U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Fatigue Risk Management Systems for Aviation Safety

Date: 8/3/10
Initiated by: AFS-220

AC No: 120-103
Change:

1. PURPOSE.

a. Contents. This advisory circular (AC):

(1) Describes the basic concepts of Fatigue Risk Management Systems (FRMS) and how they relate to aviation industry employees safely performing their duties.

(2) Provides information on the components of a FRMS as applied to aviation and how to implement a FRMS within an aviation operation.

(3) Defines a FRMS as an operator-specific process; therefore, while all FRMS will have common elements, the specifics must be tailored to an operator's particular conditions.

b. Parts of an FRMS. This AC describes the essential processes and elements for an effective FRMS.

c. Not Mandatory. This AC is not mandatory and does not constitute a regulation.

2. RELATED READING MATERIAL. (current editions):

- Proceedings of the "Aviation Fatigue Management Symposium: Partnerships for Solutions," June 17-19, 2008.
- The current edition of AC 120-92, Introduction to Safety Management Systems for Air Operators, dated June 22, 2006.
- Mahon, G. & Cross, T. The Fatigue Management Program: Alternatives to Prescription. Queensland Transport: Queensland, Australia, 1999.
- Mallis M.M., Banks S., & Dinges D.F. Aircrew fatigue, sleep need and circadian rhythmicity (Chapter). In Elsevier, E. Salas, T. Allard, & D. Maurino, (Eds), Human Factors in Aviation (2nd edition), in press; 2010.

3. INTRODUCTION.

a. Causes of Fatigue. Generally speaking, the main causes of fatigue in aviation are:

- Amount, timing, and quality of sleep each day (sleep/wake schedule),
- Amount of time since last sleep period (continuous hours awake),
- Time of day (circadian rhythm) and,
- Workload and time on task.

b. Fatigue Management. The traditional way to manage fatigue associated with aviation operations have been with prescriptive flight and duty time limitations and rest requirements. Conventional regulations following this model reduce, but do not eliminate, the conditions that contribute to fatigue. They are primarily based on ‘time on task’ theories and on the assumption that fatigue accumulates in a linear manner. Conventional regulations on fatigue management do not consider the interactions of sleep loss and circadian rhythms. Additionally, conventional regulations cannot address operational complexities on a case-by-case basis.

4. DEFINITIONS.

a. Acute Fatigue. Acute fatigue is closely related to recent sleep (last 24 hours), time since last sleep, and current time of day. Less than 8 hours sleep in the last 24 hours, being awake longer than 17 hours, and working between midnight and 0600 are associated with acute fatigue in the average person.

b. Biomarkers. Biomarkers are characteristic biological properties that can be detected and measured in the body, such as in the blood or tissue. Biomarkers may indicate either normal, abnormal, or diseased processes in the body. Currently, there are no easily obtainable biomarkers of fatigue. However, several biomarkers of the circadian rhythm exist, such as core body temperature and melatonin levels. In the absence of biomarkers to identify fatigue, we can directly measure fatigue effects in performance variables, or indirectly by using measures of sleep and time-of-day and by modeling the effects of these conditions on performance.

c. Chronic Fatigue. The average person needs about 8 hours of sleep per day. If the average person gets less than the required amount of sleep each day for multiple days, then a state of chronic fatigue can occur. With chronic fatigue, performance is degraded and recovery tends to be relatively slow. A person can hasten recovery by attempting to sleep longer than the normal amount for several days.

d. Circadian Rhythm. In humans, circadian rhythm is a daily alteration in a person’s behavior and physiology. These behavior and physiology alterations are controlled by an internal biological clock located in the brain (i.e., circadian clock). Examples of circadian rhythms include body temperature, melatonin levels, cognitive performance, alertness levels, and sleep patterns.

e. Fatigue. Fatigue is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness. Fatigue is objectively observed as changes in many aspects of performance, including increased reaction time, lapses in attention (i.e., reaction times greater than 500 milliseconds), reduced speed of cognitive tasks, reduced situational awareness, and reduced motivation. A person's perceived fatigue levels often are lower than observed decrements in performance.

f. FRMS. A management system operator's use for mitigating the effects of fatigue in its operations. A FRMS is a non-prescriptive fatigue mitigation tool that minimizes the acute and chronic sources of fatigue.

g. Safety Management System (SMS). A SMS is a structured management system to control risk in operations. It is an integrated network of people and other resources performing activities that accomplish the safety mission and reach safety goals in the aviation environment. Management of the system's activities involves planning, organizing, directing, and controlling assets to meet the organization's safety goals. The safety management process starts with design, and implementing organizational processes and procedures to control risk in aviation operations. Once controls are in place, quality management techniques can be used to provide a structured process for ensuring that the controls achieve their intended objectives, and to improve them where they fall short.

h. Window of Circadian Low (WOCL). Individuals living on a regular 24-hour routine with sleep at night have two periods of maximum sleepiness, also known as WOCL. One WOCL occurs at night, roughly from 0300 to 0500, a time when physiological sleepiness is greatest and performance capabilities are lowest. The other WOCL is in the afternoon, roughly from 1500 to 1700, and is less severe than the nighttime WOCL.

