Safety Evolution Guide: Fatigue-Related Risk

Draft example of Evolution Guide based on a SMS practice which has been recognized as Optimised by the CANSO Safety Standing Committee

1. OBJECTIVE OF GUIDE

Members of the Civil Air Navigation Services Organisation (CANSO) are committed to the improvement of their services. As part of this commitment, organisations share their practices in efforts transfer learning across the industry.

This guide captures either:

- the practices of an Air Navigation Service Provider (ANSP) in one element of the CANSO Standard of Excellence (SoE) in Safety Management System (SMS). The practices of this ANSP have been recognized by their peers as being an optimised practice within the industry (see Figure 1). The optimized practices have been selected on the basis of their novelty, innovation or the recognition of their potential to manage operational risks; or
- proposed practices which are based on contemporary thinking in the safety management sphere. These proposals have yet to be fully adopted by any ANSP, but they are viewed by the CANSO SSC as having significant potential in the industry's efforts to evolve how safety is managed.

Given the dynamic nature of safety management, the practices presented in this document may be superseded. CANSO will publish updated best practice guidance.

2. APPLICATION OF THE GUIDANCE

CANSO recognizes that this guidance will not be relevant to all ANSPs. The maturity of any ANSP's Safety Management System will be dependent on their specific context. This context will be a reflection of factors including the size and complexity of the organisation, domestic regulations and the risk appetite of the organisation.

ANSPs do not necessarily need to adopt all the practices and processes promoted by CANSO, but consider the relevance of the practices promoted in this guide to their operational environment.

3. OPTIMISED PRACTICE

This guide addresses a SMS process which was identified in 2017 as being Optimised, it details how one Air Navigation Service Provider, Airservices Australia, manages the fatigue risk to which its Air Traffic Control staff and services are exposed. The approach was reviewed by a panel of experts from the Future Safety Working Group of the Safety Standing Committee. The approach meets both the CANSO and International Civil Aviation Organisation's requirements for a Fatigue Risk Management System (FRMS) (see below).

4. SCOPE OF GUIDE

This guide does not provide detail on why fatigue occurs, or how the organization developed or implemented its approach. Readers are recommended to the ICAO Fatigue Management Guide for Air Traffic Service Providers which is available on both the ICAO and CANSO websites to find such content.

The guide focuses how Airservices currently manages the fatigue-risk associated with its air traffic control delivery and how the approach is structured within its SMS.

5. APPLICABLE STANDARDS AND REQUIREMENTS

CANSO Standard of Excellence in Safety Management Systems

10. Fatigue-related Risk Management 30

Objective	Informal Arrangements	Defined	Managed	Assured	Optimised
10.1 A data-driven means by continuously monitoring and managing fatigue-related safety risk that aims to ensure relevant personnel are performing at adequate levels of alertness.	Fatigue-related risk is not recognised as a safety risk which needs to be managed.	Fatigue-related risk is considered as an operational hazard, but there is no formal risk based system by which to manage it. Policy has been developed which recognises the need for a formal risk based approach to fatigue-related risk	A formal risk based system which focuses on fatigue-related risk is being implemented which addresses: • Responsibilities of both management and operational personnel • Methods for assessing and managing fatigue risk	Compliance with fatigue-related risk procedures is continually assessed. Processes are in place to assess and continually improve approaches to fatigue-risk management.	The organisation uses the data and information from internal and external sources to continually improve its approach to managing fatigue-related safety risk.

Extract from CANSO Standard of Excellence in Safety Management Systems

https://www.canso.org/sites/default/files/SMS_CANSO_SoE_16%20Nov%202015.pdf

ICAO Annex 11 (Air Traffic Services): Effective Date 2020

2.28.1 *States shall establish regulations for the purpose of managing fatigue in the provision of air traffic control services. These regulations shall be based upon scientific principles and knowledge, with the aim of ensuring that air traffic controllers perform at an adequate level of alertness. To that aim, States shall establish:*

a) regulations that prescribe scheduling limits in accordance with Appendix 6; and

b) where authorizing air traffic services providers to use a fatigue risk management system (FRMS) to manage fatigue, FRMS regulations in accordance with Appendix 7.

