FLIGHT SAFETY FOUNDATION

NBAA

Duty/Rest Guidelines for Business Aviation

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Foreword

The National Business Aviation Association (NBAA) and Flight Safety Foundation (FSF) committed to updating "Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation" — originally published in *Flight Safety Digest* in February 1997 by the FSF Fatigue Countermeasures Task Force — principally to consider scientific advances in the intervening 17 years and to identify how those advances should influence today's recommended practices for duty and rest scheduling.

Similar analyses of various industry sectors are being done throughout the world by regulatory authorities, leading, for example, to the U.S. Federal Aviation Administration's recent publication of Federal Aviation Regulations Part 117, *Flight and Duty Limitations and Rest Requirements: Flightcrew Members.* As in the case of Part 117, the separate aviation analyses predominantly have focused on commercial air transport. This combined effort set out to achieve an equivalent consensus that meets the safety and operational goals of the general aviation (GA) community.

Another intent of the project was to consider whether the existing guidelines still provide a sufficient safety margin for current flight operations. To answer that question, subject matter experts reviewed the relevant global accident and incident experience during the period since the publication of the 1997 guidelines.

It also was deemed important to consider the industry practices that have developed around the 1997 guidelines. One question that was asked was, on one end of the practicality spectrum, "What aspects of the guidelines have operators found helpful and practical?" Looking at the other end of this spectrum, it was asked, "What aspects, if any, were found to be impractical to implement?"

Finally, knowing how fatigue management practices advanced from 1997 until now, it was determined that a key point for today's operators to understand is where new duty/rest guidelines fit into their overall fatigue management efforts, and what to do if an operator is required to operate outside of the guidelines.

The updating process involved individuals from a broad array of disciplines. The industry panel of GA operators and experts brought experience in every type of flight operation. The scientific panel involved a number of the most highly regarded and widely published specialists in the science of fatigue. Their experience ranges from laboratory research, medicine and operational research to regulatory development and operational design. Each member of the scientific panel brought extensive knowledge of fatigue management in many operational environments, including understanding of the impact and limitations of duty guidelines and rest requirements in aviation.

Industry leaders from throughout the world served as observers to the updating process, helping to ensure the process would yield content that builds on past work and can dovetail easily with future guidance.

Among the other goals for this document was providing a useful tool that is practical, and easy to understand and to implement. These guidelines hopefully will set the cornerstone of every fatigue management effort in this sector of aviation, with both their design and recommendations easily incorporated into any operator's Flight Operations Manual.

It was recognized from the outset that the scientific considerations within the guidelines (such as circadian rhythm, continuous hours awake, etc.) would need to be clearly and simply defined and explained. These concepts and terms form the foundation for the recommendations. And they are important to advance thinking about fatigue management techniques that enable operators to develop and use effective operational fatigue mitigations.

Here's a short list of what's changed in the updated guidelines. As noted, the scientific explanations are refined from 1997 and in plain language. Elements of fatigue management are described, and they show operators where the duty/rest guidelines fit within a fatigue management effort.

The updated terminology is consistent with that of the International Civil Aviation Organization and the International Business Aviation Council in order to streamline the adoption of these guidelines into international guidance.

For operator convenience, current sources of fatigue management background material used are clearly referenced. Additionally, the guidelines look toward some of the advances in guidance anticipated in the near future — especially those most relevant for GA flight operations.

Finally, the format of this document's simple tables containing the updated duty/rest guidelines has been refreshed to make them quickly and readily readable.

Here's a short list of what hasn't changed. Values shown in the updated duty/rest guidelines tables remain fully consistent with current scientific knowledge and operational experience (that is, maximum number of flight/duty hours and minimum rest hours and intervals).

Some operators will find helpful the complete story of the original "Principles and Guidelines" document. It's available at no cost from the FSF website at <flightsafety.org/flightsafety.org/fsd/fsd_feb97.pdf>.

