built to support anyone involved in industry-facing roles related to reviewing FRMS applications. Once all the required resources are in place there is also a need to train internal staff so that their roles can be completed in a way that is consistent with the legislation and documentation, and, very importantly, consistent with each other. Some of the resources needed could be hired or contracted in, such as for building templates and conducting training. Other resources, such as suitably skilled reviewers for FRMS applications, will be required longer-term.

Recommendation 22

That CASA initiates action to acquire and / or develop a significantly increased capability for FRMS evaluation and oversight. This action should be linked with the development of clear system / documentation outcomes, including timelines, and determining the particular skills required.

5.5 CASA's capacity to oversee ongoing FRMS improvements

Elements of industry with some experience in FMS / FRMS implementation raised concerns over CASA's capacity to oversee changes to an operator's FRMS (as required under CAO 48.1, Appendix 7, Section 7) in an efficient and timely manner. Concerns focussed on interpretation of the requirement for an AOC holder to obtain the written permission of CASA before making amendments to their FRMS, which may also be in contradiction of other FRMS requirements. Doubts were expressed as to whether CASA currently has the resources and capacity to review and approve all necessary changes in a timely manner to ensure that operators can maintain effective controls within their operations and provide for the continuous improvement of their FRMS.

Finding

The Review Team finds that CASA does not currently, and may not in future, have the resources to be able to expeditiously evaluate every change to each operator's FRMS. Mature FRMS operators have a goal to continuously improve their FRMS, using data-driven approaches, and CASA's requirements as referenced above appear to again represent a highly prescriptive approach, which may impede the efficient conduct and improvement of an FRMS.

Recommendation 23

That CASA reviews the content and language used in CAO 48.1, Appendix 7, Section 7 to ensure that it allows operators sufficient autonomy to be able to manage and improve their FRMS efficiently.

5.6 Visibility of FRMS assessment processes

It is apparent that industry needs greater visibility of the processes to be used by CASA when assessing an application for Fatigue Risk Management System (FRMS) Appendix 7 approval. Several industry parties consulted stated they had requested more detail previously but that it had not been provided. While Form 817 has reportedly been helpful in some ways, it does not appear to align with ICAO's view of 'scalability', in that it applies a large-scale RPT 'gold standard' to all operators seeking an FRMS approval.

Finding

The Review Team finds that CASA needs to improve the consistency and transparency of FRMS assessment processes. This item relates to previous statements suggesting only requirements should be stated as such in regulations, and that only regulations should be associated with the use of imperative terms such as 'must', 'shall' and 'required' in guidelines, Form 817 and other supporting documents. Where multiple alternate means of compliance exist, the requirement should be related to compliance, with clear visibility that alternatives exist. Similarly, this item relates to scalability, which is associated with the content in this report suggesting one (or more) additional layers of scale is necessary (e.g., in Form 817) to provide visibility of differences in requirements for larger versus smaller operators.

Recommendation 24

That CASA provides clear and comprehensive information to operators and flight operations inspectors on the FRMS assessment process, including differences between requirements and guidelines at different levels of operational scale.

6 Conclusion

This document was prepared for the Civil Aviation Safety Authority of Australia (CASA) as the Final Report of the Independent Review into proposed aviation fatigue rules for operators and pilots (Civil Aviation Order [CAO] 48.1 Instrument 2013; Civil Aviation Safety Authority, 2017a, 2017b). The report aggregates the information and analysis from earlier project phases and three previous Interim Reports, in a set of findings and 24 recommendations.

The Independent Review Team's findings and recommendations are set out in four sections, covering:

- CASA's rationale for developing CAO 48.1, and on the appropriateness of the new regulations for the Australian aviation environment (Section 2, three recommendations);
- Outstanding industry concerns with specific requirements of CAO 48.1 (Section 3, nine recommendations);
- Findings and recommendations on the way CASA consulted and communicated with industry during the design, development and implementation of CAO 48.1 (Section 4, six Recommendations);
- Industry concerns about potential barriers to the successful implementation of CAO 48.1. (Section 5, six Recommendations).