5. THE FRMS CONCEPT. A FRMS consists of organizational processes and procedures to control fatigue risk in aviation operations. A FRMS is a data-driven and scientifically based process that allows for continuous monitoring and management of safety risks associated with fatigue-related error. It is part of a repeating performance improvement process. This process leads to continuous safety enhancements by identifying and addressing fatigue factors across time and changing physiological and operational circumstances. Structurally, a FRMS is composed of processes and procedures for measuring, modeling, managing, mitigating, and reassessing fatigue risk in a specific operational setting. A FRMS is an effective fatigue mitigation strategy when the organization bases it on valid scientific principles. A FRMS combines schedule assessment, operational data collection, continuous and systematic analysis, and both proactive and reactive fatigue mitigations, guided by information provided by scientific studies of fatigue. Overall, a FRMS offers a way to more safely conduct flights by offering flexibility not available within regulatory limits. A FRMS complements prescriptive flight time, duty time, and rest period requirements.

a. Operational Demands. A FRMS addresses the complexity of operational demands and the inherent fatigue related challenges associated with aviation operations. The FRMS approach is to apply risk management techniques to identify and reduce the risk of fatigue relevant to specific operational circumstances. When used in conjunction with prescriptive regulations, a FRMS enhances the effect of regulations by providing an equivalent or increased level of safety. A FRMS aims to ensure high levels of alertness in personnel to maintain acceptable levels of performance and safety.

b. Adaptability. A FRMS provides an interactive and collaborative approach to operation performance and safety levels on a case-by-case basis. Therefore, a FRMS permits an operator to adapt policies, procedures and practices to the specific conditions that create fatigue in a particular aviation setting. Operators may tailor their FRMS to unique operational demands and focus on mitigations of fatigue that are practical within the specific operational environment.

c. Assessment. FRMS relies on assessment of individual schedules and routes to project and, later, confirm the fatigue effects of an operation on crewmember sleep and alertness. This permits continuous assessment of fatigue levels associated with ever-changing operational conditions. The common tool for this assessment is a biomathematical model of fatigue and alertness levels.

d. SMS Component. A FRMS can be part of an organization's SMS or a stand-alone system. Similar to a SMS, the FRMS applies the risk management process to identify fatigue risks through the use of data driven systems. A FRMS includes documented processes for collecting and analyzing fatigue related safety data and implementing corrective actions – always allowing for continuous improvement. A "just" or "safety" culture is integral to a successful FRMS and it requires a shared responsibility among all levels of the organization as well the involvement of regulatory agencies.

6. TOOLS FOR AN EFFECTIVE FRMS. This section describes the four basic tools necessary for a complete, workable, effective and accountable FRMS. The four basic tools are fatigue related data, fatigue analysis methods, identification and management of fatigue drivers, and application of fatigue mitigation procedures.

a. Fatigue Related Data. An effective FRMS is data-driven, meaning it relies on the use of reports, studies, etc., rather than speculation. A FRMS is based on scientific principles, involves continuous monitoring and, when possible, can be integrated into an operator's overall SMS. Fatigue effects on performance and safety have been documented and are well recognized (Bonnet, 2000; Carskadon & Dement, 1987; Dinges, 1992; Dinges & Kribbs, 1991; Horne, 1993; Naitoh, 1975). It is difficult to detect fatigue in operational settings because there are no biomarkers for fatigue, or simple tests of how an individual will respond to sleep loss. However, the environmental conditions that promote fatigue are well known and continue to contribute to performance deficits during operations. The challenge is that aviation operators cannot totally eliminate fatigue from 24/7 aviation operations, so operators need to apply proactive and adaptive mitigation for fatigue. This is part and parcel of "managing" an operation. Managing fatigue risk depends on two types of operational evidence available to operators:

(1) The duty schedule directly affects crewmembers' opportunities to obtain restorative recovery sleep. Monitoring work schedules provides indirect evidence of potential fatigue resulting from inadequate or poorly timed opportunities to obtain sleep.