In closing, I sincerely thank NBAA and the Foundation for their unfailing support of this safety-critical work. Members of the scientific panel made a truly extraordinary effort and commitment. The industry panel members helped turn this version into a deliverable product through their thoughtful, prompt responses to our numerous requests for information and insights. The observers' focus and input was every bit as important. Personally, it's been a special privilege and joy for me to guide this effort as Fatigue Task Force lead for the NBAA Safety Committee. Fly safe!

Leigh White
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Duty/Rest Guidelines for Business Aviation

Introduction

Business Aviation: A 24-Hour Industry

Business aviation operational demands require 24-hour-a-day activities that can include shift work, night work, irregular and unpredictable work schedules, and time zone changes. These factors challenge human physiology and can result in performance-impairing fatigue and an increased risk to safety. Scientific information and practical experience with fatigue, human sleep and circadian physiology can improve aviation safety by providing guidance in mitigating and managing factors that contribute to fatigue in operational settings.

Science-based Fatigue Management

Human capabilities have been recognized as critical factors in maintaining safety in aviation since the early 1900s, and they continue to be challenged by advances in the industry. Operational capabilities and technology continue to evolve significantly while human physiology remains unchanged. Flight operations often are associated with sleep loss and circadian disruption, both of which have the potential to result in deleterious effects. While the debilitating effects of sleep loss on performance and alertness have been documented for many years, more recent research has focused on sleep, circadian rhythms, sleepiness/alertness and the performance decrements associated with operational environments. Fatigue now is a widely acknowledged operational safety risk. Specifically, the aviation community has examined the effects of sleep loss and circadian disruption on flight crews by conducting controlled research in laboratory, simulator and field studies. These studies have confirmed the presence of fatigue-related performance challenges in flight crew from the sleep loss and circadian disruption associated with corporate and business aviation operations. Based on the known challenges within corporate and business aviation operations, the majority of flight departments voluntarily have incorporated scientific findings into their operational standards based on the guidance originally provided in 1997 with the publication by Flight Safety Foundation of "Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation" (*Flight Safety Digest*, February 1997), and, in many cases, the standards are more stringent in defining company-specific limitations. Managing fatigue based on solid scientific principles is now the future in aviation, independent of the type of operations flown.

Application of Scientific Knowledge

Although research on fatigue, sleep and circadian physiology, and shiftwork schedules has generated an extensive body of scientific knowledge, the application of this information to the requirements of operational settings is relatively new. Appreciation of this knowledge is increasing, and its transfer to operations (e.g., scheduling, regulatory considerations, personal strategies, countermeasures) offers significant potential to enhance safety, productivity and pilot well-being. The International Civil Aviation Organization (ICAO) has distilled much of this understanding into its *Fatigue Risk Management Systems (FRMS) Implementation Guide for Operators*, released in collaboration with the International Air Transport Association (IATA) and the International Federation of Air Line Pilots' Associations (IFALPA) in July 2011, which uses the safety management system (SMS) framework. Current U.S. Federal

Aviation Regulations and commercial airline scheduling practices worldwide are beginning to acknowledge and incorporate such knowledge, often by practicing fatigue management principles — through training, safety programs and operational strategies.

This publication updates the 1997 FSF "Principles and Guidelines," which describes scientifically based principles that can be applied to the duty and rest scheduling requirements of the business aviation industry. Specifically, it focuses on guidelines that are supported by existing scientific data and effective operational practices from business aviation operators.

Fatigue Management

Science-based duty and rest scheduling guidelines provide a critical foundation for effectively managing operational fatigue risks. However, due to its complexity, effective fatigue management in aviation operations, large and small, is best addressed through a multi-faceted approach. There is no "one size fits all" solution. Additional policies and standard operating practices should complement the framework provided by scheduling practices that address known physiological challenges but allow for operational flexibility.

Other elements of a comprehensive fatigue management effort include fatigue education and training, and general fatigue management policies and processes that apply to all personnel within the flight operation. Depending on the size and complexity of the operation, mechanisms that allow for fatigue monitoring and reporting also may be implemented. Education and training should be provided to everyone with a mission-critical role in the aviation operation and should address the same scientific principles that guide duty and rest scheduling practices.