The findings and recommendations have been refined in response to formal feedback provided by the Independent Review Team's Expert Advisory Panel and the CASA Board.

The Independent Review Team believes that the findings and recommendations detailed in this Final Report provide CASA with a clear path for the successful future implementation of CAO 48.1.

Annex A ~ Independent Review Team and EAP Members

Brief details on the Independent Review Team and Expert Advisory Panel members are provided below.

Independent Review Team

The five members of the Independent Review Team are:

Brenton Hayward, Dédale Asia Pacific

Dr Andrew Lowe, Dédale Asia Pacific

Dr Adam Fletcher, Integrated Safety Support

Juanita Diaz, Integrated Safety Support

Dr Wayne Martin, Aviation Research Consultants.

Brenton Hayward was the Project Manager and Review Team point of contact for this project, supported by Dr Andrew Lowe. Andrew and Brent also provided broad aviation human factors and safety expertise and perspective for the Independent Review Team.

Brent and Andrew, both representing Dédale Asia Pacific, are aviation human factors specialists and professionally qualified and Registered Psychologists, each with extensive professional experience in applied organisational psychology and safety management, both within Australia and internationally. They began their careers with the RAAF Psychology Service and have each worked with the military and civil aviation communities for more than 35 years.

Brent established Dédale Asia Pacific as an independent aviation human factors and safety consultancy in 1998, and in recent years he and Andrew Lowe have led and worked on major safety enhancement projects and reviews for organisations including Airservices Australia, Airways New Zealand, Changi Airport Group (Singapore), Embraer, EUROCONTROL, MTR Railway Operations (Hong Kong), the National Rail Safety Regulators Panel (Australia), the National Transport Commission (Australia), Queensland Transport, Singapore Airlines, the Swedish Nuclear Power Regulator (SKI / Swedish Radiation Safety Authority), and CASA.

Dr Adam Fletcher, supported by Juanita Diaz, provided expert specialist fatigue & risk advice for the Independent Review Team.

Dr Adam Fletcher is the CEO and Principal Consultant of Integrated Safety Support (ISS). Adam completed his research PhD at the University of South Australia (UniSA), where he investigated the measurement and prediction of work-related fatigue. He subsequently worked as a Senior Research Fellow at UniSA's Centre for Sleep Research, and as a Research Psychologist studying the effects of sleep deprivation on operational performance and safety for the US Army. Since his return to Australia in 2006 he has been focused on developing, implementing, and reviewing fatigue-related safety programs, with an emphasis on risk-based systems, for clients in 24/7 industries. Adam has provided specialist safety and fatigue management consulting services to aviation-related clients including Air France, Airservices Australia, the Australian Federation of Air Pilots, Babcock, Cobham, easyJet, Fiji Airways, IndiGo, the RFDS, Qantas Group, Transport Canada, Vietnam Airlines, Virgin Australia and Zurich Insurance.

Dr Fletcher was also involved as a scientific advisor to ICAO for the most recent re-write of the Fatigue Risk Management System (FRMS) document suite. Furthermore, Adam has provided scientific advice to NASA and the US Army.

Juanita Diaz is a Fatigue Management and Human Factors Consultant with ISS. Juanita joined the ISS team after eight years working in the airline industry, followed by two years working at the Australian Transport Safety Bureau (ATSB). She is a private pilot and her previous operational roles involved management of staff rostering, airline operations and aircraft maintenance allocations. These combined experiences have given Juanita extensive exposure to around-the-clock shiftwork environments in multiple Australian airlines.

Dr Wayne Martin (Aviation Research Consultants) provided an applied aviation operations and safety management perspective for the Independent Review Team.

Wayne is an airline pilot with over 19,000 flying hours and holds a PhD in Human Factors. He has worked in both the military and the airline industry for nearly 40 years and has extensive operational experience both domestically, and in international operations. He currently flies the B777 for Virgin Australia and has been involved in the setting up and running of an FRMS, in a previous operation. Academically, Wayne's research has predominantly focussed on human performance and cognition, but he also has significant experience at teaching in safety management systems, Human Factors (including fatigue management), crew resource management, and non-technical skills, at undergraduate, postgraduate and practitioner levels. He continues to actively research in human performance and currently supervises 11 PhD students across a wide range of Human Factors related research topics. He has also chaired the UPRT workstream for the International Pilot Training Association (IPTA) for three years, and has run the PACDEFF CRM and Aviation Human Factors conference for the past 11 years.