(2) A non-punitive reporting system permits crewmembers and other employees to report subjective fatigue and, from time to time, request relief from duties because of chronic fatigue. These reports contain valuable data, especially when coupled with information about the conditions that contributed to fatigue, such as the work schedule for the week prior to the report. Subjective reports of fatigue can underestimate the true extent of performance impairment especially when an individual is already suffering from acute or chronic fatigue due to sleep loss or circadian disruption (Dinges, 1989; Horne, 1985; Rosekind et al., 1994; Wylie et al., 1996). Therefore, data on procedural errors, flight exceedances, Aviation Safety Action Program (ASAP) or Aviation Safety Reporting System (ASRS) reports and flight operational quality assurance (FOQA) data may help an operator to objectively document fatigue. Operators may couple data sources with scheduling information or other event data reported by crewmembers that implicate the potential for fatigue, e.g., flight delays and irregular operations. A non-punitive reporting system is essential to encourage the reporting of fatigue related events as part of the overall safety system.

b. Fatigue Analysis Methods. A FRMS should be part of the overall risk identification and management approach that employs both proactive and reactive processes to monitor, manage and mitigate operational risk. Operators can use commercially available computer models to assess average performance capability from sleep/wake history, placement within the circadian cycle and duty schedule information (Hursh and Van Dongen, 2010). Operators can embed models within the FRMS process to help understand the likely effects on individual performance of sleep obtained before and during trip patterns. Using these models, though not required, incorporates the latest scientific research on human circadian systems, sleep, and performance capability and can be useful for rapidly estimating fatigue levels associated with proposed new routes or schedule changes. However, certain assumptions and limitations need to be taken into account. Models are not a substitute for a comprehensive FRMS; they are one useful component of a FRMS.

(1) Retrospective (reactive) processes for oversight of schedules. Operators can use a validated fatigue model to assess the estimated fatigue levels associated with current or past schedules and determine which schedules are more vulnerable to increased fatigue levels and reductions in performance. First, operators identify those schedules, both trip sequences and monthly pilot schedules, which have been associated with the greatest levels of fatigue. Next, operators can derive the fatigue factors present and examine the potential for schedule changes to reduce fatigue. Such changes might include additional layover days, additional recovery days, augmented crews to permit in-flight sleep opportunities, or rescheduled block times to avoid critical tasks at times during or near the WOCL.

(2) Prospective (proactive) processes for oversight of schedules. Operators also can assess proposed schedules for potential fatigue impact by using the method described above. Trip sequences that have been identified as leading to acute and chronic fatigue can be removed or modified to prevent the accumulation of fatigue across a bid schedule. For scheduled operations, rules may be embedded into the schedule creation process to avoid those conditions that the fatigue model indicated could lead to excessive fatigue risk.

c. Identification and Management of Aviation Fatigue Drivers. Many operational drivers of fatigue occur in any aviation environment. Some of the common factors operators must manage to minimize fatigue risk in aviation operations are:

(1) Crew flight and duty periods, and rest breaks to reduce fatigue.

(2) Additional duties assigned to flightcrews that further reduce sleep opportunities.

(3) Schedule changes that extend duties beyond the published schedule.

(4) The duration and timing of layovers between successive flight segments.

(5) Recovery days following a trip that permits sufficient sleep to eliminate any accumulated sleep debt prior to scheduling or performing additional flight duties.

(6) Optimal utilization of available rest opportunities.

d. Application of Fatigue Mitigation Procedures. A FRMS is part of a process that requires shared responsibility amongst management and flight/cabin crew and builds on feedback and non-punitive reporting within a "just culture." Developing mitigation strategies and schedule adjustments should be part of a collaborative management process that includes all the stakeholders, such as crew schedulers, marketing, safety, and employee representatives. A FRMS should employ multiple layers of defense to prevent fatigue and fatigue-induced errors from progressing to a level that enables incidents or accidents. Based on an analysis of the factors that lead to fatigue and practical mitigation alternatives, one or more of these mitigations may be applied to reduce fatigue associated with specific schedules or situations. The primary levels of defense and mitigations are:

(1) The flight duty schedule, additional tasks assigned to crewmembers, and schedule change, viewed together, provide recovery sleep opportunities. It may be necessary to adjust scheduling rules to reduce the occurrence of identified fatigue drivers.

(2) Maximizing use of available sleep opportunities reduces cumulative fatigue. This level of defense is largely the responsibility of the crewmember. Comprehensive fatigue training, adequate crew rest facilities at non-domicile locations, and efficient transportation to rest facilities aid crewmembers in fulfilling their responsibility.