2.28.2 *States shall require that the air traffic services provider, for the purposes of managing its fatigue-related safety risks, establish one of the following:*

a) air traffic controller schedules commensurate with the service(s) provided and in compliance with the prescriptive limitation regulations established by the State in accordance with 2.28.1 a); or

b) an FRMS, in compliance with regulations established by the State in accordance with 2.28.1 b), for the provision of all air traffic control services; or

c) an FRMS, in compliance with regulations established by the State in accordance with 2.28.1 b), for a defined part of its air traffic control services in conjunction with schedules in compliance with the prescriptive limitation regulations established by the State in accordance with 2.28.1 a) for the remainder of its air traffic control services.

2.28.3 *Where the air traffic services provider complies with prescriptive limitation regulations in the provision of part or all of its air traffic control services in accordance with 2.28.2 a), the State:*

a) shall require evidence that the limitations are not exceeded and that non-duty period requirements are met;

b) shall require that the air traffic services provider familiarize its personnel with the principles of fatigue management and its policies with regard to fatigue management;

c) shall establish a process to allow variations from the prescriptive limitation regulations to address any additional risks associated with sudden, unforeseen operational circumstances; and

d) may approve variations to these regulations using an established process in order to address strategic operational needs in exceptional circumstances, based on the air traffic services provider demonstrating that any associated risk is being managed to a level of safety equivalent to, or better than, that achieved through the prescriptive fatigue management regulations.

Note.— Complying with the prescriptive limitations regulations does not relieve the air traffic services provider of the responsibility to manage its risks, including fatigue-related risks, using its SMS in accordance with the provisions of Annex 19.

2.28.4 *Where an air traffic services provider implements an FRMS to manage fatigue-related safety risks in the provision of part or all of its air traffic control services in accordance with 2.28.2 b), the State shall:*

a) require the air traffic services provider to have processes to integrate FRMS functions with its other safety management functions; and

b) approve an FRMS, according to a documented process, that provides a level of safety acceptable to the State.

Note.— Provisions on the protection of safety information, which support the continued availability of information required by an FRMS, are contained in Annex 19.

Extracts copied from: ICAO Fatigue Management Guide for Air Traffic Service Providers

Further guidance on the implementation of this SARP can be found at:
https://www.icao.int/safety/fatiguemanagement/Pages/Resources.aspx

6. OPERATIONAL AND ORGANISATIONAL CONTEXT

Like all safety management practices, approaches to fatigue risk must be tailored to the operations of the ANSP. The complexity of the implemented FRMS must reflect the complexity of the operations and the potential for fatigue risk. For example, an ANSP that operates three towers between 9:00 a.m. and 6:00 p.m. five days a week can have a very simple approach to fatigue management, given that its staff work a fixed roster that does not impact the normal sleeping period.

Airservices' context is more complex in that:

- It employs approximately 1000 Air Traffic Controllers;
- It operates 29 Towers, two enroute centres and two terminal control units across the Australian continent;
- Each ATC is rostered individually, ie there are no standard shift patterns and ATCs are not allocated to a team/crew who always work together;
- ATCs may hold one or a series of endorsements which would allow them to operate in a sector grouping or roles in a Tower;
- Hours of service coverage are dependent on traffic demands so ATCs may work 24 or non-24 hour rosters;
- Under the terms of their employment agreement, ATCs can be asked to work a reasonable amount of overtime to cover shifts due to the absence of other workers.

The practices described in this guide were implemented in 2013, and since this time has been refined based on data gathered from formal assurance programs. Such practices are consistent with those recommended by ICAO when organisations are adopting a fatigue risk management approach. Fatigue scientists and Safety Management System experts work in concert with ATC managers and staff union representatives in efforts to ensure that Airservices fatigue management practices are fit for purpose.