The Expert Advisory Panel

Three internationally renowned aviation safety and Human Factors specialists accepted the Review Team's invitation to form an Expert Advisory Panel (EAP) for the project. The role of the EAP was to guide the strategic direction of the review, and support the Independent Review Team with specialist knowledge, including international best practice in fatigue risk management, safety management and aviation regulation. They reviewed and critiqued key deliverables throughout the Review, including critical input into the draft findings and recommendations and the Draft Final Report of the Independent Review Team.

Brief details of the three EAP members are provided below.

Dr R. Curtis Graeber

Dr Curt Graeber is a highly respected global expert on fatigue science and risk management, safety management, and human factors. From 2009-2016 he was President of The Graeber Group, an independent consultancy specialising in human performance and aviation safety.

Earlier in his career Curt led seminal research into fatigue and flight crew performance at the NASA Ames Research Center, before spending 18 years working with the Boeing Company as a human factors and safety expert and senior project manager. Curt retired from Boeing in 2008 as a Senior Technical Fellow, Chief Engineer for Human Factors and Director of Regional Safety Programs. He also served as Chief, Crew Operations, for the development of the 737-NG airplane series.

Curt was more recently the Chair of ICAO's Global FRMS Task Force, producing industry guidance material on fatigue risk and FRMS on behalf of ICAO, IATA and IFALPA, and led the international team of aviation risk and safety experts that reviewed organisational safety processes at Air France following the AF 447 accident.

Jean Pariès

Jean Pariès is President of the Dédale SAS company, based in Paris, France. Jean graduated from ENAC, the French National School of Civil Aviation, as an aeronautical engineer in 1973. He then joined the French civil aviation authority (DGAC), where he worked in a succession of regulatory capacities and roles including airworthiness, flight operations, and pilot licensing, also contributing to several ICAO and European working groups. He served as Chairman of the JAA Professional Pilot Licences Working Group and participated in the foundation ICAO Flight Safety and Human Factors Working Group.

In the early 1990s Jean was Deputy Head, and Head of Investigations with the French state air accident investigation body, the Bureau Enquêtes Accidents (BEA). Jean left the BEA in 1994 to establish and manage the Dédale group. Since that time, he has led the Dédale consulting team on a wide variety of applied human factors training development, operational research and organisational reliability consulting assignments for clients in the aviation, health care, maritime, nuclear power, rail and road safety domains.

Jean was also involved in the Air France safety process review team following AF 447, and was a consultant to the BEA during the AF 447 accident investigation analysis.

Jean currently holds a Commercial Pilot Licence with Instrument, Multi-engine, Turboprop, and Instructor ratings and has a Private Pilot Licence for helicopters.

Dr Rob Lee, AO

Dr Rob Lee is an international consultant on human factors, systems safety, and accident/incident investigation, working with airlines, airports, regulators and air safety investigation organisations. In addition to aviation, he works in other transport modes, such as rail, and in high technology industries including nuclear power, and healthcare.

Rob worked as Senior Psychologist, Operational Command, with the Royal Australian Air Force (RAAF) and is still serving as a Group Captain in the RAAF Specialist Reserve.

In 1983 Dr Lee joined the then Bureau of Air Safety Investigation (BASI) as the Bureau's first human factors specialist, and was subsequently appointed as the Director of BASI, a position that he held from 1989-1999. In November 2000, he set up his own company, and now works as an international consultant in human factors and systems safety, in aviation and in other high technology industries.

Rob has received numerous awards from various national and international aviation safety and human factors organisations, including AAvPA, EAAP, GAPAN and the Royal Aeronautical Society. In 2012 Dr Lee was made an Officer in the General Division of the Order of Australia (AO): *"For distinguished service to the aviation industry, to the development of air safety and accident investigation standards, and to national and international professional associations"*.

