Advisory Circular

Subject: **Fatigue Risk Management System Requirements**

Issuing Office:	Civil Aviation, Standards	Document No.:	AC 700-046
File Classification No.:	Z 5000-34	Issue No.:	02
RDIMS No.:	16449163 V.3	Effective Date:	2020-12-12

TABLE OF CONTENTS

1.0 INTRODUCTION

(1) This Advisory Circular (AC) provides information and guidance to comply with regulatory requirements. This AC on its own does not set minimum standards or change, create, amend or approve deviations from regulatory requirements.

1.1 Purpose

(1) This document explains the regulatory requirements related to Fatigue Risk Management Systems (FRMS) in the *Canadian Aviation Regulations* (CAR) Part VII, Division V.

1.2 Applicability

(1) This document applies to the holders of Air Operator Certificates in accordance with CAR 705, 704, 703 and 702.

1.3 Description of Changes

(1) Regulatory references updated to reflect current regulations;

(2) Definitions have been added and updated;

(3) Some appendices removed for inclusion as resources on new webpage for flight crew fatigue management;

(4) A number of editorial changes have also been made.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

(1) Reference materials for use with this AC include but are not limited to:

(a) Part VII, Subparts 0 and 2 of the Canadian Aviation Regulations – *Commercial Air Services*;

(b) Advisory Circular (AC) 700-045 – *Exemption and Safety Case Process for Fatigue Risk Management Systems*;

(c) Advisory Circular (AC) 700-047 – *Flight Crew Member Fatigue Management – Prescriptive Regulations*;

(d) Advisory Circular (AC) SUR-002 – *Root Cause Analysis and Corrective Action for TCCA Findings*;

(e) Transport Canada Publication, TP 14572, April 2007 – *An Introduction to Managing Fatigue*;

(f) Transport Canada Publication, TP 14573, April 2007 – *Fatigue Management Strategies for Employees*;

(g) Transport Canada Publication, TP 14574, April 2007 – *Employee Training Assessment*;

(h) Transport Canada Publication, TP 14575, April 2007 – *Developing and Implementing a Fatigue Risk Management System;*

(i) Transport Canada Publication, TP 14576, April 2007 – *Policies and Procedures Development Guidelines*;

(j) Transport Canada Publication, TP 14577, April 2007 – *Fatigue Audit Tools*;

(k) Transport Canada Publication, TP 14578, April 2007 – *Trainer's Handbook*;

(l) Transport Canada webpage, *Fatigue risk management in aviation*

(m) International Standards and Recommended Practices, *Operation of Aircraft — International Commercial Air Transport — Aeroplanes* (Annex 6, Part I to the Convention on International Civil Aviation);

(n) International Civil Aviation Organization Doc 9966, Second Edition, 2016 -- *Manual for the Oversight of Fatigue Management Approaches*;

(o) International Air Transport Association, International Civil Aviation Organization, and International Federation of Air Line Pilots' Associations -- *Fatigue Management Guide for Airline Operators*, Second Edition, 2015;

(p) International Business Aviation Council, International Civil Aviation Organization, and Flight Safety Foundation -- *Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes*, First Edition, 2016;

(q) International Air Transport Association - *Fatigue Safety Performance Indicators,* Edition One, 2014-01-15;

(r) Australian Government Civil Aviation Safety Authority – *Fatigue - The Rules Have Changed, 2016-11-21;*

(s) Australian Government Civil Aviation Safety Authority – *FRMS Integration, 2016-02-17;*

(t) Australian Government Civil Aviation Safety Authority – *Fatigue Risk Register*, 2016-11-21;

(u) Australian Government Civil Aviation Safety Authority – *Biomathematical Fatigue Models Guidance Document*, March 2014;

(v) Federal Aviation Administration Advisory Circular (FAA AC) 120-103A, 2013-06-05 – *Fatigue Risk Management Systems for Aviation Safety*

(2) Page numbers cited in the *Notes* throughout this AC refer to the edition/issue of the applicable document listed in section 2.1(1).

2.2 Cancelled Documents

(1) Not applicable.

(2) The publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) **Definitions** for use with this document are:

(a) **Accountable Executive**: The individual appointed by the certificate holder to be responsible for operations or activities authorized under the certificate and accountable on the certificate holder's behalf for meeting regulatory requirements.

(b) **Actigraph:** A wristwatch-like device containing an accelerometer to detect movement. Activity counts are recorded per unit time, for example every minute. The patterns of movement can be analyzed using purpose-built software to estimate when the wearer of the actiwatch was asleep, and to provide some indication of how restless a sleep period was (i.e. sleep quality). Actigraphs are designed to record continuously for several weeks

so they are valuable tools for monitoring sleep patterns, for example before, during, and after a trip or work pattern.

(c) **Alertness:** The extent to which a person is fully awake, aware, mentally responsive, and perceptive.

(d) **Audit:** An independent and objective process to verify the level of compliance with the FRMS and associated regulatory requirements, as well as identify areas requiring corrective actions or preventive measures.

(e) **Biomathematical:** The application of mathematical principles to biological processes.

(f) **Countermeasures:** Temporary actions that flight crew members can take as a defense in response to unexpected fatigue (e.g. caffeine)

(g) **Corrective actions:** Actions taken by an air operator to eliminate the cause or reduce the effects of an identified issue.

(h) **Document**: Certificates, manuals, work instructions, uncompleted checklists and any other papers or equivalent electronic publications that detail the organization's policies, processes and procedures, training curricula, etc. that are required to hold a Canadian Aviation Document (CAD). Documents exclude records.

(i) **Fatigue**: A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, physical activity or any combination thereof, that may impair a flight crew member's ability to safely operate an aircraft or perform safety-related duties.

(j) **Fatigue-related hazard**: A work-related source of potential fatigue that could cause a fatigue-related error and contribute to an aircraft incident or accident.

(k) **Fatigue Modelling**: A method to predict an average level of flight crew member fatigue or alertness for a work schedule, based on scientific understanding of factors contributing to fatigue.

(l) **Fatigue risk**: The assessed likelihood and severity of the consequence(s) that could result from a fatigue-related error caused by a fatigue-related hazard.

(m) **Fatigue risk controls**: Actions taken by an air operator to prevent an adverse effect of the variance on an ongoing basis.

(n) **Fatigue Risk Management System**: A scientifically based, data-driven set of integrated management practices, beliefs and procedures for identifying and managing fatigue and safety risks. An FRMS allows a systematic and structured approach to implementing processes to prevent and manage fatigue, and to audit the control processes for effectiveness and compliance.

(o) **Fatigue-related event**: An error, contravention, occurrence, incident, or accident related to an undesired action or inaction by a flight crew member who was probably in a fatigued state.

(p) **Human and Organizational Factors**: The relationship between people, their working environment, and the organization's system(s).

(q) **Inputs**: People, products, services, materials, resources, and information used to produce the required outputs of a process.

(r) **Likelihood**: A measurement of the chance that a fatigue-related error caused by a fatigue hazard will occur and result in a specific consequence.

(s) **Mitigation measures**: Actions taken by an air operator to remedy an adverse effect of the variance on an ongoing basis.

(t) **Outputs:** Products, services, information, and/or materials provided to stakeholders (internal/external) from a process.

(u) **Preventive measures**: Actions taken by an air operator to prevent the recurrence of an identified issue.

(v) **Prescriptive requirements**: The flight and duty time limitations and rest period requirements contained in Part VII, Subpart 0 Divisions III and IV and Subpart 2 Division X of the *Canadian Aviation Regulations*.

(w) **Record**: The specific details of events that have occurred during the performance of activities authorized by a CAD. Records include (but are not limited to) hazard registers, risk assessments, completed checklists, audit findings, training records, and submissions made under internal fatigue reporting systems.

(x) **Regulatory requirements:** The *Canadian Aviation Regulations* and standards.

(y) **Review:** An independent and objective process to evaluate the effectiveness of the FRMS and its performance in achieving safety objectives, as well as identify areas requiring improvement.

(z) **Safety**: The condition to which risks associated with aviation activities are managed to an acceptable level.

(aa) **Safety case**: An air operator's structured written argument, validated by scientific and operational evidence, to justify that the variance from specific prescriptive provisions described in the notice of intent does not increase the level of fatigue or decrease the level of alertness of the flight crew members and that fatigue risks associated with the flight are safely managed.

(bb) **Safety culture**: The set of enduring values, norms, attitudes and practices regarding safety issues, shared by employees at every level of an organization. In a positive safety culture, a shared concern for, commitment to, and accountability for safety is promoted.

(cc) **Safety management system**: A documented system for managing risks that integrates operations and technical processes with the management of financial and human resources to ensure aviation safety or the safety of the public.

(dd) **Safety performance**: An organization's safety achievement as defined by its safety performance indicators and targets.

(ee) **Safety performance indicator**: A data-based parameter used for monitoring and assessing safety performance and fatigue risk control effectiveness.

(ff) **Safety performance target**: The planned or intended objective for a safety performance indicator over a given period.

(gg) **Scientific Studies**: Original systematic research relating to fatigue and human performance that has been tested for validity through scientific method and has been published in a reputable, peer-reviewed scientific journal or by an accredited body.

(hh) **Severity**: A measurement of the impact on the air operator of a specific consequence that could result from a fatigue-related error caused by a fatigue-related hazard.

(ii) **System**: A group of interdependent processes and people working together to achieve a defined result. A system comprises policies, processes and procedures.

(jj) **Unforeseen operational circumstances**: An event, such as unforecasted adverse weather, an equipment malfunction, or air traffic control delay, which is beyond the control of an air operator.

(kk) **Variance**: A specific deviation from prescriptive requirements permitted by an initial or continuing exemption.

(ll) **Window of Circadian Low**: The period of time between 02:00 and 05:59 at a location where the flight crew member is acclimatized.

(mm) **Work Schedule**: Planned hours of work within a defined period of time.

(2) The following **abbreviations** are used in this document:

(a) **AE**: Accountable Executive

(b) **AC**: Advisory Circular

(c) **AOC**: Air Operator Certificate

(d) **BMM**: Biomathematical (fatigue) model

(e) **CAD**: Canadian Aviation Document

(f) **CAR**: Canadian Aviation Regulations

(g) **CASA**: Civil Aviation Safety Authority of Australia

(h) **CLC:** Canada Labour Code

(i) **COM:** Company Operations Manual

(j) **EASA:** European Aviation Safety Agency

(k) **FAA:** Federal Aviation Administration of the United States

(l) **FRMS**: Fatigue Risk Management System

(m) **ICAO**: International Civil Aviation Organization

(n) **SARPs:** ICAO Standards and Recommended Practices

(o) **SMS**: Safety Management System

(p) **SPI**: Safety Performance Indicator

(q) **TCCA**: Transport Canada Civil Aviation

(r) **WOCL:** Window of Circadian Low

3.0 BACKGROUND

3.1 FRMS History

(1) FRMS was introduced into the ICAO Standards and Recommended Practices (SARPs) in 2009 as an alternate approach to prescriptive requirements to manage flight crew fatigue.

(2) In 2010, Transport Canada arranged a working group to review the new prescriptive requirements in the SARPs and the fatigue risk management requirements. The working group provided recommendations in relation to the existing flight, duty and rest requirements in the CARs and recommended adopting FRMS as an alternate form of fatigue management.

(3) Updated requirements for managing flight crew fatigue were published in the *Canada Gazette*, Part II on 12 December 2018.

(4) Upon coming into force, the FRMS provisions in Part VII, Division V are available to all air operators regulated under Part VII of the CARs, including those conducting medical evacuation flights.

(5) CAR 604 operators remain unaffected by the new requirements unless they also operate aircraft under CAR 705, 704 or 703.

Note: Guidance on complying with the prescriptive flight, duty and rest requirements can be found in AC 700-047 (Flight Crew Fatigue Management – Prescriptive Limitations).

3.2 Why FRMS?

(1) Flight crew fatigue is a hazard that can contribute to aviation accidents or incidents. Fatigue management refers to how operators address the aviation safety implications of fatigue. Flight and duty time limitations and rest requirements traditionally have provided the regulatory basis for managing fatigue. However, they are a one-size-fits-all approach that does not take into account operational differences. Transport Canada recognizes that flight crew fatigue management is a complex issue and the prescriptive requirements may not be the best solution in all operations.

(2) ICAO SARPs Annex 6 Part I require member States to establish scientifically-based flight and duty time limitations. They also provide a framework for States to allow air operators to implement an FRMS as an alternative to the prescriptive requirements, provided that flights conducted under the FRMS do not adversely affect the levels of fatigue or alertness of flight crew members.

3.3 Using an FRMS to manage fatigue

(1) FRMS implementation is mandatory only when an air operator wishes to use an exemption from specific prescriptive requirements to conduct a flight or series of flights.