At the time of the publication of this guide, the Australian Civil Aviation Safety Authority (CASA) had not published any requirements for fatigue management for Air Traffic Controllers. Airservices developed its approach ahead of the publication of the International Civil Aviation Organisation's (ICAO) Standard and Recommended Practice (SARP) on Fatigue Management. The organisation has reviewed its approach to ensure that it would meet the ICAO Annex 14 requirements.

7. OVERVIEW OF PRACTICES

Airservices fatigue-management practices are premised on its recognition that:

- Without appropriate management, human performance can be severely degraded by fatigue, particularly in environments where workers are required to work 24/7 shift cycles;
- The impact of fatigue is often insidious with people being unaware that their performance is being affected;
- Managing fatigue and associated risks are the dual responsibility of management and employees as fatigue is not only affected by work demands but all waking activities; and
- Sleep is critical, as it is the only thing which can eliminate fatigue

As such, fatigue management approaches need to address:

- Acute, the mental fatigue which builds between breaks on a duty;
- Transient, fatigue which can be alleviated between duty periods; and
- Cumulative (or Chronic) fatigue, the fatigue which builds through consecutive duty periods.

8. FATIGUE RISK MANAGEMENT SYSTEM

There are four components of Airservices' approach to fatigue management.

System Objectives & Requirements		
Work Scheduling	Education & Awareness	Assurance

Each component is discussed in the following sections.

8.1. SYSTEM OBJECTIVES AND REQUIREMENTS

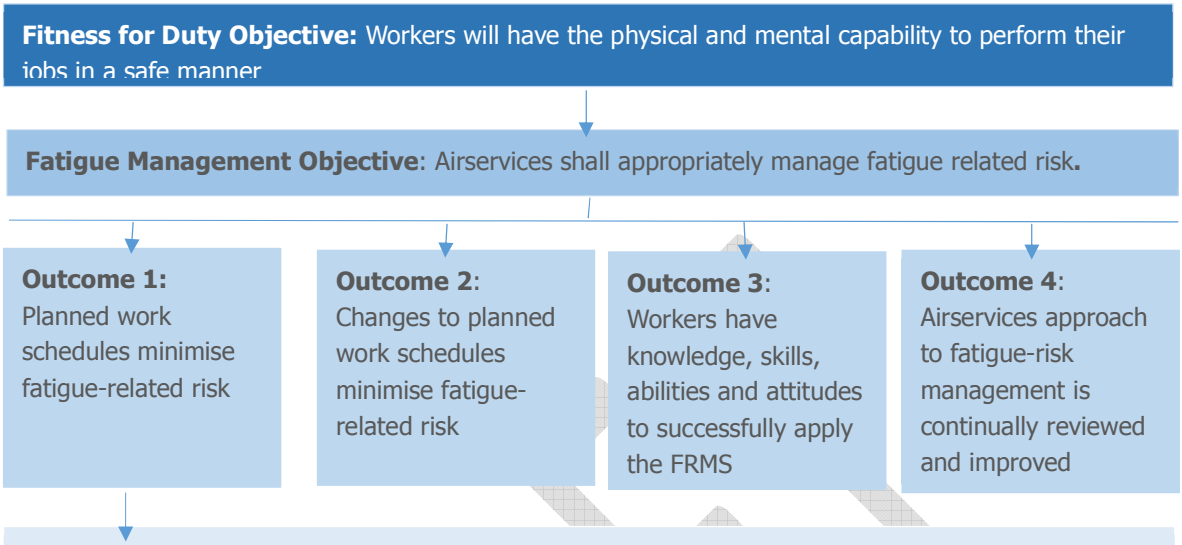
Airservices' SMS has an element which revolves around Fitness for Duty, this element has three sub elements, one of which relates to fatigue. The ICAO SARPS recommend that fatigue risk management is integrated with other safety management practices, so Airservices approach is in keeping with this recommendation.

Each element and sub-element of Airservices' SMS has an objective which is in keeping with the domestic SMS requirements established by CASA.