Annex B ~ Terms of Reference

Terms of Reference for the conduct of an independent review of aviation fatigue rules for operators and pilots (Civil Aviation Order [CAO] 48.1 Instrument 2013)

Published January 2017

Introduction

The Civil Aviation Safety Authority (CASA) requires the services of a suitably qualified specialist or team of specialists independent of CASA to undertake a review of the latest fatigue rules for operators and pilots (CAO 48.1 Instrument 2013).

The fatigue rules for air operators and pilots have been updated as part of the CASA's regulation reform program that seeks to align Australia with international standards, improve aviation safety, address known risks, and maintain our reputation for safety in aviation. The review will provide an informed basis on which CASA will complete the implementation of the new fatigue rules in the context of the current international and domestic regulatory environments.

The role of the specialist(s) will be to:

- develop an appropriate methodology to fulfil the review Terms of Reference
- implement all aspects of the required research and report on findings
- make recommendations emerging from the findings including recommendations to support CASA to achieve the aim of the Terms of Reference.

Background

The Civil Aviation Safety Authority's mission is "to promote a positive and collaborative safety culture through a fair, effective and efficient aviation safety regulatory system, supporting our aviation community".

Consistent with its mission, the regulatory functions of CASA include developing and promulgating appropriate, clear and concise aviation safety standards, and conducting regular reviews of the civil aviation safety system in order to monitor safety performance of the industry, identify safety related trends and risk factors and to promote the development and improvement of the system.

Any new legislation is also required to comply with the guiding principles of the DAS Directive 01/2015. This Directive reaffirms CASA's commitment to ensure that regulatory changes are justified on the basis of safety risk and do not impose unnecessary costs or unnecessarily hinder participation in aviation and its capacity for growth.¹

As part of the regulation reform program, CASA has introduced new fatigue risk management rules for operators and pilots. The new rules - set out in [CAO 48.1 Instrument 2013](#) - came into effect in April 2013 and are intended to better reflect modern flying conditions, scientific understanding of human performance limitations and advances in technology.

¹ Refer 2015 Statement of Expectations to CASA, Clause 15. "consider the economic and cost impact on individuals, businesses and the community in the development and finalisation of new or amended regulatory changes".

In October 2016, CASA announced a 12 month extension to the implementation period for new fatigue rules. Operators have until 1 May 2018 to transition to the provisions of CAO 48.1 Instrument 2013. In preparation to operate under CAO 48.1 Instrument 2013, operators are required to submit their draft operations manual changes, or an application for a fatigue risk management system (FRMS), to CASA by 31 October 2017.

As a result of feedback received from various sections of the industry who have attempted to comply with CAO 48.1, CASA and its Board have determined that an independent review of CAO 48.1 will be undertaken.

The aim of the review is to determine if CAO 48.1 Instrument 2013 is appropriate and satisfies the Guiding Principles in DAS Directive 01/2015.

These Principles include:

- Aviation safety regulations must be shown to be necessary.
- Regulations must not impose unnecessary costs or unnecessarily hinder levels of participation in aviation and its capacity for growth.
- Aviation safety regulations should be consistent with international best practice.
- CASA will align its regulations with those jurisdictions/NAAs that effectively address identified safety risks in the most cost-effective manner.

Terms of Reference for the independent review of aviation fatigue rules for operators and pilots (CAO 48.1 Instrument 2013)

Purpose

An independent review of CAO 48.1 Instrument 2013 will provide CASA with an informed basis on which to finalise reform of the fatigue rules for operators and pilots.

Aim

A safe, effective and efficient set of fatigue risk management rules is in place for Australian operators and pilots that:

- addresses a clearly identified risk not addressed by current regulation
- is scalable and proportionate to the type of operation being undertaken
- is consistent with CASA's requirements under the Act, and directions made to the CASA Board by the Minister (Statement of Expectations)
- is consistent with the principles contained in CASA's Regulatory Philosophy and DAS Directive 01/2015
- is appropriate to the Australian environment (meteorological and geographical)
- takes appropriate account of the Australian context (air traffic management, the needs of rural and remote communities, time-zones, economic and socio-political)
- is in step with corresponding requirements in other comparable jurisdictions.