(2) The FRMS provisions in Part VII, Division V of the CARs contain a mechanism for an air operator to vary from specific prescriptive requirements using an exemption to conduct a flight if:

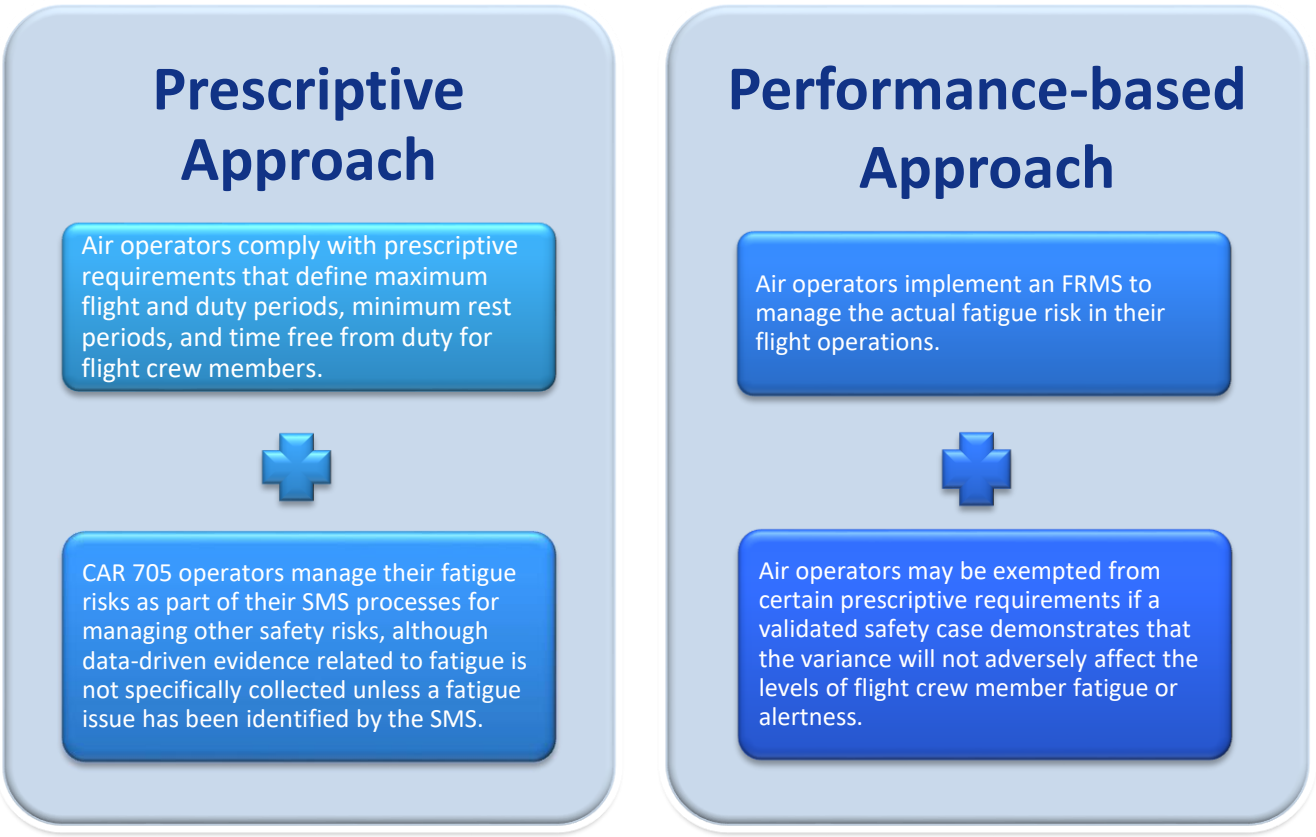
(a) All requirements of CAR 700.200 to 700.259 are met; and

(b) A validated safety case for each exemption demonstrates that the variance will not adversely affect the levels of fatigue or alertness of flight crew members.

Note: Guidance on developing and validating a safety case can be found in AC 700-045 (Exemption and Safety Case Process for FRMS).

(3) Part VII of the CARs contains the two compliance approaches for managing flight crew fatigue, shown in figure 1:

Figure 1 – Flight Crew Fatigue Management Approaches



4.0 KEY CONCEPTS ABOUT FRMS

4.1 What does an FRMS consist of?

(1) The four components of an FRMS are:

(a) Fatigue Risk Management Plan – CAR 700.215

(b) Fatigue Risk Management Process – CAR 700.216

(c) Fatigue Risk Management Promotion Program – CAR 700.218

(d) Fatigue Risk Management System Quality Assurance Program – CAR 700.219

(2) To benefit from an exemption, an air operator must show that they meet the conditions and requirements in CAR 700.200 to 700.259. These include the four components of an FRMS and their associated requirements, which are summarized in Figure 2.

Figure 2 – FRMS Components

4.2 What are the benefits of an FRMS?

(1) FRMS provides a more flexible operating environment than the prescriptive requirements, and may enable:

(a) Increased efficiency by customizing prescriptive requirements to better fit unique operating environments;

(b) Improved safety through the use of advances in scientific knowledge for more informed decision-making in managing fatigue;

(c) Other potential benefits such as:

(i) Reduced fatigue-related errors, incidents and accidents, which may be associated with financial costs and/or impact an air operator's reputation;

(ii) Reduced insurance costs if an air operator can demonstrate that fatigue risk is being managed effectively;

(iii) Reduced absenteeism previously related to fatigue;

(iv) 'Fatigue friendly' work schedules that attract and retain flight crew as a result of an improved work/life balance, and improve mental and physical health;

(v) Increased morale when work-related fatigue is more effectively managed.

4.3 What key qualities are evident in an organization with an effective FRMS?

(1) An effective FRMS shows that an air operator is committed and responsible to proactively manage flight crew fatigue. Organizations with an effective SMS and FRMS normally have a positive safety culture, which is key to successful fatigue reporting and functioning of the FRMS. It shows:

(a) A top-down commitment from management and a personal commitment from all flight crew members to reduce the fatigue and fatigue risk;

(b) A clear picture of what the FRMS is, what it is supposed to accomplish, and how it is supposed to achieve its aims;

(c) An effective fatigue reporting culture where personnel have been trained and are encouraged to confidentially report fatigue-related hazards openly in an environment of trust; and

(d) An organizational safety culture that continuously strives to improve.

4.4 Does your organization need an FRMS?

(1) If your organization is able to adjust its flight operations to comply with the prescriptive requirements and fatigue risk is low, implementing an FRMS may not be practical.

(2) However, using an FRMS can lead to a better understanding and awareness by management and flight crew of the impact of fatigue on safe operations, and ultimately reduce the level of fatigue risk.

(3) There is no "off-the-shelf" FRMS; it must be tailored to each organization's needs and unique operating conditions. The complexity of an FRMS will vary according to:

(a) The size, type and complexity of the organization and its operations; and

(b) The nature and level of the fatigue risks managed by the FRMS.

4.5 Whose responsibility is it?

(1) Regardless of how your organization chooses to manage fatigue and fatigue risk, the responsibility is shared between management and flight crew members. Whereas the organization manages work-related fatigue and fatigue risk, the employees manage non work-related fatigue and fatigue risk. These joint responsibilities are described in more detail in section 5.4.

(2) The intent of the FRMS requirements is explained in the following sections.

Note: Further information can be found in TCCA's FRMS Toolbox, the links to which are in Appendix A of this AC.

5.0 FATIGUE RISK MANAGEMENT PLAN – COMPONENT 1

(1) CAR 700.214(1)(a) requires your FRMS to include a fatigue risk management plan. The purpose of this plan is to outline your organization's commitment and approach to managing fatigue risks specific to your organizational context and operational needs.

(2) Essentially, your fatigue risk management plan is a road map. It explains to employees, management and TCCA how your FRMS works, who is responsible for it, and how it will be monitored and measured to assess whether it is working effectively.

Note: Guidance for designing and writing your FRMS policy, procedures and processes can be found in TP 14576 It provides information on the intent of the policy, points to consider, and sample text.

5.1 Fatigue Risk Management Policy

(1) CAR 700.215(a) requires your fatigue risk management plan to include a fatigue risk management policy, signed by the AE. This policy is a high level statement of your organization's commitment to FRMS and identifies the scope, purpose, and objectives of your FRMS. By signing the FRMS policy, your AE accepts accountability for the FRMS, including the allocation of adequate resources to maintain an effective FRMS.

Note: Examples of FRMS scope statements can be found on page 83 of Fatigue Management Guide for Airline Operators.

(a) Your fatigue risk management policy must establish the shared responsibility of management and flight crew members in managing fatigue. The specific responsibilities are not set out in regulation. They must be jointly determined and agreed to by management and flight crew in order to establish a policy that will work in your organization. Some examples of these responsibilities are provided in Section 5.4.

Note: Examples of shared responsibilities can also be found on page 37 of *Fatigue Management Guide for Airline Operators*.

(b) Your fatigue risk management policy must be signed by your AE to indicate senior management commitment to fatigue management. Your AE should communicate the policy with visible endorsement to all relevant areas and levels of your organization.

Note: Examples of an FRMS policy can be found on pages 86-87 of *Fatigue Management Guide for Airline Operators*, and on page 8 of *Fatigue - The Rules Have Changed*.

5.2 Safety Objectives

(1) CAR 700.215(b) requires your fatigue risk management plan to include safety objectives, which clearly define what your organization plans to achieve with the FRMS. Safety objectives are statements of desired outcomes for specific operational activities and FRMS processes. These include identifying fatigue-related hazards, reducing fatigue risks and effectively managing fatigue in your flight operations.

(2) Safety objectives need to be specific, measurable, and realistic, and tailored to the size and complexity of your organization. Example FRMS objectives could include:

- Proactively manage fatigue risks in flight operations in order to maintain a safe operation;
- Provide adequate flight crew member training and resourcing to avoid, detect and mitigate fatigue impairment;
- Encourage fatigue reporting and act on fatigue-related hazards and fatigue-related events within the specified timeframe to minimize the chance of recurrence;

- Maintain awareness and application of contemporary fatigue research as part of continuous improvement of the FRMS; and
- Ensure all areas of the organization feel well represented in the FRMS processes and decision-making.

5.3 Safety Performance Indicators

(1) CAR 700.215(c) requires your fatigue risk management plan to include safety performance indicators (SPI) to measure attainment of safety objectives. These indicators are individual measures to monitor the performance of your FRMS and the effectiveness of fatigue risk controls and mitigation measures. The key steps in safety performance monitoring are shown in Figure 3.

Figure 3 – Steps in Safety Performance Monitoring

(2) **Identify Safety Performance Indicators** - Each safety objective needs to be measured with at least one safety performance indicator and associated safety performance target. Select SPIs that reflect:

(a) The changes your organization wants to advance and the processes you need to monitor; and

(b) The type of feedback needed to adequately evaluate your organization's fatigue risk controls and mitigation measures.

(3) **Set Values/Targets** - For SPIs to be useful in decision-making, acceptable values or targets need to be set for each SPI. Defined targets will help you establish whether your organization has made the desired improvement. Safety performance values/targets need to be quantifiable, achievable, and have time components.

Note: Example SPIs can be found on TC's fatigue risk management webpage *Fatigue-related-safety-performance-indicators-air-operators* Examples of acceptable values/targets for SPIs can be found on page 78 of *Fatigue Management Guide for Airline Operators*, and an example of safety performance targets for safety objectives can be found on page 9 of *Fatigue - The Rules Have Changed*.

(4) **Collect Data** - Determine what data is required to measure safety performance and fatigue risk controls. Decide how, when and who will collect, analyze and compile the data, and report the results. Sources of data may include:

(a) Planned versus actual work schedules;

(b) Fatigue reports and investigation results;

(c) Fatigue and alertness testing results and fatigue surveys; and

(d) FRMS audit and review findings.

Note: Examples of data collection methods and SPIs can be found in *Fatigue Safety Performance Indicators*.

(5) **Evaluate Performance** -

(a) Measure actual performance against the target level, using the data collected for each SPI. Analyze the data collected to determine whether:

(i) All safety performance targets are being met; and

(ii) All SPIs for fatigue risk controls remain in the 'acceptable' region defined in your risk assessment process.

(b) Evaluate trends in SPIs to identify deviations from targets and expected safety outcomes. Trends may be identified over individual duties, patterns of work, periods of time (e.g. weekly trends, seasonal trends, yearly trends), and in relation to specific locations, types of operations or groups of employees.

Note: Examples of trend analysis output can be found on pages 73 and 79 of the *Fatigue Management Guide for Airline Operators*.

(c) Report safety performance results and comparisons, e.g. monthly to the FRMS committee, quarterly to the AE, and annually to stakeholders. As additional data is collected each year, use the data to refine SPIs and safety performance targets in order to set more realistic and specific measures.