(3) Implementing error detection and corrective processes can prevent operational consequences of fatigue. Crew Resource Management (CRM) is a recognized and widely used process to encourage crewmembers to work together to detect and prevent operational errors.

(4) Conducting comprehensive and objective accident, incident, and error analyses can help to determine when fatigue has been a potential contributing factor so that those conditions can be avoided in the future.

7. COMPONENTS OF A FRMS. A FRMS is more than a collection of tools. Like a SMS, it is a management process built on organizational policies and procedures that implement a systems approach to fatigue management. A systems approach means that FRMS is an integrated network of people and other resources performing activities designed to minimize fatigue in the operational environment. This network of people addressing potential fatigue uses the four tools described in paragraph 6. Below is a list of six organizational components of the FRMS. They will vary in complexity based on the size and diversity of the operational environment.

a. Fatigue Risk Management Policy. The first required component is a Fatigue Risk Management Policy. For organizations with a SMS, this policy will be part of the overall safety management policy of the corporation. Whether an independent set of policies or part of a SMS, this policy defines the following:

(1) The policy should define the organizational structure and composition of the FRMS in terms of people and job functions. This group may include individuals responsible for crew scheduling, operational safety, human resources, marketing, training, labor relations, and human factors research and analysis.

(2) At a minimum, scheduling policies assure that the organization adheres to all applicable Federal Aviation Administration (FAA) flight and duty time regulations. Beyond that minimum, the organization may develop additional scheduling constraints and rules that have proven to be useful in preventing fatigue under certain situations. Some of these limits and constraints may be formulated during collective bargaining agreements with labor organizations.

(3) Individuals are expected to report fit for duty. In the case of fatigue, employees are expected to report for duty sufficiently well rested to be able to safely perform the duties of the job. Likewise, it is the responsibility of the individual to alert the organization when not sufficiently rested to perform safely, and the organization must have a policy for replacing that person with someone who is well rested. The "absent for fatigue" policy must be designed to ensure that the individual reporting fatigued is not coerced into performing duties anyway.

(4) Fatigue is a complex topic and all crewmembers should have adequate training to understand the causes of fatigue, how an individual can maximize the benefits of rest opportunities, the use of various countermeasures to minimize the effects of fatigue, and the overall responsibilities of the individual to report for duty fit to safely perform duties.

(5) Policies should define mechanisms for reporting errors and events related to fatigue, including policies that define a non-punitive fatigue reporting system (see "Just Culture;" Reason, 1997).

(6) Depending on the size and complexity of the organization, this policy will define various methods utilized to collect objective data on fatigue and the effects of fatigue on performance.

(7) The overall FRMS is a Continual Improvement Process (CIP). This requires a set of policies that define how the data on fatigue are subsequently utilized to further improve the management of fatigue. In other words, these are procedures by which the system is self-corrective and adaptive to changing conditions that may cause fatigue.

(8) Policies should define manager and employee responsibilities relative to managing fatigue, both on the job and between assignments, including policies providing adequate rest opportunities between assignments and requiring individuals to report fit for duty (i.e., well rested).

b. Education and Awareness Training Program. Comprehensive education and awareness training programs are essential for providing a foundation in the management and mitigation of fatigue. The basic topics to include in a fatigue education and awareness program are as follows:

(1) Basic information on the causes of fatigue, the importance of sleep, and the effects of circadian rhythms on alertness and performance levels.

(2) Awareness of the FRMS program itself, including fatigue related policies and procedures, and the responsibilities of management and employees.

(3) Personal assessment of fatigue risk and identifying early signs of fatigue in others.

(4) Operational procedures to follow when one identifies, or suspects, fatigue risk in oneself or others.

(5) Personal strategies for preventing and managing fatigue risk.

(6) Procedures for reporting suspected fatigue related adverse events.

(7) Other topics related to fatigue management specific to the organization, such as using organization rest facilities, in-flight rest policies and procedures, and expectations for using layover rest and recovery rest opportunities.

c. Fatigue Analysis and Reporting System.

(1) This component defines the processes needed to detect, report, and investigate cases of fatigue risk from internal and external sources. It includes objective operational data and methods that enable the operator to develop and evaluate reactive and proactive methods to reduce and manage fatigue risk, including:

(a) Trip scheduling.

(b) Crew rostering.

(c) Rest periods.