Responsibility for fatigue management is shared between the organization and all individuals who participate in the flight operation. Providing all mission-critical personnel with knowledge, strategies and tools allows each person to become a strategic facilitator and to make informed decisions when managing fatigue risks within the context of operations. Educating management and primary passengers about fatigue risk and procedures in place to mitigate that risk also can improve the safety margin of an operation.

Implementing a fatigue management effort can seem like a complex task. Hence, ICAO and regulatory authorities around the world recommend the use of SMS as a framework. Managing fatigue risk is no different from managing other operational risks, which is why fatigue management processes are being incorporated into the SMS structure. The use of guidelines within SMS to specifically address fatigue factors can help minimize associated vulnerabilities. However, if an operator does not have an SMS, fatigue management easily can be an independent effort.

Objectives

The intent of this publication is solely to provide science-based guidelines for duty and rest scheduling, although it is recommended that aviation organizations implement fatigue management practices that are appropriate for the specific characteristics of their operation. Fatigue management efforts are under way in commercial aviation and in other transportation settings. As these efforts continue to evolve and mature, they will yield experience and information that may be adapted for business aviation.

Section 1 outlines scientifically based principles related to operational issues inherent in the aviation industry.

Section 2 contains science-based guidelines for duty and rest scheduling in business aviation, with specific recommendations provided where appropriate and when available.

Section 3 introduces the elements of fatigue management, including the two foundational elements for all flight operations, and additional elements and fatigue countermeasures that can be combined to actively manage fatigue in more complex flight operations.

1.0 Fatigue Factors

1.1 Sleep

Sleep is a vital physiological need. Sleep is necessary to maintain alertness and performance, positive mood, and overall health and well-being. Each individual has a basic sleep requirement that sustains optimal levels of performance and physiological alertness during wakefulness. On average, an adult requires eight hours of sleep in a 24-hour period.

It has been shown in laboratory studies that loss of as little as two hours of sleep will induce fatigue and degrade subsequent waking performance and alertness. Over successive days, sleep loss — any amount less than is required — will accrue into a cumulative sleep deficit commonly referred to as a "sleep debt." The physiological need for sleep created by sleep loss can be reversed only by sleep. Recovery from acute sleep loss takes one or two consecutive extended sleep periods. These extended sleep periods will be even longer if a person is suffering from a cumulative sleep debt. An individual who has obtained ample recovery sleep will be better prepared to perform after long hours awake or while working nonstandard schedules than a person who is operating with a sleep debt.

1.2 Recovery Periods

Recovery from acute or cumulative sleep loss is critical when a person is challenged with non-standard schedules that include extended periods of wakefulness (e.g., extended duty periods) or circadian disruption (scheduled sleep/wake periods that are misaligned with the body's circadian rhythm, described in Section 1.3). Recovery is necessary to reduce the accumulated effects of fatigue and enable an individual to perform assigned duties fully rested. Further, recovery periods should allow for recuperative sleep opportunities of an appropriate number of hours and, in some cases, an appropriate number of successive days (as noted in Section 1.1).

Placement of recovery sleep periods is crucial and can be especially challenging when schedules include changing time zones because individuals may experience circadian misalignment. Westward travel is often associated with waking up too early in relation to the local time zone, and eastward travel is associated with delay in falling asleep in relation to the local time zone. (See Section 1.3 for further discussion.)

Another challenge an individual may experience when planning recovery rest is adaptation to time zone shifts (jet lag), as discussed in Section 1.3. Many operational factors impact the scheduling of recovery periods, and a simple rule may not fully account for the role that individual differences play in recovery. It is known that meeting daily sleep requirements and using restorative breaks promote optimal performance and alertness.