(6) **Take Action** - When safety performance targets are not met or when SPIs for fatigue risk controls are not at the defined acceptable level, take corrective action to attain safety objectives. This could involve:

(a) Gathering information and investigating the cause;

(b) Checking whether fatigue-related training is being delivered as expected;

(c) Re-evaluating fatigue-related hazards and associated risks;

(d) Identifying, implementing, and evaluating new and/or revised fatigue risk controls;

(e) Reviewing compliance with FRMS processes; and/or

(f) Determining whether each SPI is still an appropriate measure of FRMS safety performance.

5.4 Fatigue Management Responsibilities

(1) CAR 700.215(d) requires your fatigue risk management plan to include defined responsibilities related to managing fatigue for: management, person(s) managing the FRMS, and other employees, such as flight crew members, and crew schedulers and planners. The purpose is to establish clear accountabilities and defined roles.

(2) Establish an appropriate organizational structure to ensure the effective functioning of your FRMS. Define clear decision-making authorities and lines of communication for all involved personnel.

Note: An example of a reporting structure can be found in Section 2.2 of TP 14576.

(3) As fatigue management is a shared responsibility, flight crew participation is needed for the program to work. In order to gain the voluntary cooperation needed for flight crew performance data collection, it may be necessary to crew the flights where data is to be collected with volunteer flight crew members.

(4) CAR 700.213(2) assigns responsibility to your Operations Manager to ensure your FRMS is compliant with regulatory requirements.

(5) Flight crew members are responsible to report for duty sufficiently well-rested to be able to safely perform their duties, in accordance with CAR 602.02.

(6) Other examples of fatigue management responsibilities include:

(a) Management:

(i) Provide an operational environment that promotes an open and fair reporting culture;

(ii) Develop and implement work schedules that minimize fatigue;

(iii) Monitor and manage fatigue risks;

(iv) Accept the displacement of a flight crew member from flight duty if he/she is too fatigued to perform his/her duties safely, in accordance with CAR 700.26;

(v) Encourage cooperation from flight crew members to measure fatigue levels;

(vi) Provide annual FRMS training to all relevant personnel, including management and the AE;

(vii) Provide adequate resources and authority to meet FRMS requirements; and

(viii) Continuously improve the FRMS.

(b) Person(s) managing the FRMS:

(i) The person managing the FRMS is the focal point for implementing and maintaining your FRMS. Depending on the size of your organization, this role may be carried out by:

(A) A designated person; or

(B) A committee representing all stakeholders within the organization (e.g. flight operations management, scheduling staff, flight crew, and specialists with access to scientific, statistical, and medical expertise).

Note: In smaller organizations, a single individual may represent more than one stakeholder (e.g. both a flight crew member and a scheduler).

(ii) Key responsibilities of the person(s) managing the FRMS may include:

(A) Develop and implement your FRMS;

(B) Oversee the ongoing operation of your FRMS processes and monitor FRMS performance;

(C) Maintain your FRMS documentation; and

(D) Provide ongoing FRMS training and communication.

(iii) The person(s) managing the FRMS may not need to be engaged full-time on FRMS, but they will need to be allocated a balance of duties which allow them sufficient time to oversee the FRMS.

Note: An example Terms of Reference for an FRMS committee can be found on page 137 of the *Manual for the Oversight of Fatigue Management Approaches*.

(c) Flight crew members:

(i) Manage their own fatigue levels;

(ii) Make appropriate use of rest periods in order to be adequately rested and fit for duty;

(iii) Alert management and submit fatigue reports when too fatigued to perform his/her flight duties safely;

(iv) Decide when to use countermeasures to lessen the risks of personal fatigue while on duty;

(v) Complete FRMS-related training;

(vi) Report fatigue, fatigue-related hazards and fatigue-related events; and

(vii) Participate when fatigue and alertness levels and sleep data need to be measured to perform analysis on the effect of the variance, in accordance with CAR 700.225(2)(g), and as referenced in AC 700-045, section 6.3.5.

Note: Examples of flight crew member responsibilities can be found in Section 2.3 of TP 14576.

(d) Fatigue Safety Action Group (FSAG):

(i) Although not a regulatory requirement, it is recommended that where appropriate, a fatigue safety action group be established. This group has responsibility to coordinate fatigue management activities, such as overseeing the development of the FRMS, assisting in its implementation and overseeing its ongoing operation. This group would typically comprise representatives from management, scheduling staff, flight crew and other specialists as needed.

Note: More information on the establishment of an FSAG can be found on pages 5-4 to 5-6 of the *Manual for the Oversight of Fatigue Management Approaches*

5.5 Training Plan

(1) CAR 700.215(e) requires your fatigue risk management plan to include a training plan that identifies the content of the initial and annual training. The purpose is to ensure that all personnel whose role could influence flight crew fatigue are trained and competent to perform their roles effectively in your FRMS.

(2) Refer to the steps in the training program development process in section 7.1 of this AC.

5.6 Communication Plan

(1) CAR 700.215(f) requires your fatigue risk management plan to include a plan for communicating fatigue-related information to flight crew members. The purpose is to identify the types of information to be communicated, objectives, responsibilities, audience, methods of delivery, and schedule for FRMS communication activities. To achieve this, your communication plan should address at least the following areas:

(a) What fatigue-related information needs to be communicated?

(i) CAR 700.218(4)(a) to (f) requires the following information to be communicated to employees:

(A) Industry reports on fatigue;

(B) Industry best practices in fatigue risk management;

(C) Advancements in fatigue-related science;

(D) Results of data analysis from your fatigue risk management process, as referred to in CAR 700.216(2);

(E) Updates to your FRMS; and

(F) Results of the review of your FRMS.

Note: Communication of industry reports on fatigue, FRM best practices, and updates to fatigue-related science should focus on those used in support of your FRMS processes.

(ii) Examples of related information to communicate include:

(A) FRMS policies, procedures, objectives and responsibilities; and

(B) Recent fatigue-related events, fatigue-related hazards and investigation results.

(b) What do you want to accomplish by communicating this information?

(i) Examples of objectives for various communication activities may include:

(A) Providing timely information on FRMS-related activities, trends, corrective actions, scheduling policy changes, and fatigue management tips for flight crew members;

(B) Reminding all personnel that fatigue management is a shared responsibility and encouraging continued commitment to your FRMS processes;

(C) Fostering greater awareness of fatigue risk in your operations; and

(D) Encouraging feedback to improve the effectiveness of your FRMS.

(c) Who needs to receive fatigue-related information?

(i) Examples of stakeholder groups include flight crew members, crew schedulers and dispatchers, operational decision-makers, personnel involved in fatigue risk assessment activities, FRMS auditors/reviewers, and senior management.

(ii) Key messages should be tailored to the needs and roles of different stakeholder groups, to convey information that is relevant, practical, clear and concise.

(d) Who will be communicating the information?

(i) Examples may include the AE, the person(s) managing your FRMS, operational management, etc.

(e) How will the information be distributed?

(i) Examples of delivery methods may include email, text message, blogs, posters, safety notice boards, newsletters, bulletins, websites, online forums, e-zines, videos, briefings, presentations, meetings and videoconferences.

(ii) Leverage existing communication processes that are effective and appropriate to your organization's structure and complexity.

(f) When and how often do you plan to communicate fatigue-related information?

(i) Timing and frequency should correspond to how critical the information and required actions are to safety.

(g) How you will measure the results of your communication activities?

(i) Periodically monitor the effectiveness of your communication strategies to ensure all affected stakeholders are receiving and understanding the information they need. Adjust your communication plan accordingly.

Note: An example of a communication plan excerpt can be found on page 10 of *FRMS Integration*.

5.7 Internal Fatigue Reporting Policy

(1) CAR 700.216(1)(a) requires your fatigue risk management process to include procedures for the internal reporting of fatigue by flight crew members. CAR 700.215(g) requires you to set a policy whereby flight crew members who report fatigue do not fear reprisal for doing so. The purpose is to foster trust that the intent of the reporting process is to improve safety, not to assign blame. Flight crew members are more likely to report fatigue and cooperate in an internal investigation

when they know that confidentiality will be maintained, their reports will be acted upon, and they do not fear reprisal for reporting fatigue.

(2) An effective internal fatigue reporting policy is based on open communications and a positive safety culture which builds confidence in your reporting system. To foster a positive safety culture, actively and consistently encourage internal fatigue reporting by flight crew members.

(3) CAR 700.217 requires you to have a process to collaborate with employees on the development of the internal fatigue reporting policy and procedure. The intent is that users of the reporting system be able to provide their input into its design. It is expected that the output of this collaborative process will provide a clear definition of reprisal, and an explanation of what constitutes it, with examples. Your internal fatigue reporting policy should give all stakeholders a clear understanding:

(a) that flight crew members are expected to report fatigue, fatigue-related hazards and fatigue-related events;

(b) that fatigue reports are kept confidential to protect the privacy of reporters;

(c) that flight crew members are protected from reprisal for reporting fatigue, and.

(d) of the defining line between acceptable performance (which can include unintended errors) and unacceptable performance (such as negligence, recklessness, violations).

Note: An example of an internal fatigue reporting policy can be found in Section 3.7 of TP 14576.

(4) An acknowledgment in writing must be provided to flight crew members for each submitted fatigue report, advising of follow-up actions.

6.0 FATIGUE RISK MANAGEMENT PROCESS – COMPONENT 2

(1) CAR 700.200(1)(b) requires your FRMS to include a fatigue risk management process. The purpose is to identify, assess and control fatigue risks in your flight operations. This is a data-driven process which uses reactive, proactive, and predictive data to monitor and manage fatigue risks.

6.1 Fatigue-Related Hazard Information:

(1) CAR 700.216(1)(c) requires that procedures be established to collect information to identify fatigue-related hazards from multiple sources, including:

(a) Flight crew member performance data;

(b) Accident or incident information;

(c) Data from work schedules;

(i) This is to ensure work schedules provide sufficient sleep opportunity by considering factors known to affect sleep and fatigue, for example:

(A) length and timing of flight duty period;

(B) length and timing of breaks;

(C) number of days worked in a row;

(D) number of days off between flight duty periods;

(ii) The data can be assessed using a computer-based biomathematical modelling for fatigue, or manually by use of a fatigue likelihood scoring matrix.

Note: More information on assessing data from work schedules can be found in Section 3.3 of TP 14576. A sample fatigue scoring matrix is found in Appendix C of this AC.

(d) Comparisons of planned schedules in relation to time worked; and

(e) Data from a review of flight crew members' operational and administrative duties.

6.2 Safety Data and Scientific Studies

(1) CAR 700.216(1)(d) requires your fatigue risk management process to include procedures to develop a list of the safety data and scientific studies used:

(a) in support of your FRMS processes, and

(b) to demonstrate that the variance is not likely to have an adverse effect on the levels of fatigue and alertness of flight crew members, in accordance with CARs 700.206(1)(e) and 700.225(2)(f)

Note: A list of scientific studies related to fatigue and human performance is available on the TC webpage *Fatigue risk management in aviation*.

(2) The purpose is to consider external sources of validated information for relevance to your FRMS operations, to keep up to date with changes in the state of knowledge of fatigue risk management, and to ensure the FRMS is based on valid scientific principles..

(3) Sources of safety data include databases maintained by transportation safety boards, civil aviation authorities, or aviation industry associations.

(4) There are resources available to assist air operators in researching the availability and applicability of up-to-date scientific studies for their operation, such as industry associations, universities and other research institutes.

(5) Some examples of organizations conducting research include the following:

(a) Center for Sleep & Human Performance (Calgary, Alberta)

(b) Centre d'études avancées en médecine du sommeil CÉAMS (Université de Montréal, Québec)

(c) London Health Sciences Centre Sleep Medicine Clinic and Lab (London, Ontario}

(d) Sleep, Cognition & Neuroimaging Laboratory SCNLab (Concordia, Montréal, Quebec)

(e) Sleep Research Laboratory (University of Ottawa, Ontario)

6.3 Fatigue Data and Information Management

(1) CAR 700.216(1)(e) requires your fatigue risk management process to include procedures for managing the associated data and information. This is important because effective fatigue management is data-driven. A database or software program is a valuable tool for monitoring and managing fatigue data and information resources.

(2) Your organization's information management system should provide functions to:

(a) Record fatigue data, analysis, actions, and decisions;

(b) Track progress on managing reported fatigue-related hazards and fatigue-related events; and

(c) Maintain the fatigue hazard/risk register.

(3) Your fatigue data and information management procedure should explain:

(a) Types of fatigue data and information to be captured and managed by your system;

(b) Data collection consent and non-disclosure protocols;

Note: The consent that is required for the collection of flight crew member performance data, and the requirement to obtain that consent and use the data for stated purposes only, is covered under the *Personal Information Protection and Electronic Documents Act* (PIPEDA), which is governed by the Office of the Privacy Commissioner of Canada. This is a link to their legislation and related regulations, PIPEDA.