In order to drive and measure performance, outcomes and requirements are then established for how the organization achieves its SMS objectives. This is particularly important in the sphere of fatigue management, as there are no domestic regulations for the organisation to adopt. The objectives and examples of the outcomes and requirements are presented below for information.

It is also relevant to note that as Airservices provides both Air Navigation and Aviation Rescue and Fire Fighting Services, the SMS contains consistent outcomes and requirements for its services but implements different processes and practices given the

differing operating context, the risk controls available and the safety criticality of the services provided.



Requirements to achieve Outcome 1

FFD2.1	The work schedules of shift workers must be premised on contemporary understanding of fatigue and its management.
FFD2.2	Work schedule planning requirements, termed Strategic Roster Planning Rules (SRPRs), must address factors which are known to influence the development and promulgation of fatigue, including maximum duty periods, minimum time off between consecutive shifts, the number of consecutive shifts which can be work, shift rotations and time of day.
FFD2.3	The SRPRs must be tailored to the operational context and serve as a proxy via which the fatigue risk tolerance for specific job functions (e.g. air traffic control, aviation rescue and firefighting) is embodied.
FFD2.4	For shift cycles which are planned on the basis of workers operating the full shift, the quality and quantity of sleep opportunities must be assessed using a bio-mathematical model against a nominated threshold.
FFD2.5	Approvals for exemptions from the SRPRs, for either an individual or sub-group of workers within a job function, must be justified and approved by the FRMS system owner.
FFD2.6	Business Groups must identify and implement strategic risk controls that will assist in the management of fatigue-related risk for specific job functions.
FFD2.7	Risk controls that would have a beneficial impact on fatigue-related risk must be implemented when they are deemed to have negligible impact on business efficiency or effectiveness.

8.2 PLANNED WORK SCHEDULES

Work scheduling is the most critical risk control to manage the fatigue related risk. It is critical that work schedules provide opportunities for:

- breaks from the task within a shift;
- sleep opportunities between shifts and blocks of shifts; and
- social interaction, as people will forgo sleep for social interaction if work does not effectively integrate with workers lives.

Roster Design

The graphic below summarizes the key steps taken by Airservices in its efforts to design rosters for ATCs which seek to minimise exposure to fatigue.

Airservices established, and has then refined, a set of work scheduling requirements for planned rosters are premised on:

- scientific knowledge in regard to fatigue and sleep,
- operational input and experience; and
- assurance information collected during ongoing monitoring and key assurance reviews.

The 11 rules which must be complied with when rosters are planned address all fatigue drivers including:

- length of shift,
- amount of time between shifts,
- time off after a night shift,
- quantum of backwards rotation and
- number of shifts which can be worked consecutively.

The rules at the time of the development of this guide are presented below. As will become evident in the section on Assurance, actual rosters rarely reach any of the limits which are imposed.

The majority of the rules apply to both 24 hour and non-24 hour roster designs. The rules work to drive forward rotation within rosters, ie Morning-Afternoon-Night, and ensure that when night shifts are present in a roster they are worked consecutively as they recognized as having the most negative impact on circadian rhythms and therefore fatigue.

The rosters produced must also conform to the provisions of the employment agreement between Airservices and its Air Traffic Controllers which contains a number of what are termed Principles of Rostering.

As an additional check to ensure that rosters achieved an optimum outcome, all planned rosters are also checked against a bio-mathematical model (FAID) and must not exceed a peak score of 80.4. Bio-mathematical models are sets of equations that quantitatively predict a fatigue risk metric or corresponding output, based on factors such as sleep opportunities, time of day and in some instances workload. More details of bio-mathematical models can be found at:

https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/aoc/fatigue/fatigue_modelling.pdf

When a roster is being modified, the impacted ATCs are presented with three alternative options (all of which conform to roster design principles described above) to consider and vote on before the agreed roster is uploaded into the rostering system. The planned roster for a 90 day period must be published 45 days out from its commencement.