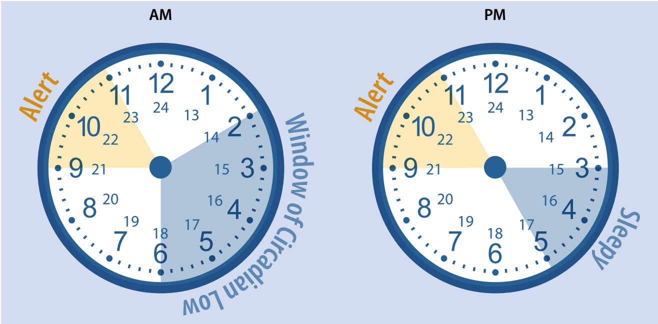
Frequent recovery periods reduce cumulative fatigue more effectively than less frequent ones. For example, weekly recovery periods are more likely to relieve acute fatigue than monthly recovery periods. Consequently, guidelines that ensure a minimum number of days off per week are necessary for minimizing cumulative fatigue effects over longer periods of time (e.g., month, year).

1.3 Time-of-Day and Circadian Physiology

Time-of-day or circadian effects are important considerations in determining 24-hour operational requirements because circadian rhythms do not adjust rapidly to change. In fact, the rhythms of many physiological functions adjust at different rates.

There is a 24-hour biological "clock" in the human brain, as in other organisms, that regulates 24-hour patterns of body functions. This clock controls not only sleep and wakefulness alternating in parallel with the environmental light/dark cycle, but also the oscillatory nature of most physiological, psychological and behavioral functions. The wide range of body functions controlled by the clock includes body temperature, hormone secretion, digestion, physical and mental performance, mood and many others. On a 24-hour basis, these functions fluctuate in a regular pattern with a high level at one time of day and a low level at another time.

The clock's circadian (*circa* meaning "around," *dies* meaning "day") pattern of wakefulness and sleep programs the human body for wakefulness during the day and sleep at night. This *circadian system* repeats this pattern on a daily basis. Certain hours of the 24-hour cycle — that is, roughly 0200 to 0600 (for individuals adapted to a usual day-wake/night-sleep schedule), called the *window of circadian low* (WOCL) — are identified as a time when the body is programmed to sleep, and during which alertness and performance are degraded. There is a second, less pronounced, period of reduced alertness between 1500 and 1700. The body is also programmed for two periods of enhanced alertness and performance, and these periods are estimated to occur roughly between 0900 and 1100 and again between 2100 and 2300.



Non-standard schedules interrupt daily wake and sleep patterns, resulting in internal circadian disruption. For example, an individual working during the night is maintaining wakefulness in direct opposition to physiological programming to be asleep. Physiological, psychological and behavioral functions are set by the circadian system to a low status during the WOCL and a person cannot compensate by being awake and active. Conversely, the same individual sleeping during the day is in direct opposition to physiological programming to be awake. The circadian system provides a high level of functioning during the day that counteracts the drive to sleep.

Circadian disruption also occurs with jet lag. When the biological clock is not aligned with the external environment's time cues, desynchronization occurs both in relation to the external environment and among the various internal physiological functions. Such circadian disruptions can lead to acute sleep loss, sleep debt, decrements in performance and alertness, and various health problems (e.g., gastrointestinal).

Scientists agree there is no simple equation to determine the rate of circadian adjustment in any one individual. Numerous factors play a role, such as number of time zones crossed, direction of travel, amount and timing of light exposure, morning/evening types, and long sleepers vs. short sleepers. While one study in the 1970s on non-pilot volunteers suggests that when adjusting to eastbound travel, circadian rhythms adjust at a rate of 1.0 hour per day and when traveling westbound, the adjustment rate is 1.5 hours per day, this has not been confirmed with additional scientific study.

1.4 Continuous Waking Hours

Extended wakefulness and prolonged periods of continuous performance or vigilance on a task will result in sleepiness and fatigue. Across duty periods, these effects can accumulate further. One way to minimize the accumulation of these effects is to limit the length of a duty period (i.e., the continuous hours of wakefulness during operations). Acute effects can be addressed through daily duty limits, and cumulative effects can be minimized by weekly limits.

More scientific evidence is available to support guidelines for acute limits than for determining specific cumulative limits. Nevertheless, cumulative limits (weekly and beyond) remain an accepted operational approach for minimizing accumulation of fatigue effects.