(c) Fatigue data de-identification mechanisms;

(d) Protocols for management of outsourced data analysis;

(e) Storage, backup, archiving, retrieval, retention and disposition requirements;

(f) Associated roles and responsibilities; and

(g) Internal protection provisions governing fatigue data and information, such as:

(i) Who in your organization is authorized to access your system's fatigue data and information;

(ii) What internal use(s) of fatigue data and information are authorized (e.g. corrective action and preventive measures to address safety issues and minimize exposure to fatigue risks);

(iii) With whom fatigue data and information can be shared internally, and for what purpose;

(iv) How internal security and confidentiality of fatigue data and information will be maintained.

Note: Examples of effective practices in information protection can be found on pages 20-21 of the Global Safety Information Project's *GSIP Toolkits*, Level 1.

6.4 Assessing Levels of Fatigue and Alertness

(1) CAR 700.216(1)(f) requires you to identify and assess flight crew member levels of fatigue and alertness with respect to their schedules, through modelling. This can be achieved using a biomathematical model or through a manual modelling method.

6.5 Analysis of Work Schedules

(1) Data on actual work periods can identify times when fatique may have been higher than expected from the planned schedule. CAR 700.216(1)(g) requires you to analyze planned work schedules in relation to the actual time worked in order to assess whether fatigue is being managed.

6.6 Fatigue Risk Assessment Process

(1) A fatigue risk assessment is a structured, evidence-based assessment of the likelihood that fatigue could reduce the ability of an individual, who is otherwise fit to work, to maintain the levels of attention and cognitive performance necessary to perform an assigned activity to the expected standard during a defined period of time.

(2) The approach to performing a fatigue risk assessment will depend on why the assessment is being performed, and its scope and complexity. A risk assessment may be needed for a particular duty or work pattern, or it could be required to assess the risk of a particular flight or major organizational change.

(3) It is essential to identify:

(a) The hazard itself – what is the thing or condition that could cause harm?

(b) What can happen and how as a result of the hazard? What would it look like?

(c) What are the consequences – who could be affected and how?

Figure 4 - Steps in Fatigue Risk Assessment

6.6.1 Identify Hazard and Causes

(1) The starting point of risk management is identifying hazards. CAR 700.216(1)(c) requires your fatigue risk management process to include a procedure to collect information to identify fatigue hazards and their causes.

(2) To achieve this, your FRMS needs to include three types of hazard identification:

(a) **Predictive** – To identify fatigue-related hazards in future operations.. Methods of predictive hazard identification may include:

(i) Previous internal or industry experience and fatigue data collected for similar flights (in sufficient quantities to represent a trend or tendency);

(ii) Evidence-based scheduling practices; and

Note: Examples of evidence-based scheduling practices can be found in section 6.1(4) of this AC.

(iii) Fatigue modelling of flight crew members' schedules to identify and assess levels of fatigue and alertness, per CAR 700.216(1)(f).

Note: Guidance on predictive hazard identification methods can be found on pages 5-10 to 5-12 of the *Manual for the Oversight of Fatigue Management Approaches*, and pages 53-54 of the *Fatigue Management Guide for Airline Operators*. Considerations for fatigue modelling can be found in section 6.0 of this AC.

(b) **Proactive** – To identify fatigue-related hazards in current operations. Methods of proactive hazard identification may include:

(i) Fatigue-related hazard reports;

(ii) Flight crew fatigue surveys;

(iii) Analysis of planned versus actual hours worked and rest periods;

(iv) Flight crew member fatigue and alertness data and sleep data, examples include:

(A) fatigue surveys,

(B) sleep diaries or sleep tracking records,

(C) actigraphy,

(D) performance and alertness measurements. e.g.

(I) the Karolinska sleepiness scale (KSS) which measures the subjective sleepiness of an individual at a particular time,

(II) the Samn-Perelli fatigue scale (SPS) which measures the subjective fatigue level of an individual at a particular time; and

(III) a Psychomotor Vigilance Test (PVT) which is a sustained-attention, reaction-timed task that measures the speed with which subjects respond to a visual stimulus to evaluate alertness and vigilance.

(v) Fatigue-related hazard information from industry associations;

(vi) Industry or sector-specific fatigue hazard registers; and

(vii) Safety databases and scientific studies.

Note: Guidance on proactive hazard identification methods can be found on pages 5-12 to 5-15 of *Manual for the Oversight of Fatigue Management Approaches*, and pages 55-61 of *Fatigue Management Guide for Airline Operators*.

(c) **Reactive** – To identify fatigue-related hazards in previous operations by assessing the contribution of flight crew member fatigue to errors and events that have occurred. Triggers for reactive hazard identification may include:

(i) Fatigue-related event reports;

(ii) Audit reports;

(iii) Incident and accident investigations; and

(iv) Correlated operational errors from analysis of aircraft flight data monitoring.

Note: Guidance on reactive hazard identification methods can be found on page 5-18 of the *Manual for the Oversight of Fatigue Management Approaches*, and page 61 of the *Fatigue Management Guide for Airline Operators*.

(3) CAR 700.216(2)(a) requires your fatigue risk management process to include a procedure to identify the cause of fatigue-related hazards. The purpose is to identify operational factors that are likely to cause flight crew member fatigue in your operations. Examples of common factors in aviation operations that may affect fatigue risk include:

(a) Length of flight duty periods

(b) Number of flights/sectors in each flight duty period

(c) Length and timing of breaks

(d) Number of consecutive flight duty periods

(e) Rest periods between flight duty periods

(f) Number of hours of night duty

(g) Early duty start times and late duty end times

(h) Number of time zones crossed per 24 hours

(i) Duration and timing of layovers in different time zones

(j) Split sleep patterns

(k) Multiple high workload periods in a flight duty period

(l) High density airspace

(m) Unplanned extension of flight duty periods

(n) Pre and post-flight duties assigned to flight crew members.

(o) Insufficient / poor quality sleep

(p) Task overload

Note: A summary of causes of flight crew fatigue identified in daytime short-haul, domestic night cargo, and long-haul operations can be found on pages 50-52 of the *Fatigue Management Guide for Airline Operators*.

(4) Evidence-based scheduling practices – General scheduling principles can be used by a scheduler trained in fatigue-related hazard identification, to develop evidence-based scheduling rules.

(a) Record the scientific basis for the scheduling rules in your organization's FRMS documentation.

(b) Validate this approach by monitoring the reported or estimated levels of fatigue across work schedules, using roster metrics.

(c) Use the validation data to refine and improve your evidence-based scheduling rules.

(d) Examples of these principles based on fatigue science include:

(i) The perfect schedule for the human body is daytime duties with unrestricted sleep at night;

(ii) The circadian body clock does not adapt fully to night work;

(iii) The circadian body clock adapts progressively to a new time zone, but full adaptation usually takes longer than the 24-48 hours of most layovers;

(iv) Whenever a duty period overlaps WOCL, it can be expected to restrict sleep. Examples include early duty start times, late duty end times, and night work;

(v) Across consecutive duties with restricted sleep, flight crew members will accumulate a sleep debt and fatigue-related impairment will increase;

(vi) To recover from sleep debt, flight crew members need a minimum of two full nights of sleep in a row, when they are fully adapted to the local time zone. The frequency of rest periods should be related to the rate of accumulation of sleep debt.

6.6.2 Evaluate Fatigue Risk

(1) Once a fatigue-related hazard and its cause has been identified, the level of risk that its consequences pose must be evaluated. The purpose is to ensure that fatigue risks are managed to an acceptable level. To accomplish this, CAR 700.216(2) requires your FRMS to have a fatigue risk assessment process which includes procedures to:

(a) Assess the likelihood that a fatigue-related event will occur in relation to the identified hazard and the degree of severity of its consequences;

(b) Develop and update a record of the risks that are identified;

(c) Identify and prioritize the risks that need to be managed;

(d) Determine the actions to be taken to manage those risks and the corrective actions or preventive measures to be taken with respect to those risks; and

(e) Develop safety performance indicators to measure the effectiveness of those risk management actions and corrective actions or preventive measures.

(2) **Identify Consequences and Risks** - Your risk assessment process needs to determine the potential consequences and risks of fatigue-related hazards. Remember that it is the task being undertaken that determines the severity of the consequences, and how that will impact on flight crew performance. For example, falling asleep while performing an administrative task may have

no safety consequence, while falling asleep on the flight deck or during any other safety critical task can have a catastrophic result. Questions to consider include

(a) When in a work schedule are the risks of fatigue-related hazards increased (e.g. time in a flight duty period, critical phases of flight, what tasks are most susceptible to fatigue impairment)?

(b) How does the increased fatigue risk affect your operation (e.g. how could flight crew performance change, what could result, who could be impacted)?

Examples of consequences may include: error leading to catastrophic incident, error leading to near miss or minor incident, reduced productivity / efficiency, increased absenteeism and high staff turnover.

Note: Examples of particular times of the day when the risks associated with fatigue are increased can be found in Chapter 2 of TP 14573. Examples of general performance effects of fatigue can be found on page 49 of the *Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes*.

(3) **Assess Likelihood and Severity** –

(a) Your risk assessment process must have a procedure to determine:

(i) The likelihood that a fatigue-related error caused by a fatigue-related hazard will occur and result in a specific consequence; and

(ii) The severity of the impact on your operations of a specific consequence that could result from a fatigue-related error caused by a fatigue-related hazard.

(b) The below table in Figure 5 is an example of severity classification:

Figure 5 - Example safety risk severity table (ICAO SMM, 4th Edition)

Severity	Meaning	Value
Catastrophic	- Multiple deaths - Equipment destroyed	A
Hazardous	- A large reduction in safety margins, physical distress or a workload such that crew members or controllers cannot be relied upon to perform their tasks accurately or completely - Serious injury - Major equipment damage	B
Major	- A significant reduction in safety margins, a reduction in the ability of crew members or controllers to cope with adverse operating conditions as a result of increase in workload, or as a result of conditions impairing their efficiency - Serious incident - Injury to persons	C
Minor	- Nuisance - Operating limitations - Use of emergency procedures - Minor incident	D
Negligible	- Little consequences	E

(4) **Determine Risk Level** – Typically, the level of safety risk is defined as the projected likelihood and severity of the consequence or outcome from an existing hazard or situation. A likelihood and severity matrix may be used to assess the level of risk associated with the consequence of a hazard, and should be customized by carefully selecting how likelihood and severity are

classified, and to reflect that the outcome may depend on the type of work being performed when fatigued.

(5) Figure 6 below is an example of a safety risk matrix:

Figure 6 – Example Safety risk matrix (ICAO SMM, 4th Edition)

Likelihood		Fatigue Severity									
		Catastrophic A		Hazardous B		Major C		Minor D	Negligible E
Frequent	5	5A	Accident	5B	Large Safety Reduction	5C	Significant Safety Reduction	5D	5E
Occasional	4	4A		4B		4C		4D	4E
Remote	3	3A		3B		3C		3D	3E
Improbable	2	2A		2B		2C		2D	2E
Extremely Improbable	1	1A		1B		1C		1D	1E

Note: Examples of methods for classifying fatigue risk severity and likelihood can be found on page 5-22 of the *Manual for the Oversight of Fatigue Management Approaches*.

6.6.3 Evaluate Risk Acceptability

(1) Your risk assessment process must have a procedure to identify and prioritize which risks need to be managed. To accomplish this, your FRMS needs to define what constitutes the organization's acceptable level of fatigue risk. The purpose is to decide whether it is necessary to invest resources in fatigue risk controls.

(a) Use the risk level resulting from the likelihood and severity determination to decide whether the assessed risk is within your organization's defined acceptable level of risk:

(i) If Yes, accept the risk.

(ii) If No, identify fatigue risk controls to reduce the risk to the defined acceptable level.

Note: An example of a risk acceptability table based on fatigue scores can be found on page 5-25 of the *Manual for the Oversight of Fatigue Management Approaches*.

(b) While all risks that exceed the defined acceptable level must be addressed, prioritize action to address the risks with the highest level first. If the assessed risk level is the same for more than one unacceptable risk:

(i) When the severity rating is the same, address the risk(s) with the highest likelihood first;

(ii) When the likelihood rating is the same, address the risk(s) with the highest severity first.

6.6.4 **Control Risks**

(1) Your risk assessment process must have a procedure to determine the fatigue risk controls that will be taken to manage the risks of fatigue-related hazards.

(a) Fatigue-proofing strategies are a type of risk control, are an important defense against latent failures, and are steps typically taken by management. Once an analysis of a work schedule has been completed using work design principles, modelling techniques, assessment of sleep patterns, or other approaches, target the areas of highest fatigue in the schedule with fatigue-proofing strategies. Some examples are:

(i) providing additional breaks when extended hours of work arise;

(ii) maintaining appropriate staffing levels;

(iii) scheduling less complex or less safety critical tasks at times of highest fatigue risk;

(iv) self-assessment checklists for signs and symptoms of fatigue;

(v) employee training about personal limitations and strategies to include alertness.