Objectives

The review has the following objectives:

- To determine, by evidence-based risk analysis, whether the new rules are necessary (in accordance with DAS Directive 01/2015), having regard to other current regulation including human factors training and safety management systems.
- To evaluate the extent and relevance of the research and evidence applied in the development of the latest fatigue rules (CAO 48.1 Instrument 2013) including:
 - the development of the limits in the prescriptive appendices to CAO 48.1 Instrument 2013, and
 - the application of fatigue risk management systems (FRMS).
- To evaluate the extent to which CAO 48.1 Instrument 2013 applies the underpinning research and evidence, takes into account the Australian operating environment and enables industry to establish modern fatigue management regimes.
- To evaluate the extent to which the latest fatigue rules are consistent with the principles in CASA's regulatory philosophy and Director of Aviation Safety Directive 1/2015, in particular:
 - Regulation must be shown to be necessary to address known or likely risks.

- Regulation should have particular regard to the safety of passengers and other persons likely to be affected by an activity.
- Regulation must not impose unnecessary costs on industry, nor unnecessarily hinder growth or participation.
- Regulation should conform to international standards except where differences can be justified on safety risk grounds due to unique Australian conditions.
- Regulation will address safety risks in the most cost-effective manner, proportionate to the risks involved.
- Where appropriate, regulations will specify safety outcomes.

Scope of the review

- CAO 48.1 Instrument 2013 (as amended by the 2016 improvements) and the associated Civil Aviation Advisory Publication (CAAP) 48-01 - Fatigue management for flight crew members.
- Previous legislative provisions of CAO 48 including standard industry exemptions.
- Legislative provisions governing Safety Management Systems.
- Legislative provisions requiring Human Factors and Non-technical skills training.

Considerations

The following considerations are relevant to the review:

- The main objective of the Civil Aviation Act is "to establish a regulatory framework for maintaining, enhancing and promoting the safety of civil aviation, with particular emphasis on preventing aviation accidents and incidents".
- CASA's regulatory philosophy and Director of Aviation Safety Directive 1/2015.
- The Minister's Statement of Expectations to the CASA Board 2015.
- Standards and Recommended Practices of the International Civil Aviation Organization along with current and proposed fatigue rules of the European Aviation Safety Agency and the following countries:
 - New Zealand
 - United States
 - United Kingdom
 - Canada.
- Previous studies into fatigue and the management of fatigue risk in aviation.
- Reports and investigations into fatigue-related accidents and incidents produced by the Australian Transport Safety Bureau and other domestic and international transport accident investigation agencies.
- The extent to which CAO 48.1 Instrument 2013 would address the root cause of those accidents, in the context of other recently introduced legislative requirements such as

human factors training and the implementation of a Safety Management System by operators.

- The approach to fatigue regulation taken by other Australian transport regulators (e.g. maritime, road and rail).
- The approach to fatigue management taken by other industries and businesses engaged in activities with high consequential risks (e.g. oil and gas, mining, nuclear, transport).

How will the review be conducted?

CASA will conduct an open tender to commission a suitably qualified specialist or team of specialists independent of CASA to conduct the review and make recommendations. The successful tenderer will recommend the most appropriate methodology to conduct the review given the scope and objectives of these Terms of Reference, conduct all aspects of the research and report to the Board on findings. The reviewing specialist or team of specialists will make recommendations emerging from the findings.

Deliverables

Deliverables for the review include:

- a full report including recommendations emerging from the findings
- an executive summary of no more than four A4 pages (a presentation initially to the CASA Board and subsequently to CASA executives and possibly industry representatives will also be required).

When will it be achieved?

The specialist(s) will deliver a final report and presentation to CASA within six months of commencement of the contract.

ANNEX C to Final Report
on the Independent Review of CAO 48.1

Annex C ~ Stakeholder Consultation Summary

The table below lists the industry stakeholders directly consulted by the Review Team.