1.5 Individual Differences

There are considerable individual differences in the magnitude of fatigue effects on performance, physiological alertness and subjective reports of fatigue. These differences extend to the effects of sleep loss, night work, required sleep and recovery time for an individual.

Individuals vary from one another in sleep requirement, overall health, age and other factors. Individuals' fatigue level can also vary from day to day based on their participation in activities that contribute to fatigue while on duty and prior to a duty period. In this regard, long-duration commutes immediately before a duty period are of concern.

Scientists agree that increased workload amplifies the performance degradation produced by extended hours of wakefulness and adverse circadian phase (that is, being awake during the WOCL). And individuals respond differently to the effects of workload. In aviation, workload factors can include the number of flight segments, time on task, airport characteristics, weather conditions, aircraft capabilities and other environmental conditions.

The aviation industry represents a diverse range of required work demands and operational environments. Section 2.0 highlights the diverse conditions and individual differences that are encompassed by generalized guidelines. This diversity further illustrates that one set of guidelines cannot cover all personnel or operational conditions, and that there is no single or absolute solution to these challenges.

2.0 Guidelines and Recommendations

The following guidelines and recommendations, based on the general principles introduced in Section 1.0, address the 24-hour duty and rest scheduling requirements of the business aviation industry. They are designed for application to minimum flight crew complements of two or more.

An overview of the guidelines and recommendations is provided in Tables 1 and 2 (p. 6). Definitions of terms used in the table are provided in the section following the table. It is important to become familiar with the definitions used to develop these guidelines, and apply the guidelines within the context of the definitions. An easily printable version of the tables can be found in the appendix.

2.1 WOCL Operations

Due to individual differences and operational factors, it is difficult to accurately estimate the adjustment of the circadian rhythm in individuals when crossing time zones. For purposes of scheduling, a common regulatory approach for estimating time zone adjustment is the following. For duty periods that cross three or fewer time zones, the WOCL is roughly 0200 to 0600 home-base/domicile time. For duty periods that cross four or more time zones, the WOCL is estimated to remain at home-base/domicile time for the first 48 hours only. After a crewmember remains away more than 48 hours from home-base/domicile, the WOCL is roughly 0200 to 0600 local time.

Recommended guidelines related to the WOCL should be applied when any of the following operations occur:

- Landing occurs during the WOCL;
- Flight time occurs during the WOCL; or,
- Duty period begins at 0400 or earlier within the WOCL.

Table 1
Recommended Guidance for Non-Augmented Crews
24-Hour Period

Type of Operation	Duty Period (maximum hours)	Flight Time (maximum hours)	Off-Duty Period (minimum hours)
Standard[1]	14	10	10 **Weekly:** Minimum of 36 continuous hours, including two consecutive nights, in seven-day period
WOCL[2]	12	10 Restricted landings (see Section 2.4.2)	12 48 continuous hours in 7-day period following multiple WOCL duty periods
Extended[3]	14	12 Restricted landings and compensatory time off duty (see Section 2.4.2) **Weekly:** Maximum of 4 cumulative hours of extension	12
WOCL	No extensions recommended		48 continuous hours in a 7-day period following multiple WOCL duty periods
Multiple Time Zones			48 continuous hours off duty on return home following a duty period crossing multiple time zones

Notes

1. *Standard operation*s are defined as operations that do not encroach on the WOCL and are not extended operations.
2. *Window of circadian low (WOCL) operations* are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL, or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).
3. *Extended operations* are defined as any operation with a duty period longer than 14 hours or flight time longer than 10 hours. Extended operations can involve duty/rest cycles longer than 24 hours.