(b) Fatigue countermeasures are a defense used by flight crew members when encountering unexpected fatigue, to reduce their fatigue risk. It is important to note that countermeasures cannot be relied on as being available, and therefore cannot be planned for. Some examples include:

(i) controlled rest on the flight deck;

(ii) strategic use of caffeine (fluid or chewing gum);

(iii) napping before night duty;

(iv) cockpit lighting control;

(v) air flow / temperature control

Note: Example fatigue risk controls can be found in EASA's hazard mitigation table, on pages 70 and 140-141 of the *Fatigue Management Guide for Airline Operators*, and on pages 54-55 of the *Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes*.

(2) Your risk assessment process must have a procedure to develop and update a record of the fatigue risks that are identified. The purpose is to build a register that prioritizes your organization's fatigue risks from all identified fatigue hazards. This register summarizes the output of your procedures for identifying fatigue hazards, their causes, associated risks, risk ratings, and risk controls. Your fatigue hazard/risk register should summarize at least the following information for each fatigue hazard:

(a) Unique hazard reference number;

(b) Hazard description;

(c) Potential causes of the hazard;

(d) Risks associated with the hazard;

(e) Assessed risk in terms of likelihood and severity;

(f) Fatigue risk controls; and

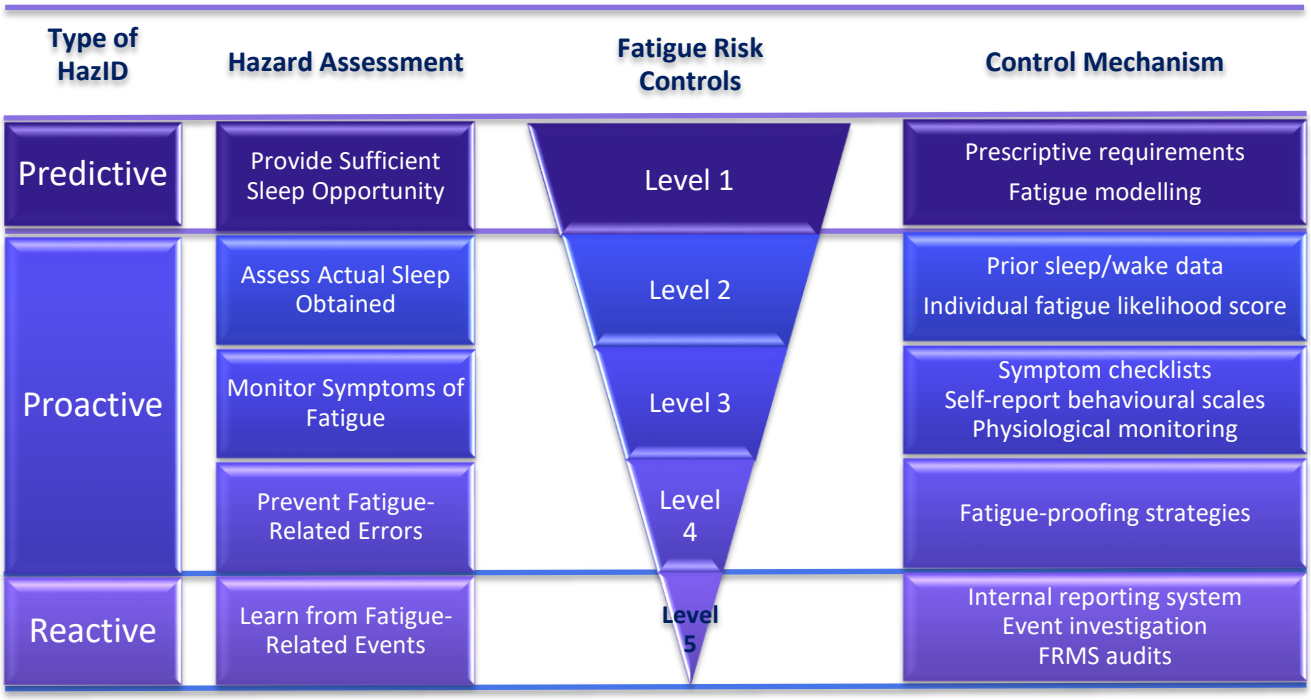
(g) Ranking of risks into a priority order.

(h) Depending on the size and complexity of your operation, the format of your hazard/risk register may range from a simple table or spreadsheet to an integrated database linking risk assessments, risk control responsibilities, and follow-up monitoring.

Note: An example of a fatigue hazard/risk register can be found on CASA's website.

(3) To effectively manage fatigue risk, multiple levels of controls are needed to form a comprehensive defence. Figure 7 shows the systems approach to minimizing fatigue risks using a 5-level fatigue hazard and risk control model [Source: Dawson and McCulloch (2005)]. This approach is contained in more detail in Appendix B of this AC.

Figure 7 – Fatigue Hazard and Risk Control Model



Note: Further information on this model and a detailed explanation of the 5 levels of controls can be found in Chapters 5-8 of TP 14575.

6.6.5 Evaluate Effectiveness

(1) CAR 700.216(2)(f) requires your fatigue risk assessment process to include a procedure for developing safety performance indicators to measure the effectiveness of the actions taken to manage fatigue and fatigue risks. The purpose is to ensure that the intended outcome of fatigue risk controls and mitigation measures is achieved and maintained.

Note: Guidance on developing and measuring SPIs can be found in section 5.3 of this AC.

(2) If the fatigue risk controls and mitigation measures perform to the defined acceptable level (i.e. the associated SPIs must reach their pre-defined acceptable values or targets in order to reduce fatigue risk to the defined acceptable level), they become part of normal operations and are monitored by your FRMS quality assurance program.

(3) If the fatigue risk controls and mitigation measures do not perform to the defined acceptable level, then go back to the appropriate step in your fatigue risk management process. This could involve:

(a) Gathering additional data and information;

(b) Re-evaluating the fatigue-related hazard and the associated risks; and/or

(c) Identifying, implementing and evaluating new and/or revised fatigue risk controls and mitigation measures.

6.6.6 Fatigue Hazard / Risk Register

(1) Your risk assessment process must have a procedure to develop and update a record of the fatigue risks that are identified. The purpose is to build a register that prioritizes your organization's fatigue risks from all identified fatigue hazards. This register summarizes the output of your procedures for identifying fatigue hazards, their causes, associated risks, risk ratings, and risk controls. Your fatigue hazard/risk register should summarize at least the following information for each fatigue hazard:

(a) Unique hazard reference number;

(b) Hazard description;

(c) Potential causes of the hazard;

(d) Risks associated with the hazard;

(e) Assessed risk in terms of likelihood and severity;

(f) Fatigue risk controls; and

(g) Ranking of risks into a priority order.

(h) Depending on the size and complexity of your operation, the format of your hazard/risk register may range from a simple table or spreadsheet to an integrated database linking risk assessments, risk control responsibilities, and follow-up monitoring.

Note: An example of a fatigue hazard/risk register can be found on CASA's website.

7.0 FATIGUE RISK MANAGEMENT PROMOTION PROGRAM – COMPONENT 3

(1) CAR 700.214(1)(c) requires your FRMS to include a program for fatigue risk management promotion. This consists of:

(a) Training on the components and functioning of the FRMS, employee responsibilities and actions, and fatigue-related science; and

(b) A communication procedure.

7.1 Competency-Based Training

(1) CAR 700.218 requires your organization to have competency-based training for persons who have been assigned duties in your FRMS. The purpose is to provide a foundation and understanding for managing fatigue risk in your flight operations. The key steps to an effective training program are shown in Figure 8.

Figure 8 – Steps to an Effective Training Program

(2) Determine Training Needs

(a) For your FRMS to be effective, everyone whose role in your organization could influence flight crew member fatigue needs to have an appropriate understanding of fatigue and their responsibilities in your FRMS. Identify who needs to be trained, which should include:

(i) Flight crew members;

(ii) Crew schedulers and dispatchers;

(iii) Person(s) managing your FRMS;

(iv) Operational decision-makers;

(v) FRMS auditors/reviewers;

(vi) Personnel involved in fatigue risk assessment and mitigation; and

(vii) The AE, and senior leadership in any department managing operations within your FRMS.

(b) Identify what training and competencies are needed for each stakeholder group to perform their roles effectively in your FRMS. The content of your FRMS training should be tailored to specific roles. For example, in addition to the training topics set out in CAR 700.218(1) and (2), role-specific training may include:

(i) *Schedulers and dispatchers* - How fatigue risk can be mitigated through scheduling, and the use and limitations of any scheduling tools or BMMs to predict the levels of flight crew member fatigue across work schedules.

(ii) *Personnel involved in FRMS design and implementation* – In addition to the topics in (a), more in-depth training on building an effective FRMS and tailoring it for specific types of operations.

(iii) *Flight crew members* – Fatigue risks and countermeasures related to the routes, schedules and flying duties to which they are assigned.

(iv) *FRMS auditors/reviewers* – Audit and review plans, methods, and tools, as well as in-depth training on your FRMS objectives, policies and procedures.

Note: Recommended fatigue management training topics for specific groups of employees can be found on pages App J1 to App J3 of the *Manual for the Oversight of Fatigue Management Approaches*.

(3) Design Training Program Outline

(a) Specify learning objectives that correspond to the competencies you identified in the previous step. Decide how you will measure that these learning objectives are met when training is provided. For example, to evaluate immediate knowledge transfer from a training session, participants can be given a quiz at the end to see how well they understood what was taught. Consider setting a minimum pass mark, and decide how you will handle re-training and re-assessment needs.

(b) CAR 700.255(1) requires your organization to conduct FRMS training at least every 12 months. Establish a training schedule and timeframe for completion. Training should be delivered to affected personnel before undertaking their FRMS-related responsibilities.

(c) Decide how the training will be delivered. Methods may include:

(i) Classroom instruction;

(ii) Videoconferencing;

(iii) Web-based learning;

(iv) Distributed learning (e.g. multi-media training delivery); and

(v) Case studies/workshops.

(4) Develop Training Program Content

(a) CAR 700.218(1) and (2) set out the subjects that your training program must cover. Using the learning objectives you identified in the previous step, develop training topics and materials (e.g. presentation tools, training guides, participant manuals, etc.).

Note: An example of a fatigue training syllabus can be found on CASA's website. Training tools can be found in Transport Canada's FRMS Toolbox: TP 14578 (trainer's handbook including training presentation with speaking notes), TP 14572 (introductory material about fatigue), TP 14573 (instruction for employees to apply fatigue management strategies), TP 14574 (to assess competence in topics covered by TP 14573).

(5) Implement Training Program

(a) Decide who will deliver the training. Trainer(s) should have a comprehensive understanding of the workings of your FRMS and fatigue-related science relevant to the scope of your operations. Trainers could be the person(s) managing your FRMS, a member of your internal training department, an external contractor or third-party training provider.

(b) The first training session could be offered as a 'pilot', with an opportunity to debrief and make changes based on feedback from participants and observers.

(c) At the end of each training session, conduct the testing method you established per section 7.1.3 to determine if each participant achieved the minimum pass mark and whether re-training and re-assessment is needed.

(d) CAR 700.255(2) requires your organization to maintain a training record that includes for each employee a description of all training received and evaluation results.

(6) Evaluate and Revise Training Program

(a) CAR 700.218(3)(b) requires your training program to include a means of measuring the level of competency attained by each person trained. To evaluate the extent to which participants have applied the training and developed the required competencies, follow-up at a fixed time (e.g. 6 months) after training. For example, a survey could be conducted to determine the amount of knowledge retained by participants and what behaviours changed as a result of the training.

(b) Based on this feedback, revise your training program as needed, such as:

(i) Revise content to improve the training on topics that a significant proportion of participants have not fully understood;

(ii) Provide feedback to FRMS trainers on areas where they may need to change or improve instructional techniques; and

(iii) Identify topics that need to be reviewed or added in annual training.

7.2 Communication Procedure

(1) To promote fatigue risk management, CAR 700.218(4) requires your organization to have a procedure for communicating the following information to employees:

(a) Industry reports on fatigue;

(b) Industry best practices in fatigue risk management;

(c) Advancements in fatigue-related science;

(d) Results of data analysis from your fatigue risk management process;

(e) Updates to your FRMS; and

(f) Results of the review of your FRMS.

Note: Communication of industry reports on fatigue, FRM best practices, and updates to fatigue-related science should focus on those used in support of your FRMS processes.

(2) The purpose of your communication procedure is to give specific step-by-step directions for implementing the actions identified in your communication plan *(see section 5.1.6 of this AC)*.

(3) Communication activities should progress through the stages of FRMS implementation and maturity:

(a) *Awareness* – Share information about your FRMS and what it means for each stakeholder group (e.g. training required, any changes in work schedules, and answer questions that have been raised)

(b) *Understanding* – Build on the initial awareness to create deeper knowledge about who does what (accountabilities and responsibilities), timelines, what operations are in and out of your FRMS scope, etc.