Organisation / Individual Consulted	Consultation status
Aerial Agricultural Association of Australia (AAAA)	Completed
Alliance Airlines	Completed
Australian Federation of Air Pilots (AFAP)	Completed
Australian & International Pilots Association (AIPA)	Completed
Dr Matthew Thomas (Westwood-Thomas Associates)	Completed
Global Ballooning Australia	Completed
Jetstar Airways	Completed
NSW Police Air Wing (POLAIR)	Completed
Qantas Airways Limited	Completed
Regional Aviation Association of Australia (RAAA)	Completed
Regional Express (Rex)	Completed
Singapore Flying College, Jandakot WA	Completed
The Association for Virgin Australia Group Pilots (VIPA)	Completed
Virgin Australia	Completed

Annex D: International Comparisons ~ Flight Duty Periods and Off Duty Periods

**Table D-1
CAO 48.1 and SIEs versus International Averages:
Flight Duty Periods and Augmented Crew Acclimatised**

Notes: N/S = Not Specified

The SIE does not define an augmented crew per se.
(It is assumed to be 4 Pilots for this analysis).

* Seat recline is not specified

** Some FAA figures rounded to nearest 0.1

Legend

- >= 1 Hour higher than average
- >= 1 Hour lower than average

Class of Rest		Class 1		Class 2		Class 3	
Crew Complement		3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot
Local Report Time	SIE	N/S #	22	N/S	16*	N/S	14
0000-0559	48.1	14	15	12.5	13.5	11	11.5
Appendix 2	UK	18	18	15*	15*	15	15
	EU	16	17	15	16	14	15
Transport Canada - Canada	TC CG1	15	18	15	16.5	14	15.25
Gazette 1	FAA	13.8	16.1	12.9	14.3	11.75	12.25
(International Average)	Average	15.7	17.3	14.5	15.5	13.7	14.4
Local Report Time	SIE	N/S	22	N/S	16 *	N/S	14
0600-0659	48.1	15.5	17.5	14.5	16	13.5	14
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	15.2	17.7	14.2	15.7	12.9	13.4
(International Average)	Average	16.1	17.7	14.8	15.8	14.0	14.7
Local Report Time	SIE	N/S	22	N/S	16 *	N/S	14
0700-0759	48.1	15.5	17.5	14.5	16	13.5	14
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	16	18	15.25	17.1	14	14.5
(International Average)	Average	16.3	17.8	15.1	16.2	14.3	14.9
Local Report Time	SIE	N/S	22	N/S	16 *	N/S	14
0800-1059	48.1	16	18	14	16	13.5	14
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	16	18	15.25	17.1	14	14.5
(International Average)	Average	16.3	17.8	15.1	16.2	14.3	14.9
Local Report Time	SIE	N/S	22	N/S	16 *	N/S	14
1100-1259	48.1	15.5	17.5	15	16	13.5	14
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	16	18	15.25	17.1	14	14.5
(International Average)	Average	16.3	17.8	15.1	16.2	14.3	14.9

**Table D-1 (cont.)
CAO 48.1 and SIEs versus International Averages:
Flight Duty Periods and Augmented Crew Acclimatised**

Notes: N/S = Not Specified
The SIE does not define an augmented crew per se.
(It is assumed to be 4 Pilots for this analysis).
* Seat recline is not specified
** Rounded to nearest 0.1