Changes to Planned Rosters

In the initial development phase of Airservices' FRMS, feedback from staff was that more fatigue was introduced through the need to modify planned work schedules to accommodate changes of allocations to shifts and situations where staff were working additional shifts.

Airservices' rostering system was therefore built to incorporate software algorithms (developed in-house) and workflow which support a tactical fatigue risk assessment process which is used when a shift needs to be filled. The steps in this process are presented in the graphic and described below.

ATC Listing

When an unit needs to replace a person on a roster, the rostering software identifies available ATCs with the appropriate endorsements and lists their fatigue potential. This potential is calculated on the basis of the degree to which the proposed shift deviates from the planning rules. As can be seen in the example below that strategic rules becomes a tactical principle and coding structure reflects the amount of points to allocate to the person and to which shift they should be allocated.

Strategic Rule: A minimum rest period of 11 hours is required between two consecutive shifts.

Tactical Principle There should be a minimum rest period of 11 hours between two consecutive shifts.

Assessment within Software

3	Is there a Rest Period of at least 11 hours immediately prior to each shift?		If No, how long would each Rest Period of <11 hours duration be?	hrs	10- <11hrs = 8 9 <10 =12 <9 = 25	Points allocated to shifts that are not immediately preceded by an 11-hour Rest Period (sliding scale as a function of reduced Rest Period duration (sliding scale Column (g))

The number of points allocated and the shifts to which they are allocated were developed by a team comprising of fatigue scientists and Air Traffic Controllers. The system recognizes that the fatigue impact of a shift change may not occur on the additional or changed shift but may impact later in the schedule as for example: they are required more consecutive shifts than the organisation considered to be optimum.

The proposed shift change may also mean more than one fatigue principle is not met, the points are added and then are grouped into one of three categories which are termed Initial Fatigue Potential. The ATC with the least fatigue potential must be asked to fill the shift. Protocols require that the ATC is asked if they are fit for duty and if they are filling to accept the new shift, if they decline, those with higher fatigue potential are contacted.

Risk Assessment

Once an appropriately endorsed Air Traffic Controller has been identified, a risk assessment commences which is completed by an ATC supervisor. The workflow within the rostering system incorporates a risk assessment that addresses the fatigue potential of the nominated staff member and the shift attributes (eg traffic levels, weather, degraded equipment). This results in an initial fatigue risk level.

The supervisor is then required to nominate a series of controls or mitigators to be enacted to reduce the initial risk level, and make an assessment of the residual risk level following the application of the controls/mitigators. The software automatically logs the risk assessment, and the controls/mitigators to the day on which the fatigue risk will occur, eg the fatigue impact may not be realised on the day of the additional shift, but in the days following when the ATC exceeds the maximum number of consecutive shifts.

In situations when a number of consecutive shifts are worked which are classified as having low fatigue risk, the software will automatically raise the level of the following shifts (until an extended rest period), requiring fatigue controls to be implemented.

A further work scheduling control used is that staff are only allowed to mutually change shifts which have either no or low fatigue risk.

Risk Sign Off

At the conclusion of the risk assessment, a change will be classified as having one of four levels of residual fatigue risk. If cases where risk levels are elevated, increasingly senior levels of management is required to sign off on the fatigue risk, ie they are accepting that the individual is working with potentially a higher level of fatigue than the organisations usual risk tolerance.

Implementation

On the day of operation, any risk assessment associated with a shift are highlighted to the supervisor who is required to review the situational factors (ie the weather and traffic levels) which may have changed from the day the original risk assessment was undertaken. A printed 'day sheet' provides details of the risk controls to be applied was undertaken. A printed 'day sheet' provides details of the risk controls to be applied.

Benefits to the Organisation

There were obvious cost impacts associated with the modification of the rostering system to support this risk assessment program, however these were outweighed by the flow on benefits to the organisation. These benefits include:

- standardized approach to the assessment of fatigue risk across a geographically dispersed workforce;
- decision support tools for supervisors which works to minimised workload in identifying appropriate shift replacements; and
- delivery of data about planned and actual work schedules and changed risk profiles support the delivery of the assurance program.