(c) *Adoption* – Continue to answer questions, as well as show where earlier suggestions have been woven into your updated FRMS.

8.0 FATIGUE RISK MGMT. SYSTEM QUALITY ASSURANCE PROGRAM - COMPONENT 4

(1) CAR 700.214(1)(d) requires your FRMS to include a program for FRMS quality assurance. The purpose is to provide the AE and senior management with feedback on the level of:

(a) Compliance with regulatory requirements and with your FRMS policies, processes and procedures, including where corrective or preventive action is required; and

(b) Effectiveness of your FRMS processes, fatigue risk controls, and safety performance.

(2) Both compliance and effectiveness are essential to achieve your safety objectives.

Note: An example of an FRMS evaluation form that can be used to assess compliance and effectiveness can be found on pages App K-1 to App K-2 of the *Manual for the Oversight of Fatigue Management Approaches*.

8.1 FRMS Audit

(1) CAR 700.219(1) requires your quality assurance program to have a process to audit your FRMS that includes procedures for:

(a) Auditing the extent to which your FRMS has been implemented, including:

(i) A checklist setting out all of the components of your FRMS to be verified; and

(ii) A plan establishing the frequency of the audit and the manner in which it will be conducted;

(b) Auditing your FRMS in the event of an accident or incident;

(c) Analyzing audit findings and determining the contributing factors of those findings;

(d) Developing, implementing and monitoring preventive or corrective measures to address the results of the audit; and

(e) Keeping and updating records, including the findings of the audit, preventive or corrective measures to address the results of the audit and any follow-up action taken.

(2) The purpose is to ensure that regulatory requirements are effectively implemented, compliance is monitored, and any non-compliances are corrected. The key steps in the internal audit process are shown in Figure 9.

Figure 9 – Steps in the Internal Audit Process

(3) Plan Audits

(a) CAR 700.231(1) and 700.247 require your organization to conduct an FRMS audit:

(i) Upon validation of the first safety case;

(ii) Within 1 year after the initial audit conducted upon validation of the first safety case;

(iii) Within 1 year after the day on which the previous audit was completed;

(iv) After an incident or accident; and

(v) After a major change in your activities that could affect the level of fatigue or alertness of flight crew members.

(b) The purpose of the audit plan required by CAR 700.219(1)(a)(ii) is to identify and schedule the audits to be done in the coming year. Your audit plan needs to address:

(i) *Scope* – Define the focus, extent and boundary of each audit (e.g. the activities, processes, and/or areas to be audited), as well as how far back in time each audit will look.

(ii) *Criteria* - Specify the requirements that each audit will verify compliance with. This includes regulatory requirements as well as your organization's requirements set out in your FRMS policies, processes and procedures.

(iii) *Schedule* – Identify when in the annual audit cycle each audit will be conducted. All functions associated with your FRMS must be audited within the 1–year audit cycle; however, this can be done as a single audit or as a progressive audit spread over the audit cycle. If you use a progressive audit, priority should be given to auditing areas of higher risk and/or previous non-compliance earlier in the audit cycle.

(iv) *Methods* – Explain how audits will be conducted and what tools will be used (e.g. checklists, process flowcharts, sampling methods, etc.)

(c) Your FRMS audit procedures should also address:

(i) Who is responsible for audit planning?

(ii) How is the audit plan documented?

(iii) Who approves the audit plan?

(d) In addition to the planned audits, audits required by CAR 700.219(1)(b) and 700.247(c) must be conducted following an accident or incident.

(4) Conduct Audits

(a) The purpose of the audit checklists required by CAR 700.219(1)(a)(i) is to identify all of the activities and functions covered by your FRMS documentation and the associated criteria to be verified. These checklists are used by your auditor(s) to determine if your FRMS policies and procedures are compliant and are being followed consistently.

(b) Checklists are living documents that must continue to reflect all activities described in your FRMS documentation on an ongoing basis. Take into account all changes to your operations during the past audit cycle and confirm before each audit that the checklists reflect these changes.

(c) For each FRMS process/procedure, questions to assess compliance may include:

(i) Does the required process exist?

(ii) Is it documented (inputs, activities, interfaces, and outputs defined)?

(iii) Does it meet requirements (the criteria)?

(iv) Is it understood by users?

(v) Is it in use?

(vi) Is it being followed consistently by all affected personnel?

(vii) Are the defined outputs being produced?

(viii) Have process changes been documented and implemented?

(d) Your FRMS audit procedures should also address:

(i) Who develops and maintains the audit checklists to confirm they still cover all activities of your FRMS? When is this done?

(ii) How and when are sampling methods used?

(iii) How are findings of compliance recorded?

(iv) How are findings of non-compliance documented?

(v) What evidence must be gathered to confirm findings?

(vi) How does management stay informed during the audit? Is the auditor required to provide briefings?

Note: Sample audit questions can be found in Chapter 9 of TP 14575. A random sampling tool can be found on Measurement Canada's website.

(5) Report Results

(a) The audit report is a written summary of the outcome of the audit, and includes any findings and opportunities for improvement. CAR 700.213(3) requires that findings are reported to the Operations Manager and the AE is notified of any systemic deficiency. The purpose of reporting this information is for any necessary corrective actions to be taken in a timely manner.

(b) Your FRMS audit procedures should also address:

(i) What format is used for audit findings and reports?

(i) Who approves the audit report?

(ii) Within what timeframe must the audit report be sent to the Operations Manager?

(6) Take Action

(a) CAR 700.219(1)(c) and (d) and 700.231(2) require your organization to investigate and analyze the root cause and contributing factors of audit findings, and to develop and implement corrective actions and preventive measures. The purpose is to prevent recurrence of the findings.

Note: Guidance on root cause analysis can be found in *AC SUR-002 (Root Cause Analysis and Corrective Action*).

(b) For each corrective action and preventive measure to address audit findings, your records should include:

(i) Name of person who raised the action;

(ii) Reason the action was raised;

(iii) Root cause of the issue or problem;

(iv) Recommended solution(s);

(v) Approved action to be taken;

(vi) Name of person assigned to take action;

(vii) Date action to be taken by;

(viii) Outcome of action taken; and

(ix) Measurement applied to ensure action taken was effective and permanent.

(c) Your FRMS audit procedures should also address:

(i) Which root cause analysis tools are used? How are they used?

(ii) Who is responsible for developing corrective actions and preventive measures?

(iii) What format is used for documenting corrective and preventive measures

(iv) Who approves the corrective actions and preventive measures and implementation timelines?

(7) Follow-up

(a) CAR 700.219(1)(d) and 700.231(3) require your organization to monitor and assess the corrective actions and preventive measures to ensure they are effective in preventing a recurrence of the finding. For example, a follow-up inspection could be done within a timeframe that would allow the previously non-compliant activity enough time to repeat.

(b) If your monitoring activities identify continued non-compliance, generate another finding. Re-examine the root cause analysis and take corrective action and preventive measures until the non-compliance is corrected and compliance is maintained.

(c) Your FRMS audit procedures should also address:

(i) How and when are follow-up inspections conducted?

(ii) When is the audit considered to be closed and who does this?

8.2 FRMS Review

(1) CAR 700.219(2) and 700.249(2) require your organization to have a process to periodically review the effectiveness of your FRMS, including procedures to assess:

(a) Your fatigue risk management processes;

(b) The reliability of your SPIs; and

(c) The attainment of your safety objectives.

(2) The purpose is to monitor how well your FRMS is functioning and achieving its safety objectives, as well as identify areas requiring improvement.

(3) CAR 700.249(1) requires your organization to conduct the FRMS review at least once every year after the initial audit required by CAR 700.247 is conducted. You should also conduct an FRMS review when you recognize a deficiency that reduces the effectiveness of any part of your FRMS.

Note: Considerations for the FRMS review process can be found in Chapter 5 of TP 14576.

(4) The key steps in the FRMS review process are shown in Figure 10.

Figure 10 – Steps in the FRMS Review Process

(5) Review Inputs

(a) Collect and review internal and external inputs to your FRMS review, which may include:

(i) Trends identified from fatigue reports (voluntary reports from flight crew members as well as safety events in which fatigue was identified as a contributing factor);

(ii) Fatigue hazard/risk register updates;

(iii) Outcomes of investigations conducted;

(iv) Results of fatigue surveys and studies;

(v) Trends in fatigue-related SPIs;

(vi) Audit reports (from your internal FRMS audits and any external audits with observations related to fatigue management);

(vii) Status of corrective actions and preventive measures, including those from previous FRMS audits and reviews;

(viii) Fatigue management training program results;

(ix) Updates to fatigue management regulatory requirements;

(x) Scientific advances in fatigue management;

(xi) Changes in your organization and operational environment (e.g. new schedules or routes, increased use of night or emergency response flights, etc.);

(xii) FRMS processes that were changed as a result of the previous FRMS review; and

(xiii) Suggestions and rationale for change to any FRMS process.

(6) Evaluate FRMS Performance

(a) Assess the information gathered in the previous step (5). Questions to consider may include:

(i) Is the FRMS meeting the safety objectives defined in your FRM policy?

(ii) Are all SPIs within the defined acceptable values?

(iii) Are all safety performance targets being met?

(iv) Are fatigue risks being managed and controlled to acceptable levels?

(v) Have changes in your organization or operating environment increased fatigue risk?

(vi) Are there emerging fatigue-related hazards?

(vii) Have corrective actions and preventive measures implemented since the previous FRMS review worked as planned and prevented recurrence of problems?

(viii) Is FRMS training resulting in the expected level of competency?

(ix) Do trends in fatigue reporting rates indicate issues with communication channels or stakeholder engagement?

(x) Are all FRMS processes effective?

(A) For each FRMS process, questions to assess effectiveness may include:

(I) Is the process objective (purpose) being achieved consistently?

(II) Is the process outcome (result) what your organization expected?

(III) Have process improvements resulted in the expected benefits?

Note: Guidance on evaluating SPIs can be found in section 5.1.3.4; guidance on evaluating risk controls can be found in section 5.2.3; guidance on evaluating training can be found in section 5.3.1.5 of this AC. Methods for assessing the effectiveness of FRM processes can be found on pages 71-74 of the *Fatigue Management Guide for Airline Operators*.

(7) Identify Issues

(a) Potential issues that may be identified in your FRMS review could include:

(i) New fatigue-related hazards and risks may have emerged;

(ii) Risk controls and mitigation measures may not have managed fatigue risk to acceptable levels;

(iii) Corrective actions and preventive measures may have had unintended consequences, introduced new problems, or findings may have recurred;

(iv) Safety objectives may not have been attained or SPIs may have measured the wrong things, or safety performance targets may not have been realistic;

(v) Significant changes in an area of safety performance may have occurred;

(vi) Process improvements may not have fixed the original problem or are inconsistently followed;

(vii) FRMS documentation may be inadequate, outdated or not meeting user needs; and

(viii) FRMS training may not have achieved its objectives.

(8) Report Results

(a) Your FRMS review should result in recommendations to management for action to address deficiencies and ineffectiveness. Document the outcome of your FRMS reviews

and inform your AE of the results. Essentially, this is the AE's report card on how well the FRMS is performing.

(b) The AE should formally communicate decisions to address the FRMS review outcome, including:

(i) Accept the recommended corrective actions and improvements to the FRMS;

(ii) Allocate the appropriate resources to implement the required changes; and

(iii) Set implementation timelines, as well as monitoring and follow-up responsibilities.

(9) Take Action

(a) CAR 700.249(3) requires your organization to:

(i) Determine and carry out corrective actions to address any deficiency identified by your FRMS review;

(ii) Keep a record of that determination and the reason for it; and

(iii) Provide a copy of the determination to any person assigned FRMS management functions under CAR 700.213(4).

(b) Corrective actions to address the issues identified in your FRMS review may include:

(i) Revise ineffective corrective actions and preventive measures;

(ii) Eliminate fatigue risk controls that are no longer needed due to changes in your organization or operational environment;

(iii) Modify fatigue risk controls that had unintended consequences or were ineffective;

(iv) Introduce new risk controls to mitigate fatigue risks of emerging or newly identified fatigue-related hazards;

(v) Update and/or set new FRMS safety objectives, SPIs, and safety performance targets to focus on the most important fatigue risks;

(vi) Improve FRMS processes and documentation to address user feedback and operational changes;

(vii) Incorporate new scientific knowledge in your FRMS processes to enhance the management of fatigue; and

(viii) Update your FRMS training program to incorporate the implemented changes.

8.3 Independence of Audits and Reviews

(1) CAR 700.249(4) requires that duties related to the FRMS quality assurance program be fulfilled by persons who are not responsible for carrying out the task or activity being evaluated unless:

(a) The size, nature and complexity of your operations and activities make this impractical;

(b) Based on a risk analysis, assigning this duty to a person responsible for carrying out the task or activity will not result in an increased risk to aviation safety; and

(c) Your FRMS audit will not be compromised.