(2) There are analysis methods, such as biomathematical models of fatigue, which can be used to evaluate the fatigue implications of specific city-pairs or trips and monthly pilot schedules. This system includes two components: an analysis of the risk of fatigue associated with the trip/schedule and an analysis of the potential consequences of that fatigue risk. Based on this risk and consequence analysis, proactive corrective action can be taken to mitigate the risk. In addition, the fatigue reporting system may suggest that certain schedules are causing fatigue and corrective steps can be taken to analyze the source of the fatigue and prevent a similar set of circumstances in the future.

d. Monitoring Fatigue in Flight and Cabin Crew. Conceptually, this is similar to the prior component but focuses on individual crewmember reports of fatigue. These reports provide feedback to the operator about conditions perceived to contribute to fatigue.

(1) To maximize the utility of such reports, procedures must be arranged to capture all relevant information, such as the schedule leading up to the fatigue report, the actions of the employee to obtain rest, subjective and objective evidence of fatigue, environmental conditions that may have exaggerated or contributed to fatigue, relevant health or medical conditions, specific actions (commissions and/or omissions) related to the incident, and communications prior to and during the event. Corporate policy must provide for protection of privacy and methods to protect the employee from adverse actions that would discourage reports of fatigue.

(2) Technologies developed to monitor sleep and performance in crewmembers can be used to supplement self-reports of fatigue. While it may not be practical to apply these technologies continuously, periodic studies of actual sleep (using actigraphs or logbooks) and fatigue (using performance measures and subjective ratings) can be highly valuable for objectively measuring the extent of fatigue across different kinds of operations and isolating key fatigue drivers (Hursh and Van Dongen, 2010). The operator can use the results of these assessments to inform the analysis and forecasting functions of the FRMS to better assess potential fatigue in future operations (proposed new schedules, for example).

e. Incident Reporting Process. Reports of adverse events that may be attributable wholly or in part to fatigue are similar to crew reports, and can serve as a mechanism for obtaining all relevant information regarding fatigue contributions to the incident. Ideally, corporate policy would define how an adverse event is evaluated for potential fatigue involvement as well as define a methodology for conducting a detailed root cause analysis. Details of root cause analysis are available elsewhere (see AC 120-92, current edition) but at a minimum, the incident investigation and reporting process must obtain all the necessary information to trace the root cause of the incident, especially the potential level of fatigue and the conditions that contributed to the fatigue-related event. The elements of this report are similar to those described in subparagraph d above for fatigue reporting. The policy must provide for protection of privacy and methods to protect the employee from adverse actions that would discourage reporting events and conditions surrounding the events.

f. Performance Evaluation. A FRMS is a self-correcting process that includes evaluating the results of prior monitoring, analysis, training, and mitigation. Policies and procedures, based on the evaluation of results and the effectiveness of the FRMS in reducing fatigue, provide feedback to the system for continuous performance improvement. The continuous improvement process includes the following:

(1) A system for evaluating and reporting the effectiveness of the FRMS, including reporting that is available to the regulator.

(2) A process whereby the results of evaluations provide guidance to the FRMS program for self-correction and improvement.

(3) A system for periodic independent review of the FRMS for its effectiveness in managing fatigue related risk.

(4) While not required, it is also desirable to have a process for capturing economic benefits and costs of the program to establish return on investment.

8. STEPS IN THE FRMS PROCESS. This section reviews four steps that comprise a continuous FRMS process (see Figure 1). Saying FRMS is a "process," means that it consists of a series of actions that build on corporate policies, organizations, and procedures. A FRMS is not just a written set of rules but a living system that consists of operators detecting and adapting to fatigue impact on their operation, and employees carrying out specific actions that implement the policies and procedures within an established organization. The specific actions that comprise the FRMS process break down into four general steps that repeat, leading to continuous performance improvement and reductions in fatigue related risk. Each step in the process relies on one or more of the fatigue management tools described in paragraph 7.

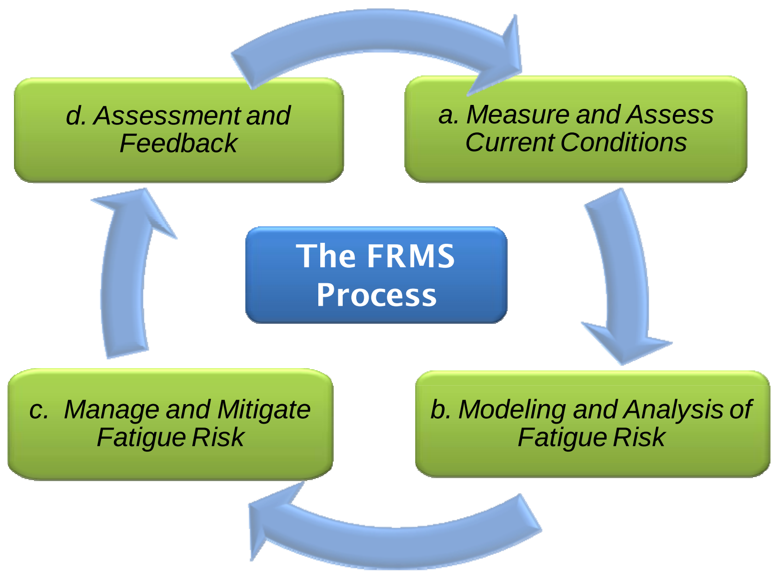
a. Measurement and Assessment of Current Conditions. The first step is to measure and assess the level of fatigue risk associated with current schedules and operations, by collecting information on crewmember reports of fatigue or fatigue related errors and incidents, and information on the schedules that led up to these reported fatigue-related errors and incidents. Understanding the current conditions within the organization is critical for the development of a valid mitigation plan.