Legend

>= 1 Hour higher than average
>= 1 Hour lower than average

Class of Rest		Class 1	Class 1	Class 2	Class 2	Class 3	Class 3
Crew Complement		3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot
Local Report Time 1300-1359	SIE	N/S	22	N/S	16 *	N/S	14
	48.1	15.5	17.5	15	16	13.5	14
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	15.2	17.7	14.2	17.7	12.8	13.3
	(International Average) Average	16.1	17.7	14.8	16.3	14.0	14.6
Local Report Time 1400-1559	SIE	N/S	22	N/S	16 *	N/S	14
	48.1	15	16.5	13.5	15	12	13
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	15.2	17.7	14.2	17.7	12.8	13.3
	(International Average) Average	16.1	17.7	14.8	16.3	14.0	14.6
Local Report Time 1600-1659	SIE	N/S	22	N/S	16 *	N/S	14
	48.1	14	15	12.5	13	11	11.5
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	15.2	17.7	14.2	17.7	12.8	13.3
	(International Average) Average	16.1	17.7	14.8	16.3	14.0	14.6
Local Report Time 1700-2359	SIE	N/S	22	N/S	16 *	N/S	14
	48.1	14	15	12.5	13	11	11.5
	UK	18	18	15*	15 *	15	15
	EU	16	17	15	16	14	15
	TC CG1	15	18	15	16.5	14	15.25
	FAA	13.8	16.1	12.9	14.3	11.75	12.25
	(International Average) Average	15.7	17.3	14.5	15.5	13.7	14.4

**Table D-2
CAO 48.1 and SIE's vs International Averages:
International Comparisons of Minimum Rest Periods Between Flight Duty Periods**

Legend: >= 1 Hour higher than average
>= 1 Hour lower than average

Local Report Time		Home Base Basic Rule	Home Base Unacclimat-ised	Away From Home Base	Away From Home Base Unacclimat-ised	Following Extended Duty	Local Night Definition (Acclim.)
Standard Industry Exemption	SIE	10 **	N/S	10 **	N/S	> 12 hours 1.5Hrs / Hr 12+	N/S
CAO 48.1 (2016) Appendix 2	48.1	12	14 #	10	10 #	Various	2200-0500
CAP 371	UK	12 **	N/S	10 *	N/S	See ** note	2200-0800
CS-FTL.1	EU	12 **	Depends on TZ's	10 **	14 **	See ** note	2200-0800
Transport Canada - Canada Gazette 1	TC CG1	12	13	10 *	11	Add 1HR/HR Worked	2230-0730
RIN 2120-AJ58	FAA	10 *	-	10	-	N/S	N/S
International Average	Average	11.5	13.0	10.0	12.5		

Notes: # Add time zone diff if West > 3 hours or East > 2 hours
 * At the Accommodation
 ** Or previous FDP if greater
 N/S = Not Specified

Table E-1
ICAO Fatigue Risk Management System (FRMS) Component Analysis ~
CAO 48.1 and Comparable International Jurisdictions

		Legend:					
		Considered	Partially Considered	Not Considered	Document	Implementation date	Notes
		EASA	UK CAA	NZ CAA	FAA	TC	CASA
		EU No 83/2014	EU No 83/2014	AC-119-2	120-103A	Canada Gazette, Vol. 151, No. 26 Jul-17 Draft	CAO 48.1
		29-Jan-14	29-Jan-14	2006	May-13		Oct-16 Draft
1	FRMS POLICY & DOCUMENTATION						
1.1	FRMS Policy						
1.1.1	The operator shall define its FRMS policy, with all elements of the FRMS clearly identified.						
1.1.2	The policy shall require that the scope of FRMS operations be clearly defined in the operations manual.						
1.1.3	The policy shall:						
a	reflect the shared responsibility of management, flight and cabin crews, and other involved personnel;						
b	clearly state the safety objectives of the FRMS;						
c	be signed by the accountable executive of the organization;						
d	be communicated, with visible endorsement, to all the relevant areas and levels of the organization;						
e	declare management commitment to effective safety reporting;						
f	declare management commitment to the provision of adequate resources for the FRMS						
g	declare management commitment to continuous improvement of the FRMS						
h	require that clear lines of accountability for management, flight and cabin crews, and all other involved personnel are identified						
i	require periodic reviews to ensure it remains relevant and appropriate						
1.2	An operator shall develop and keep current FRMS documentation that describes and records:						
a	FRMS policy and objectives;						
b	FRMS processes and procedures;						
c	accountabilities, responsibilities and authorities for these processes and procedures;						
d	mechanisms for ongoing involvement of management, flight and cabin crew members, and all other involved personnel						
e	FRMS training programmes, training requirements and attendance records;						
f	scheduled and actual flight times, duty periods and rest periods with significant deviations and reasons for deviations noted						
g	FRMS outputs including findings from collected data, recommendations, and actions taken.						
2	FATIGUE RISK MANAGEMENT PROCESSES						
2.1	Identification of hazards						
2.1.1	Predictive - The predictive process shall identify fatigue hazards by examining crew scheduling and taking into account factors known to affect sleep and fatigue and their effects on performance. Methods of examination may include but are not limited to:						
a	Operator or industry operational experience and data collected on similar types of operations						
b	evidence-based scheduling practices						
c	bio-mathematical models						
2.1.2	Proactive - The proactive process shall identify fatigue hazards within current flight operations. Methods of examination may include but are not limited to:						
	Self-reporting of fatigue risks						
	Crew fatigue surveys						
	Relevant flight and cabin crew performance data					Flight crew only currently	
	Available safety databases and scientific studies						
	Analysis of planned versus actual time worked						
2.1.3	Reactive - The reactive process shall identify the contribution of fatigue hazards to reports and events associated with potential negative safety consequences in order to determine how the impact of fatigue could have been minimized. At a minimum, the process may be triggered by any of the following:						
a	Fatigue reports						
b	Confidential reports						