(2) The purpose is to maintain objectivity and provide an independent review. For example, the person(s) managing your FRMS should not be auditing or reviewing the FRMS because they are an integral part of the system. Larger organizations could use dedicated quality assurance staff, while smaller organizations could use employees who are not involved in the FRMS. In very

small operators, the independence of these functions may not be feasible, in which case the air operator must either:

(a) Complete a risk analysis of the impact on aviation safety and audit integrity of assigning the audit/review function to a person involved with the tasks or activities being audited; or

(b) Use contracted external evaluators.

Note: Examples of how FRMS quality assurance roles could be assigned can be found on pages 75-76 of the *Fatigue Management Guide for Airline Operators*.

9.0 FATIGUE MODELLING

(1) Fatigue modelling is used to predict an average level of flight crew member fatigue or alertness for a work schedule, based on scientific understanding of factors contributing to fatigue. Fatigue modelling can be done using manual or automated methods:

(a) *Manual techniques* – For organizations with simple work schedules, manual calculations can be performed to generate scores that provide an indication of fatigue likelihood.

(b) *Automated systems* – Biomathematical fatigue modelling software can predict how much sleep flight crew members are likely to obtain in a given work schedule. The software can calculate a fatigue likelihood score at any given point in the schedule.

Note: An overview of automated and manual methods to predict work-related fatigue can be found in Chapters 1-3 of TP 14577. Guidance on using automated and manual methods can be found in Section 3.3 of TP 14576.

Note: A customizable tool to assess a specific duty or work pattern for fatigue risk, for flights identified as needing closer examination, can be found at *Fatigue risk assessment methodologies K. Tritschler*, and an overview of how to use the tool can be found at *KrisTritschler_Fatigue Risk Assessment presentation*.

9.1 Biomathematical Fatigue Models

(1) Biomathematical fatigue models (BMM) incorporate the latest scientific research on human circadian systems, sleep, and performance capability into work scheduling to reduce fatigue risks. If biomathematical models are used appropriately, and the results are interpreted intelligently, taking account of the assumptions and limitations associated with each, they can provide an effective means of estimating the typical fatigue likely to be experienced in operational settings. BMMs do not constitute an FRMS on their own, but are one tool of many that may be used within an FRMS. Potential applications of BMMs include:

(a) Evaluating against a scientifically-based standard the fatigue risk of a flight crew schedule that would exceed prescriptive requirements;

(b) Predicting and comparing fatigue levels associated with past, current or proposed work schedules;

(c) Highlighting operational periods where elevated fatigue levels and reduced performance may coincide with critical tasks;

(d) Estimating the likely effects on flight crew performance of sleep obtained before and between consecutive flight duty periods;

(e) Evaluating different flight crew pairing options for fatigue risk;

(f) Assessing changes in fatigue risk from unscheduled flight duty period changes or unforeseen operational circumstances;

(g) Determining optimal work/in-flight rest cycles for augmented flight crew operations;

(h) Testing potential impact of fatigue risk controls and mitigation measures to reduce the effects of fatigue;

(i) Developing optimal flight crew schedules that reduce fatigue risk; and

(j) Investigating the potential contribution of schedule-related fatigue to safety events.

(2) To use a BMM appropriately requires an understanding of what the models can and cannot predict. Currently available BMMs may not all account for:

(a) Differences in fatigue accumulation associated with the nature, intensity and risk of the work being performed and workload fluctuation during flight duty periods (e.g. take-off and landing phases of flight, multiple flight sectors);

(b) The effects of personal fatigue countermeasures that may be used by flight crew members;

(c) The cumulative effect of chronic exposure to circadian disruption on cognitive function (e.g. duration of exposure to night duty); or

(d) The impact of extended commuting times and personal and work-related stressors on the fatigue and alertness level of flight crew members.

(3) Most BMMs provide a fatigue or alertness prediction value for the 'average' person over a given work period. These numerical scores can be used for performing comparisons of work schedules or for evaluating a schedule against a specified fatigue limit.

(4) It is essential to avoid overly simplistic interpretations of numerical scores. They do not definitively answer the question of whether a particular work schedule is safe. When making decisions about schedule design, any specified fatigue limit must first be validated within the operational environment in which it will be used.

(5) BMMs are not a substitute for risk assessment, because the models do not predict the safety risk that fatigued flight crew members represent in a particular operation nor the safety consequences of that fatigue risk. The acceptable level of risk will depend on the fatigue-related hazards in a specific operation and how the associated risks are managed. It is important to understand the assumptions and limitations inherent to each model, and recognize that the maximum fatigue exposure for the flight crew members operating under a variance who are being assessed may be significantly higher than that predicted by any model.

Note: An overview of several BMMs can be found in Chapter 2 of TP 14577. More recent guidance on the capabilities and limitations of seven BMMs can be found in the *Biomathematical Fatigue Models Guidance Document*. Guidance on the use and limitations of BMMs can be found in *IATA – Uses and Limitations of Biomathematical Fatigue Models*.

10.0 FRMS DOCUMENTATION

10.1 What documentation is needed?

(1) CAR 700.256(1) requires your FRMS documentation to reflect the procedures and processes your organization has implemented. FRMS documentation explains your organization's FRMS policies, processes, and procedures to all stakeholders (including staff, contractors, auditors, and TCCA):

(a) Policies provide your organization's guiding principles for the FRMS. Policies are supported by processes and procedures.

(b) Procedures give specific step-by-step directions for performing a process. Procedures explain who does what, when, where, and how.

(c) Processes comprise inputs **plus** sequence of key activities and decisions **plus** outputs.

(2) Your documentation should reflect the size and complexity of your organization, and meet your operation's specific needs. Keep your FRMS documentation clear and concise. Each FRMS process and procedure should be documented in sufficient detail to provide a repeatable and auditable series of steps for the user.

(3) Make your FRMS documentation accessible to all applicable areas and levels of your organization. FRMS documentation can be either:

(a) Housed within your COM;

(b) Centralized in an FRMS Manual, or

(c) For CAR 705 operators, integrated into your SMS Manual.

(4) There is no regulatory requirement for approval for FRMS documentation or an FRMS manual. Use a document control process to distribute and amend your FRMS documentation.

Note: An example of a document control process can be found in Section 1.2 of TP 14576.

(5) CAR 700.214(3) requires your organization to update the FRMS in the following circumstances:

(a) A change in the size and scope of your operations;

(b) Any actions taken as a result of your FRMS audits;

(c) An increase in the level of flight crew fatigue or decrease in the level of alertness determined when validating your safety case; and

(d) When data collection and analysis from your fatigue risk management process indicates that flight crew members may be subject to increased fatigue or decreased alertness.

(6) Review your FRMS documentation periodically to ensure that it:

(a) Remains suitable, adequate and effective; and

(b) Reflects any changes made to the FRMS.

(7) CAR 700.257(2) requires your organization to notify TCCA of any changes to your fatigue risk management system within 60 days after the change is made. This notification should be done in writing to your TCCA Principal Operations Inspector (e.g. by email).

(8) Notify (in writing) the flight crew members who will conduct the flights operated under a variance that the initial exemption or continuing exemption in effect, as applicable.

10.2 What records are needed?

(1) CAR 700.257 requires your organization to keep data and records of:

(a) Material produced under your FRMS, including from audits and reviews;

(b) The fatigue model used to assess the levels of flight crew member fatigue and alertness;

(c) Records of testing flight crew members for fatigue and alertness; and

(d) Evaluation of the level of flight crew member fatigue and alertness against the established baseline level.

Note: Where a flight crew member refuses to give consent to participate in a fatigue or alertness data collection activity, the air operator should request a reason why and keep a de-identified record. The purpose is to provide evidence that flight crew member refusals are isolated and not

widespread, as the latter could indicate issues with the effectiveness of the FRMS. TCCA may take this evidence into consideration when reviewing safety cases for approval

(2) Records provide historical evidence of compliance as an auditable trace of your organization's activities. FRMS records are outputs from your FRMS processes, and may include:

(a) Employee fatigue reports and follow-up records;

(b) Fatigue hazard/risk register;

(c) Risk assessment and causal analysis results;

(d) Corrective action and preventive measures and follow-up logs;

(e) Fatigue and alertness data;

(f) Work schedules;

(g) Safety cases;

(h) Training records;

(i) Fatigue-related information communiqués;

(j) Safety performance measurement results;

(k) Internal FRMS audit schedules, checklists, sampling plans, reports and findings;

(l) FRMS effectiveness review results.

(3) CAR 700.258 requires your organization to keep FRMS records for 5 years after the day on which the information was collected or produced. Your FRMS should have a process to ensure appropriate record storage, protection, archiving, retrieval, retention time, and disposition.

11.0 FRMS INTERACTIONS

11.1 How do FRMS and SMS interact?

(1) Since flight crew fatigue is a safety issue, fatigue management logically is an integral part of safety management. For CAR 705 operators, your FRMS should interface with your SMS. FRMS processes should complement SMS processes to avoid duplication and maximize your system effectiveness and efficiency.

(2) SMS requirements have some elements in common with FRMS, as shown in Figure 11. Elements of an existing SMS that could be used to satisfy the requirements of an FRMS include, for example, processes for self-reporting, investigation and corrective action, safety performance management, documentation control, quality assurance, and promotion.

(3) However, in order to identify fatigue hazards and minimize the safety risks, specific tools are needed such as methods to understand when work schedules are fatiguing, policies that deal uniquely with fatigue-related situations, and training and awareness that highlights fatigue risks.

(4) If your organization chooses to use your SMS to meet FRMS requirements, you will need:

(a) A table of concordance to show where the required FRMS policies, procedures and processes can be found and how the SMS will be applied to the management of flight crew fatigue; and

(b) To be able to demonstrate to TCCA that you have tailored your existing SMS components to address flight crew fatigue specifically and in a manner that is effective.

(5) CAR 705 operators who do not have an FRMS must comply with the prescriptive requirements and manage fatigue risks through their SMS.

Figure 11 – Comparison of SMS and FRMS Frameworks

SMS	FRMS
Safety management plan • Safety policy • Non-punitive safety reporting policy • Roles and responsibilities • Communication • Safety planning • Performance measurement • Management review	**Fatigue Risk Management Plan** • Fatigue risk management policy • Safety objectives • Safety performance indicators • Fatigue management responsibilities • Training plan • Communication plan • Internal fatigue reporting policy
Safety management documentation • Identification and maintenance of applicable regulations • SMS documentation • Records management	**Fatigue Risk Management Documentation** • System documentation and records
Safety oversight • Reactive reporting process • Proactive hazard identification processes • Investigation and analysis • Risk management	**Fatigue Risk Management Process** • Internal fatigue reporting procedure • Procedure to identify fatigue-related hazards • Safety data and scientific studies used to support FRMS processes • Fatigue data and information management procedure • Procedure for fatigue modelling of flight crew schedules • Procedure to analyze planned work schedules • Fatigue risk assessment process
Training, awareness and competence	**Fatigue Risk Management Promotion Program** • Competency-based training program • Means to measure competency attainment • Communication procedure
Quality assurance	**Fatigue Risk Management System Assurance Program** • FRMS audit process • FRMS effectiveness review process • Variance monitoring procedures for effect on pilot fatigue and alertness
Emergency preparedness and response	n/a

11.2 How do FRMS and CLC interact?

(1) While both FRMS and the Canada Labour Code (CLC) focus on the proactive management of hazards, their objectives are different. A comparison of these objectives is shown in Figure 12.

Figure 12 – Comparison of FRMS and CLC Objectives

(2) There may be some overlaps in information requirements between the health and safety reporting obligations in the CLC and the fatigue reporting obligations under FRMS. There may also be occasions when information submitted to one program impacts the other program.

12.0 INFORMATION MANAGEMENT

(1) Not applicable.

13.0 DOCUMENT HISTORY

(1) Advisory Circular (AC) 700-046 **Issue 01**, RDIMS 12181964 (E), 13075079 (F), dated 2017-02-01 – Fatigue Risk Management System Requirements

14.0 CONTACT OFFICE

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APPENDIX A — TCCA'S FRMS TOOLBOX

TCCA's FRMS Toolbox is accessible at https://www.tc.gc.ca/eng/civilaviation/standards/sms-frms-menu-634.htm. The FRMS Toolbox contains the documents listed below.