b. Modeling and Analysis. The second step helps to determine the root cause of fatigue by modeling the work schedules and analyzing fatigue risk associated with them. This step is crucial to the process because it uses scientific principles about fatigue, perhaps aided by computer modeling, to find the specific operational and crewmember factors that could contribute to significant performance changes due to fatigue (Hursh and Van Dongen, 2010). Managing and mitigating fatigue depends on this step because fatigue risk needs to be measured and connected to the conditions (fatigue drivers) that contribute to the risk. Analysis of the fatigue risk can be broken down into two components: likelihood of occurrence of a particular level of fatigue and the severity of the consequence of fatigue, should it occur (Van Dongen and Hursh, 2010). For example, flight time that occurs between midnight and 0600 will inevitably include the period identified as the WOCL. This low point in performance should be evaluated in relation to the duties to be performed at that time; an expected raised level of fatigue is of greater concern if it coincides with critical flight maneuvers. Evaluation of risk and consequences within an operational setting is described in general in AC 120-92.

c. Management and Mitigation of the Fatigue Risk. This third step is based on the measurement and analysis of the fatigue-causing conditions. It requires explicit and regular management activity to consider the information from the first two steps and engage all the stakeholders in a collaborative process to develop solutions to address the fatigue-causing factors. Mitigation may involve making changes at any or all levels of defense listed in subparagraph 7d above.

d. Assessment and Feedback. The fourth step in the process is collection of evidence of success in the form of improved schedules, additional sleep opportunities, enhanced training, and revised policies combined with objective data that demonstrate that these changes have effectively reduced fatigue. Evidence of reduced fatigue includes fewer reports of fatigue and/or errors due to fatigue, evidence of increased sleep, or modeling of schedules that predicts improved performance and reductions in fatigue related risk. This step is important and essential for continuous process improvement. Some measures may not prove to be as effective in reducing fatigue as anticipated, leading to a need for further adjustments. Additionally, changes in schedules, turnover in the workforce, added demands for service, and the addition of new routes can lead to emerging pressures that contribute to increased fatigue risk. This step allows for further adjustments to improve current operations and correct for changes in future operations.

FIGURE 1. THE FRMS PROCESS



9. ROLES AND RESPONSIBILITIES. This section describes the general roles and responsibilities of the three primary stakeholders in the FRMS process: the operator, the employees, and the government regulatory agency, in this case, the FAA. The stakeholders should regard the roles and responsibilities described here as a starting point. These general roles and responsibilities are not an exhaustive description of the various actions to be taken by each group during the development and execution of the FRMS. Many of the details left to be defined depend on the specifics of each operation.

a. Operator. For the *operator,* there are five general responsibilities:

(1) The operator is responsible for taking the initiative to develop, document, and implement the scientifically based FRMS. First, the organization must understand what developing a FRMS entails and must garner the commitment of the leadership to support the process. Second, the organization must be willing to commit the resources of time and money to assign individuals in the organization to develop and sustain the FRMS.

(2) Once the operator identifies a team to develop the FRMS, the operator is responsible for tasking the team to develop policies, training, data acquisition processes, analysis methods, and management procedures to implement, audit, and guide the FRMS process.

(3) A FRMS is not a one-time activity; a FRMS is a living system that requires a continuous commitment of resources to support the effectiveness and progressive improvement of the process. The size of the resource commitment will depend on the size and complexity of the operation, but it does not end once the operator establishes the FRMS.

(4) An effective FRMS is a collaborative process that involves all the stakeholders in discussion and joint action to be successful. It is the operator's responsibility to provide the mechanisms for collaboration/consultation among managers, employees, and the regulator. The operator is responsible for creating a "just culture" where managers and employees can share information about fatigue without threat of reprisal or disciplinary action. In keeping with the responsibility of each crewmember to only accept duty when adequately rested to safely perform duties, it is the responsibility of the organization to develop a non-punitive policy for responding to legitimate reports of fatigue and providing reserves to replace fatigue impaired crewmembers.