**Table E-1 (cont.)
ICAO Fatigue Risk Management System (FRMS) Component Analysis ~
CAO 48.1 and Comparable International Jurisdictions**

		EASA	UK CAA	NZ CAA	FAA	TC	CASA
		EU No 83/2014	EU No 83/2014	AC-119-2	120-103A	Canada Gazette, Vol. 151, No. 26 Jul-17 Draft	CAO 48.1
		29-Jan-14	29-Jan-14	2006	May-13		Oct-16 Draft
Legend:							
		Considered					
		Partially Considered					
		Not Considered					
		<i>Document</i>					
		<i>Implementation date</i>					
		<i>Notes</i>					
c	Audit reports						
d	Incidents						
e	Flight data analysis events						
2.2	Risk assessment						
2.2.1	An operator shall develop and implement risk assessment procedures that determine the probability and potential severity of fatigue-related events and identify when the associated risks require mitigation.						
2.2.2	The risk assessment procedures shall review identified hazards and link them to:						
a	Operational processes						
b	Their probability						
c	Possible consequences						
d	The effectiveness of existing safety barriers and controls						
2.3	Risk mitigation						
	An operator shall develop and implement risk mitigation procedures that:						
a	Select the appropriate mitigation strategies						
b	Implement the mitigation strategies						
c	Monitor the strategies implementation and effectiveness						
3	FRMS SAFETY ASSURANCE PROCESSES						
	The operator shall develop and maintain FRMS safety assurance processes to:						
a	provide for continuous FRMS performance monitoring, analysis of trends, and measurement to validate the effectiveness of the fatigue safety risk controls. The sources of data may include, but are not limited to:						
i	hazard reporting and investigations						
ii	audits and surveys						
iii	reviews and fatigue studies						
b	provide a formal process for the management of change which shall include but is not limited to:						
i	identification of changes in the operational environment that may affect FRMS;						
ii	identification of changes within the organization that may affect FRMS;						
iii	consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes; and						
c	provide for the continuous improvement of the FRMS. This shall include but is not limited to:						
i	the elimination and/or modification of risk controls that have had unintended consequences or that are no longer needed due to changes in the operational or organizational environment;						
ii	routine evaluations of facilities, equipment, documentation and procedures; and						
iii	the determination of the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.						
4	FRMS PROMOTION PROCESSES						
	FRMS promotion processes support the ongoing development of the FRMS, the continuous improvement of its overall performance, and attainment of optimum safety levels. The following shall be established and implemented by the operator as part of its FRMS:						
a	training programmes to ensure competency commensurate with the roles and responsibilities of management, flight and cabin crew, and all other involved personnel under the planned FRMS; and						
b	an effective FRMS communication plan that:						
i	explain FRMS policies, procedures and responsibilities to all relevant stakeholders; and						
ii	describe communication channels used to gather and disseminate FRMS-related information.						

Annex F ~ References

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