FRMS Toolbox

Document Number	Document Title	Target Audience
TP 14572	**An Introduction to Managing Fatigue**	Employees
TP 14573	**Fatigue Management Strategies for Employees**	Employees
TP 14574	**Employee Training Assessment**	Trainers
TP 14575	**Developing and Implementing a Fatigue Risk Management System**	Managers
TP 14576	**Policies and Procedures Development Guidelines**	Managers
TP 14577	**Fatigue Audit Tools**	Managers
TP 14578	**Trainer's Handbook**	Trainers

APPENDIX B — LEVELS OF RISK CONTROL

Level 1 Controls: Providing Sufficient Sleep Opportunity

(1) Predictive hazard identification methods examine planned flight crew schedules before they are actually worked. CAR 700.216(1)(f) requires your fatigue risk management process to include procedures to identify and assess the level of fatigue through modelling of flight crew members' schedules. The purpose is to ensure that proposed schedules provide flight crew members with adequate sleep opportunity to ensure they are fit for duty. Key steps include:

(a) Analyzing planned work schedules to identify factors that may increase the likelihood that flight crew members might become fatigued.

Note: Examples of these factors can be found in section 6.6.1(3) of this AC.

(b) Adjust the work schedules to remove or reduce the factors that increase the likelihood of fatigue.

Note: Guidance on assessing work schedules for adequate sleep opportunity and maximizing sleep opportunity in designing work schedules can be found in Chapter 5 of TP 14575.

(2) There are automated and manual methods of fatigue modelling:

(a) Automated systems – Biomathematical fatigue modelling software can predict how much sleep flight crew members are likely to obtain in a given schedule. The software can calculate a fatigue likelihood score at any given point in the schedule.

(b) Manual *systems* – For organizations with simple schedules, manual calculations can be performed to generate scores that provide an indication of fatigue likelihood.

Note: An overview of automated and manual methods to predict work-related fatigue can be found in Chapter 1-3 of TP 14577. Guidance on using automated and manual methods can be found in Section 3.3 of TP 14576. Capabilities and limitations of biomathematical fatigue models can be found in section 9.1 of this AC.

Level 2 Controls: Assessing Actual Sleep Obtained

(1) Proactive hazard identification methods assess flight crew member fatigue levels in current operations. CAR 700.216(1)(g) requires your fatigue risk management process to include procedures to analyze planned work schedules in relation to actual time worked. The purpose is to assess whether:

(a) Current work schedules have resulted in work-related fatigue; and

(b) Flight crew members actually obtained adequate sleep when Level 1 controls provided sufficient sleep opportunity.

(2) Key steps include:

(a) Comparing planned and actual hours worked, focusing on factors such as:

(i) Exceeded maximum flight duty periods;

(ii) Use of pilot-in-command's discretion to extend a flight;

(iii) Standby usage;

(iv) Trip swapping, etc.

Note: Examples of data that could be analyzed to identify potential fatigue-related hazards from actual time worked can be found on page 59 of the *Fatigue Management Guide for Airline Operators*.

(b) Measuring sleep obtained and fatigue levels experienced (e.g. sleep-wake diary, actigraph to monitor sleep, fatigue survey questionnaire, or flight crew alertness testing and fatigue ratings at different stages of flight)

Note: An example of a Sleep Diary template can be found in Chapter 6 of TP 14576. A measure of fitness-for-duty based on time asleep and awake can be calculated using the method explained in Chapter 6 of TP 14575. A summary of the strengths and weaknesses of fatigue, sleep, performance and workload measures can be found on pages 125-126 of the *Manual for the Oversight of Fatigue Management Approaches*.

Note: Guidance on measuring flight crew member fatigue can be found on pages 56-61 and 109-132 of the *Fatigue Management Guide for Airline Operators*, and on pages 48-49 and 67-71 of the *Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes*.

Level 3 Controls: Monitoring Symptoms of Fatigue

(1) Your FRMS needs to monitor for symptoms that indicate flight crew members are fatigued, even though Level 1 controls provided sufficient sleep opportunity and Level 2 controls verified employees actually obtained adequate sleep. The purpose is to identify flight crew members who may be at an elevated level of risk for fatigue-related error.

(2) Key steps to do this include:

(a) Observing and reporting fatigue-related symptoms (by employees experiencing symptoms in themselves and observing symptoms in others);

Note: Typical physical, mental, and emotional symptoms of fatigue are listed in Chapter 7 of TP 14575, which also suggests the use of a fatigue-related symptoms checklist for employees. Guidance on internal fatigue reporting can be found in Level 5 Controls in section 5.7 of this AC.

(b) Monitoring the frequency that flight crew members exhibit fatigue-related symptoms; and

(c) Investigating and addressing the potential causes (e.g. adjust work scheduling parameters, minimum sleep requirements and/or work environment factors; determine whether non-work factors are affecting the risk of work-related fatigue or individuals may have a sleep disorder).

Note: A summary of common sleep disorders can be found in Chapter 7 of TP 14575, and an explanation of the initial screening to identify at-risk employees who may need referral to a medical specialist.

Level 4 Controls: Preventing Fatigue-Related Errors

(1) Your FRMS should implement fatigue-proofing strategies to prevent fatigue-related errors:

(a) When unforeseen operational circumstances result in extended flight duty periods (e.g. due to weather conditions, equipment failures, flight crew member illness, etc.); and

(b) For the areas of highest fatigue risk in work schedules.

(2) Adjust flight crew member's schedules to compensate for exceedances, and apply defenses when insufficient sleep is obtained. Fatigue-proofing strategies, (a) to (c), and fatigue countermeasures,(d) to (f) may include:

(a) Providing additional breaks when extended hours of work arise;

(b) Scheduling additional breaks when extended hours of work arise;

(c) Monitoring and double-check systems to increase the likelihood of detecting errors;

Note: Guidance on fatigue-proofing strategies can be found in Section 3.6 of TP 14576 and in Chapter 8 of TP 14575.

(d) Controlled napping to improve alertness;

(e) Strategic use of caffeine.

Note: Guidance on quantifying 'sufficient sleep' and examples of fatigue-proofing strategies and countermeasures that may be taken by management and employees can be found in Chapter 6 of TP 14575.

Level 5 Controls: Learning from Fatigue-Related Events

(1) Reactive hazard identification methods assess the contribution of flight crew member fatigue to event reports. Your FRMS needs to ensure that fatigue-related events are reported and investigated to determine how the impact of fatigue could have been minimized. The purpose is to improve fatigue risk controls to reduce the likelihood of similar events.

(2) CAR 700.216(1)(a) requires your fatigue risk management process to include procedures for flight crew members to report fatigue internally. CAR 700.217 requires you to have a process for a policy and these procedures to be developed in collaboration with your employees. Fatigue reports are essential for fatigue-related hazard identification, for feedback on the effectiveness of fatigue risk controls and mitigation measures, and in providing information for SPIs.

(3) Your internal fatigue reporting procedure needs to define what should be reported by flight crew members. This includes fatigue, fatigue-related hazards, and fatigue-related events.

(a) Information to identify fatigue as a contributing factor should also be included in your organization's mandatory incident/accident reporting forms.

(4) Explain in your fatigue reporting procedures:

(a) How and where to report in urgent situations;

(b) Where report forms are located;

(c) How to submit reports (e.g. electronic, hard copy);

(d) Who to submit reports to (e.g. supervisor, person managing your FRMS); and

(e) Timeline for submitting reports (e.g. within 24 hours of a fatigue-related event).

(5) Your fatigue reporting forms need to gather adequate information for fatigue involvement to be evaluated. Fatigue reports should also provide space for written commentary so that the person reporting can explain the context of the event and give his/her view of why it happened.

Note: Examples of fatigue report forms can be found on page 110 of the *Fatigue Management Guide for Airline Operators*.

(6) Describe in your fatigue reporting procedure the actions to be taken when fatigue reports are submitted. This includes documenting your process for investigating and analyzing to:

(a) Establish whether fatigue was a contributing factor to any event, by determining if:

(i) The flight crew member was probably in a fatigued state;

(ii) The actions or decisions of the flight crew member were causal in any actual or potential consequence; and

(iii) Those actions or decisions are consistent with the probable behaviour of a fatigued flight crew member.

Note: Guidance on information to collect in fatigue reports and investigations can be found on pages App I-1 to App I-5 of the *Manual for the Oversight of Fatigue Management Approaches*, pages 128-132 of *Fatigue Management Guide for Airline Operators*, and in *AC 120-103A* Appendix 2 pages 19-23.

(b) Determine the level of fatigue and the conditions that contributed to fatigue-related errors and events. A series of fatigue reports related to a specific flight, route or series of flight duty periods could be a trigger for further investigation.

Note: Guidance on root cause analysis can be found in AC SUR-002 (Root Cause Analysis and Corrective Action). A flowchart of an internal investigation process can be found on page 16 of *Fatigue - The Rules Have Changed*

(7) CAR 700.216(1)(b) requires your fatigue risk management process to include procedures to confirm in writing the receipt of the fatigue report to the flight crew member and to advise of any follow-up action. The purpose is to encourage reporting by giving timely feedback to those who submit fatigue reports. Responding to all fatigue reports confirms to the reporter that their report has been received, and explains the planned follow-up activity specific to each report.

Note: An example of initial feedback to reporters can be found on page 90 of *Fatigue Management Guide for Airline Operators*.

(8) For fatigue reports which require further investigation, follow up with another response to the reporter when the investigation is completed. This feedback should summarize any findings and corrective actions or preventive measures, or explain why it was determined that no action was necessary.

APPENDIX C — MANUAL FATIGUE MODELLING EXAMPLE

Introduction

CAR 700.216(1)(c) requires that the air operator's fatigue risk management process include procedures for modelling of fatigue hazards that may be present in the work schedule.[1] Modelling may be conducted using a software-based automated system, or manually using a matrix scoring approach. This section provides an example of the latter.

Fatigue Likelihood Scoring Matrix

The fatigue scoring matrix used in this example is based on the approach described in TP 14577E, *Introduction to Fatigue Audit Tools,* available on the Transport Canada Fatigue risk management system toolbox for Canadian aviation website. Each column of the matrix is labeled with a specific risk score, and the rows describe various states of five schedule-based fatigue factors as shown in Table 1. The overall risk score is determined by summing the scores associated with each fatigue factor.

Table 1

Fatigue Factor	Risk Score				
	0	1	2	4	8
Total duty hours in 7 days	≤ 36	36.1 – 43.9	44 – 47.9	48 – 54.9	≥ 55
Maximum duration of a single duty period (hours)	≤ 8	8.1 – 9.9	10 – 11.9	12 – 13.9	≥ 14
Minimum duration of a short break (hours)[2]	≥ 16	15.9 - 13	12.9 – 10	9.9 - 8	< 8
Total hours of night work in 7 days[3]	0	0.1 – 8	8.1 – 16	16.1 – 24	> 24
Frequency of long breaks[4]	> 1 in 7 days	≤ 1 in 7 days	≤ 1 in 14 days	≤ 1 in 21 days	≤ 1 in 28 days

[1] See AC 700-046 section 6.1(1)(c)
[2] A short break refers to a single sleep opportunity between work periods, typically a period shorter than 32 hours.
[3] Night work refers to any duty period within the hours of 21:00 to 09:00.
[4] A long break refers to a period of two night sleeps with a non-working day in between.

Example

An air operator decides to conduct fatigue modelling on a previous work schedule, as shown in Table 2, in order to gain understanding of their past fatigue exposure. The seven-day schedule period includes nine to 11 flights per day, each less than 30 minutes in duration and all within one time zone. Three days off were given immediately prior to this schedule and for the remainder of the period in which the schedule was operated, one long break was given every 21 days.

Table 2

Day	Duty Start	Duty End	Duty Hours	Night Duty Hours	Duration of Short Break Prior to Duty[5]	Start / End Times Short Break
Sunday	05:30	16:30	11	3.5	6.5	2200 – 0430
Monday	05:30	16:00	10.5	3.5	6.5	2200 – 0430
Tuesday	08:00	21:00	13	1	9	2200 – 0700
Wednesday	06:00	17:30	11.5	3	7	2200 – 0500
Thursday	06:30	18:30	12	2.5	7.5	2200 – 0530
Friday	05:00	15:00	10	4	6	2200 – 0400
Saturday	06:00	17:30	11.5	3	7	2200 – 0500
TOTALS	**--**	**--**	**79.5**	**20.5**	**--**	

[5] Assumes the flight crew member goes to bed each night at 22:00 in operator-provided suitable accommodation, and wakes up 1 hour prior to reporting for duty to allow time for personal hygiene, nutrition, and transit to check-in location.

Table 3 shows how each of the fatigue factors arrays in the fatigue likelihood scoring matrix:

Table 3

Fatigue Factor	Risk Score				
	0	1	2	4	8
Total duty hours in 7 days					79.5
Maximum duration of a single duty period (hours)				13	
Minimum duration of a short break (hours)					6
Total hours of night work in 7 days				20.5	
Frequency of long breaks				1 in 21 days	

The highest possible score for this matrix is 40. Reading the score for each factor from the heading row and adding the scores together, the total score for this schedule is 8 + 4 + 8 + 4 + 4 = **28**.

Figure 1 shows how a score of 28 compares in fatigue likelihood to some other schedules.

Figure 1 – Fatigue Likelihood Score