(5) The operator can tailor an FRMS to the size of the organization. For a large organization with entire departments dedicated to each primary function, it will be necessary to have a Fatigue Management Steering Committee (FMSC) to coordinate the fatigue related initiatives across departmental boundaries. Within a smaller organization, it may only require that a single person be assigned the responsibilities to oversee the program. Likewise, within a large organization, there may be multiple sources available to support the data requirements of the FRMS while, in a small organization, data may be limited to reports of fatigue from pilots and occasional reports of procedural errors. Despite the differences in scale and complexity, a FRMS still uses the tools defined in paragraph 6.

b. Employees/Crew. For the *employees/crew* there are three main responsibilities:

(1) The only remedy for sleep deprivation is sleep and it is the employee's responsibility to use the facilities and sleep opportunities to obtain rest, sleep, and meals. Each person has a unique requirement for sleep and only the individual can decide how much sleep is adequate to maintain alertness and performance. As a general guide, the average person is thought to require about 8 hours of sleep per day, although individual differences exist in sleep need, ranging from 7-9 hours. In general, it is the employee's responsibility to get as much sleep as they need and to take additional sleep when they feel fatigued or unfit for duty.

(2) Getting adequate sleep requires planning with future duty times in mind. For example, if duty will require an early morning awakening, then the employee should plan to go to bed early the night before so as to be fully rested for the next duty. If the next duty will commence in the evening, the employee is responsible for taking an afternoon or evening nap so that the employee does not start work with eight or more hours of continuous wakefulness before the start of duty.

(3) If circumstances preclude sufficient sleep to be alert and rested and to perform duty, whether the result of the schedule, delays, illness, life events, or personal actions, it is the employee's responsibility to report their state of fatigue to the operator. The employee should not accept the responsibilities of duty when fatigued or feeling unfit to perform assigned duties to the extent that the safety of the flight may be jeopardized.

c. Regulator. A regulator needs to be able to see that an operator has a well defined FRMS plan that provides for at least an equivalent level of safety to that provided by fatigue related regulations. Beyond evaluation of the plan, the regulator has the responsibility to monitor the application of the FRMS plan and evaluate measures of outcomes to ensure that an equivalent level of safety is in fact provided by the FRMS. Both of these steps are critical to the success and public acceptance of a FRMS. The assessment requires evaluation of both the FRMS plan and the FRMS process and outcomes. The following are the regulator responsibilities for guiding and assessing an operator's FRMS:

(1) The regulator has the responsibility to provide descriptions of the essential components and guidance for the steps required to implement an acceptable FRMS. Given the complexity of the aviation industry, such guidance will necessarily be general in nature to allow for adaptation to the size of the organization. This AC provides useful guidance for the regulator and operator.

(2) For each operator, the regulator reviews the components of the system (structures, policies and process) and assesses whether those components are implemented on an on-going basis.

(3) Prior to implementation, the regulator evaluates whether the FRMS as planned, would be expected to establish an equivalent level of safety (forecasting function) to that provided by compliance with established flight time/duty time regulations.

(4) Once implemented, the regulator periodically evaluates if the FRMS in practice, is meeting safety goals (auditing function).

(5) The regulator must evaluate if the FRMS process itself is responsive to feedback for continuous improvement (tracking progress).

10. IMPLEMENTATION OUTLINE. Details of implementation will depend greatly on the complexity of the organization and the demands of the operational conditions confronted by flightcrew. This AC does not provide a step-by-step implementation guide, but rather details the general progression of the implementation process and several potential implementation pitfalls.

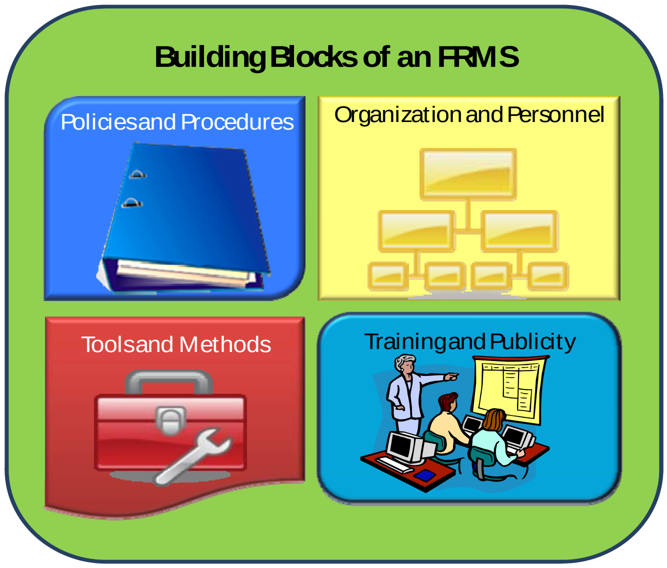
a. Resources. In order to implement an effective FRMS, the organization must commit resources to acquire and develop the four basic building blocks (see Figure 2):