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration

Table 2

Recommended Guidance for Augmented[1] Crews

24-Hour Period[2]

Type of Operation	Duty Period (maximum hours)	Flight Time (maximum hours)	Off-Duty Period (minimum hours)
Reclining seat available for rest	18	16	12
Supine bunk available for rest	20	18 Each flight crewmember to have maximum sleep opportunity with a minimum of 4 hours total	12 Maximum of two consecutive duty periods with 18 hours off duty after the two consecutive duty periods
WOCL[3]	No extensions recommended		
Multiple time zones			48 continuous hours off duty on return home following a duty period crossing multiple time zones

Notes

1. *Augumented crew* is a flight crew that comprises more than the minimum number required to operate the aeroplane so that each crewmember can leave his or her assigned post to obtain in-flight rest and be replaced by another appropriately qualified crewmember.
2. Augmented operations can involve duty/rest cycles longer than 24 hours.
3. *Window of circadian low (WOCL) operations* are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL, or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration

2.2 Off-Duty Period

Definition of *Off Duty*

Off duty is a continuous, defined period of time, subsequent to and/or prior to duty, during which time crewmembers are free of all duties.

2.2.1 Off-Duty Period: Sleep Opportunity

There are two important factors to be considered when scheduling off-duty periods during a trip. The most important factor is to ensure that the off-duty period provides an eight-hour sleep opportunity to allow for recovery. Also, it should be recognized that an appropriate “wind-down” period is needed to allow the individual to relax and unwind prior to falling asleep. This wind-down period is in addition to the eight-hour sleep opportunity.

The second factor that is important when scheduling off-duty periods is to provide time for the other necessary activities during an off-duty period. These activities can include transportation to and from layover accommodations, hotel check in/out, meals, shower, exercise and personal hygiene. Therefore, the off-duty period should be a minimum of 10 hours uninterrupted within any 24-hour period, to include an eight-hour sleep opportunity, a wind-down period, and time for the other necessary activities. (In the event of extended duty, see Section 2.3.3; for extended flight time, see Section 2.4.2.)

2.2.2 Off-Duty Period: Recovery Opportunities

The general principles outline the importance of recovery to minimize the cumulative effects of sleep loss and fatigue over multiple duty days. Two consecutive nights of normal sleep is a minimum requirement to recover from sleep loss and to enable an individual to return to duty sufficiently rested. Therefore, the standard off-duty period for recovery should be a minimum of 36 continuous hours, to include two consecutive nights of recovery sleep, within a seven-day period (calculated on a seven-day or 168-hour rolling basis). To provide operational flexibility, an alternate off-duty period could be a minimum of 48 continuous hours, to include two consecutive nights of recovery sleep, within a 10-day period.

2.2.3 Off-Duty Period (WOCL Operations)

Extensive scientific research, including aviation data, demonstrates that maintaining wakefulness during the WOCL is associated with higher levels of performance-impairing fatigue than during daytime wakefulness. Duty periods that occur during the WOCL will have a higher potential for reduced performance and alertness than those that occur during daytime.

It is recommended that following duty during the WOCL, the off-duty period should be a minimum of 12 uninterrupted hours within any 24-hour period. If three or more duty periods within a seven-day period encroach on all or any portion of the WOCL, it is recommended that the standard off-duty period (36 continuous hours within seven days) be extended to 48 hours to ensure recovery.

2.2.4 Off-Duty Period: Time Zone Changes

In general, the longer a flight crewmember is away from the home-base/domicile time zone, the more recovery time is needed for readjustment to home-base/domicile time. Therefore, it is recommended that for duty periods that include crossing four or more time zones and that involve 48 hours or more in a time zone away from the home-base/domicile time zone, a minimum of 48 hours off duty be scheduled upon return to home-base/domicile time.

2.3 Duty Period

Definition of *Duty*

Duty is any task that crewmembers are required by the operator to perform, including for example, flight duty, aircraft maintenance, administrative work, training, positioning, and standby when it is likely to induce fatigue.

Definition of *Duty Period*

Duty period is a period that starts when a crewmember is required by an operator to report for or to commence a duty and ends when that crewmember is free from all duties.

2.3.1 Duty Period

To reduce vulnerability to performance-impairing fatigue from extended hours of continuous wakefulness and prolonged periods of continuous performance requirements, cumulative duty per 24 hours should be limited. It is recommended that this limit not exceed 14 hours within a 24-hour period. The 14-hour duty period can be extended only with augmented flight crew (see Section 2.3.3).

2.3.2 Duty Period: WOCL

Given the performance decrements associated with the WOCL, it is recommended that this limit not exceed 12 hours within a 24-hour period.