Time on Task

As mentioned previously, fatigue can also build as people work extended periods or under significant workload. Organisational guidance which was introduced in the mid-1990s recommended that ATCs were provided with a break from their tasking at least every two hours dependent on workload. Operational experience and academic research reinforced that a two hour window was appropriate as a general guideline, but that in some units breaks are required on a more regular basis to address high workload conditions. The frequency, duration and timing of breaks within the shift is managed by the operational unit. The minimum amount of time which ATCs are provided within a shift is agreed via an employment agreement with the staff, and was confirmed as being appropriate from a fatigue perspective.

In a small number of units, ATCs may be asked to work more than two hours. These situations tend to be associated with traffic scenarios where workload is very low and traffic activity is sporadic. Risk assessments and monitoring is conducted to confirm that such practices are appropriate. In these scenarios, staff are able to leave their consoles for short periods of time when alternative traffic oversight options are available and also use reading matter to maintain alertness.

8.3 EDUCATION AND PROMOTION

Relevant workers must also undertake the fatigue education program prior to commencing their initial operational shift, and must then undertake refresher education in fatigue and its management on a biennial basis. Training covers:

- how and why fatigue impacts on performance
- strategies to control and mitigate fatigue
- how the organisation works to address fatigue

Airservices also promotes through regular safety program activities:

- how it manages the risk which fatigue poses to its service delivery,
- the dual responsibility which exists between the organisation and workers in this regard;
- fatigue issues, and its response, which have been identified through data collection and assurance programs.

8.4 ASSURANCE

As acknowledged by ICAO significant work is required to deliver assurance that an organisation's approach to fatigue is working appropriately. This requires that organisation's collect and analyse the data, and also conduct formal reviews of its approach to ensure that it consistent with contemporary practice. Information and data from assurance programs are used to refine fatigue management approaches. Airservices devotes a significant amount of effort to deliver its fatigue assurance program, it uses reactive, proactive and predictive data assessment methods.

Key performance indicators relate to:

- Number of fatigue related occurrences *(Reactive)* Target - zero;
- Number of fatigue hazard reports *(Proactive)* No Target established, as the belief is that numbers of fatigue hazards report could be both a positive and negative performance indicator, ie if many reports were received it could be viewed that staff were invested in the program and were wanting to refine it or that fatigue management strategies were actually inappropriate;
- Proportion of shifts worked at a High level of calculated residual fatigue risk *(Proactive)* Target: 1% (this target has reduced over time as more assurance data has become available),

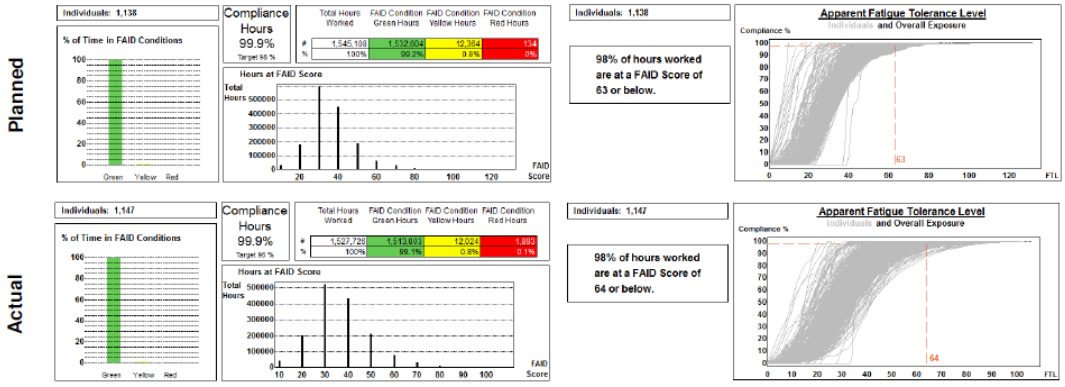
Data Collection

Airservices uses the following methods to gain assurance information which are categorized as to whether they are ongoing or are scheduled to support FRMS reviews, and whether they are a reactive, proactive or predictive assurance mechansim:

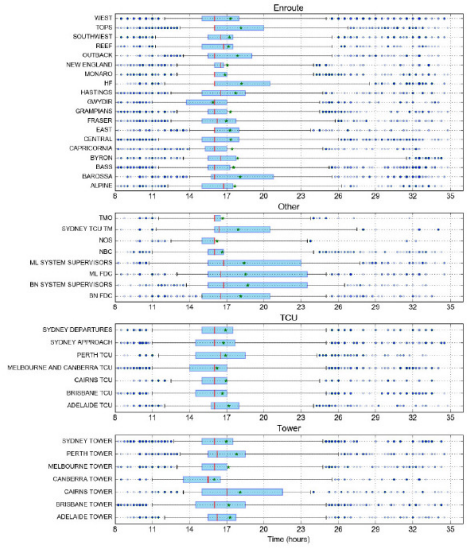
Ongoing

- fatigue hazard reports, which can be a self report, a concern about another controller or a system concern *(Reactive)*;

- safety occurrence reports and investigations *(Reactive)*;
- roster system data *(Predictive: bio-mathematical modelling of planned rosters, Proactive: comparison of planned versus actual bio-mathematical assessments)*



This diagram present the results of analysis of the differentials in bio-mathematical assessments of planned and actual 24 hour shifts for the year to June 2017

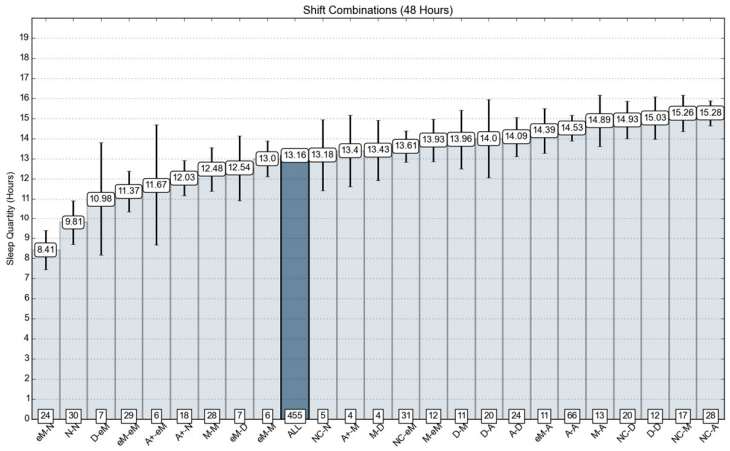


This diagram presents the actual Time off Between Consecutive Shifts in a block of shifts in those groups working 24 hour shifts in the year to June 2017. Rosters are planned on the basis of 11 hours between consecutive shifts in a shift block.

- review of air traffic services or industry operational experience and data collected on similar types of operations or from other industries with shift work or 24-hour operations *(Predictive)*

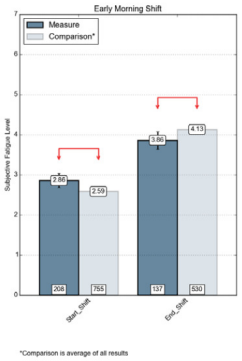
Scheduled

- Sleep studies in which ATCs wear Actigraphs for a prolonged period of time (see https://www.icao.int/safety/fatiguemanagement/Pages/Resources.aspx for more details of this study methodology). These studies are used to confirm that ATCs are achieving adequate sleep between rosters, and identify any combinations which do not provide adequate sleep opportunities (*Proactive)*;



This is a diagram presenting the amount of sleep achieved between shifts in the 24 hours to end of the second shift. The results were used as evidence that certain shift combinations needed to be removed as a rostering option.