(1) The foundation of the FRMS is documentation that defines the policies and procedures that guide fatigue risk management, representing the commitment of the organization to the process and clear statements defining how the system will function. The basic elements of that documentation have been outlined in this AC, but the detail and complexity of the system will depend on the size and diversity of the organization and its operation.

(2) A FRMS is more than documentation; it is an active process that is implemented by members of the organization who regularly meet to review data on fatigue indicators, analyze contributing factors to fatigue, take reactive and proactive actions to mitigate fatigue, audit the effectiveness of the system, and take corrective action to continuously improve the system. Most organizations can form a defined FMSC to implement the system. The committee should include representatives of all departments and groups that have a role in reporting, managing, and mitigating fatigue.

(3) A variety of tools and methods are instrumental in aiding the activities of the FRMS organization, such as fatigue modeling, statistical analysis software, performance and sleep measurement systems, and reporting forms and databases. The tools do not constitute a FRMS but they are essential for the system to function effectively. The organization must be willing to commit resources to procure the necessary supporting tools if the FRMS is to be effective.

FIGURE 2. BUILDING BLOCKS OF AN FRMS



(4) Training operational personnel and managers about the physiological and behavioral foundations of fatigue, the operational and environmental drivers of fatigue, and effective fatigue mitigations is essential to manage fatigue risk. Furthermore, all personnel must know the corporate policies that are the foundation of the corporate FRMS process, including policies and procedures that govern fatigue reporting, fitness for duty and absence for fatigue, incident reporting, employee privacy, and prevention of coercion to perform duties while fatigued. Finally, an effective FRMS includes feedback and publicity about the system to all affected employees to encourage cooperative participation in the corporate fatigue risk management strategy.

b. Extending Processes. If the organization already has a SMS, then the building blocks of the FRMS will be an extension of existing processes to manage overall operational safety. For example, incident-reporting forms may already exist and need only be expanded to collect information relevant to a fatigue analysis. An organizational structure may already exist to implement safety management and the addition of a FMSC might be the only change in the organization.

c. Starting FRMS. The initial implementation of a FRMS will start by assembling the building blocks described above, starting with developing the policies and procedures and establishing the FRMS organization. The organization will then acquire the necessary tools and methods, and develop supporting training and publicity programs. There are several pitfalls to avoid in this complex process.

(1) The fatigue risk management organization, such as the FMSC, should include representatives of all the key departments and groups that have a role in identifying, managing and mitigating fatigue in operations. FRMS is a collaborative process and will require the commitment of key leaders of the organization and the cooperative participation of relevant groups. An example would be the marketing department which plays a key role in defining trips and schedules. While their primary responsibility is to advance the business interests of the corporation and provide service to customers, marketing also has a key role in defining the requirements of schedules that may be causing excessive fatigue. Its participation in finding acceptable alternatives that reduce fatigue is essential to a successful FRMS. At the same time, employee groups (union representatives, for example) must also participate in the process because managing and mitigating fatigue is a shared responsibility between the organization and the employees. Ensuring that employees understand and embrace their responsibilities to report for duty well rested is just as important as arranging schedules that provide sufficient rest opportunities.

(2) There is a danger that the FMSC will adopt a reactive approach to fatigue management, taking constructive action only in response to reports of fatigue or fatigue related adverse events. The more effective approach is to minimize fatigue by using available tools to forecast potential fatigue well in advance of actual operations, and taking corrective action to proactively eliminate potentially fatiguing schedules or conditions prior to their occurrence. An indicator of a highly effective FRMS is the frequency of such proactive corrective actions.

(3) The FRMS should include a methodology to evaluate the success of the program and make changes in the program for process improvement. Two equally important parts of the evaluation and validation process are necessary. The first is self-evaluation using established metrics that reflect the degree of fatigue in the organization. The FMSC should monitor those metrics regularly, looking for trends over time, which suggest the need for change or validate the effectiveness of actions already taken. The second is an occasional independent audit of the program by an outside agency or consultant. An outside observer familiar with FRMS principles and cognizance of best practices developed by other organizations can be an invaluable aid to improving the effectiveness and efficiency of the FRMS process.

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for
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