- Surveys which use recognized measures to collect data about alertness or sleep propensity. To ensure long term data comparison within the organisation and with other industries, Airservices consistency uses to the following measures: Epworth Sleepiness Scales; Samn Perilli Alertness Scale *(Proactive)*



Samn Perelli 7-point scale	
1	Fully alert, wide awake
2	Very lively, responsive, but not at peak
3	Okay, somewhat fresh
4	A little tired, less than fresh
5	Moderately tired, let down
6	Extremely tired, very difficult to concentrate
7	Completely exhausted, unable to function effectively

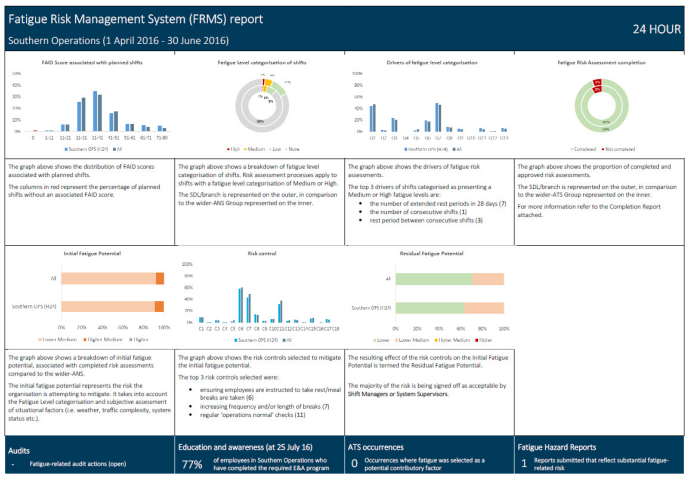
This diagram presents survey results from staff working an early morning shifts (commencing between 0500 and 0629)

- Education program completion (captured on a quarterly basis) *(Proactive)*
- Compliance audits *(Proactive)*

Reporting

Quarterly reports are developed for Operational Management which provide information:

- Bio-mathematical assessments of the planned and actual shifts worked;
- Numbers of shifts, and risk categories, worked with differing risk levels;
- Number of safety occurrences or audits which have raised fatigue related risk issues;
- Proportion of staff which have completed all required training



This diagram is an example of a quarterly management report

Such reports aim to provide evidence that the system is working as designed and is producing appropriate results.

Attribute	24-hour rosters	Non-24 hour rosters
Hours worked with a Peak FAID Score greater than 80[4]	0.1%	0%
Percentage of shifts with a Peak FAID Score greater than 80	1.1%	0%
98% of hours worked presented a FAID score at or below	65	52
Proportion of shifts subject to a fatigue risk assessment	5%	1%
Proportion of shifts categorised as presenting a Medium fatigue level	4%	1%
Proportion of shifts categorised as presenting a High fatigue level	1%	0%
Average shift length (hrs)	7.8	7.9
Average time off between consecutive shifts[5] (hrs)	17.2	15.7
Average time off between blocks of shifts[6] (hrs)	64.6	65.5

This diagram presents summarized results of the output of the system.

Since the implementation of the revised fatigue management approach, an annual (scheduled) reviews have been conducted with staff representatives to refine and evolve the system. Specific terms of reference are developed which reflect any particular concerns or opportunities which any party to the review believes needs to be considered. The review team have access to all data outputs, and may commission additional data to support its decision making. Recommendations to change any attribute of the approach must be confirmed by data or scientific evidence. The review outcomes and data are presented to staff to ensure transparency.

9.0 SUMMARY

The practices in this guide present an example of how one ANSP has used both external understanding of the science and how other industries manage fatigue risk and internally derived data from its robust assurance program to demonstrate that fatigue risk is managed and to continually refine its approach. The practices may not be appropriate for

other ANSPs as ATCs at Airservices are individually rostered rather than be scheduled as a team or crew which may allow ANSPs to consider different alternatives. Airservices believes its approach ensure that its risk tolerance is embedded, and risks are assessed, controlled and accepted in a standardized manner across its network.