2.3.3 Extended Duty Period: Augmented Flight Crew

Augmenting the flight crew provides for reduced time at the controls for each crewmember and allows for a sleep opportunity during a duty period. Consequently, with additional flight crew and an opportunity for sleep, fatigue would be expected to accumulate more slowly. In such circumstances, duty periods can be increased beyond the recommended limit of 14 hours within each 24-hour period. When an additional flight crewmember rotates into the flight deck positions, the duty period can be extended, with specified restrictions. In each circumstance, it is required that each flight crewmember be provided one or more on-duty sleep opportunities.

The guidelines acknowledge that an extended duty period with augmented flight crew will usually involve operating during the WOCL. All of the following guidelines should be observed when scheduling extended duty periods:

- Each crewmember should be given maximum sleep opportunities when scheduling in-flight rest periods in augmented operations. At least four total hours per duty period should be provided for these sleep opportunities.
- A minimum of 12 hours off duty should be provided following each augmented duty period.
- A maximum of two consecutive extended duty periods should be scheduled.
- Following two consecutive extended duty periods, a minimum of 18 hours off duty should be provided to crewmembers.

Controlled rest on the flight deck should not be considered as a substitute for the sleep opportunities or facilities required when additional crewmembers are assigned to a flight operation.

2.3.3.1 Extended Duty Periods: 18-Hour and 20-Hour

In order to extend duty periods beyond the recommended limits, the flight crew should have access to a dedicated sleep facility to be used during scheduled sleep periods. Extensions up to 18 hours require a reclining seat that is separated and screened from the flight deck and passengers. Extensions up to 20 hours require a sleep facility permitting a supine position that is separated and screened from the flight deck and passengers.

2.4 Flight Time

Definition of *Flight Time*

Flight time is the total time from the moment an aircraft first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.

2.4.1 Standard Flight Time

To reduce vulnerability to performance-impairing fatigue from extended hours of continuous wakefulness and prolonged periods of continuous performance requirements, cumulative flight time per 24 hours should be limited. It is recommended that for standard operations, cumulative flight time should not exceed 10 hours within a 24-hour period.

Standard operations include multiple flight segments and day or night flying.

2.4.2 Extended Flight Time: Non-Augmented

To provide operational flexibility, cumulative flight time can be extended beyond 10 hours when accompanied by additional restrictions and compensatory off-duty periods. This extended flight time should not exceed 12 hours within a 24-hour period.

If cumulative flight time is extended beyond 10 hours, the following restrictions and compensatory off-duty periods should be applied:

Workload: Restricted Number of Landings. Accident data and performance-based and physiology-based fatigue research suggest that increased vulnerability and risk occur during critical phases of operation, with the highest risk levels occurring during descent and landing. Each additional landing can increase workload, further degrade performance and represent a period of increased vulnerability. Because sufficient scientific data in aviation settings are not available, it is necessary to apply general principles. If flight time for non-augmented crew operating during the WOCL contains a single, long and continuous block-to-block flight time (e.g., approaching the maximum of 10 hours), then it is recommended that the flight crew perform no other flight duties after landing, such as repositioning flights or short passenger drop-off flights.

Cumulative Effects: Maximum Cumulative Hours of Extension. Over time, extended flight time can result in cumulative effects of fatigue. To support operational flexibility and still minimize the potential for cumulative effects of fatigue, it is recommended that flight time can be extended by a cumulative total of four hours within a seven-day period. For example, there could be two two-hour extensions of the standard 10-hour flight time (2 hours x 2 = 4 hours) in a seven-day period. These extensions should not be scheduled on consecutive days.

Recovery: Compensatory Off-Duty Period. An extended off-duty period is recommended to promote recovery from the acute fatigue associated with flight time extensions. The subsequent 10-hour off-duty period should be extended to 12 hours.

Flight Time: WOCL. While operational circumstances may necessitate extended flight time into the WOCL, it is recommended that there be no planned extensions of flight time for non-augmented crew operating during the WOCL.

2.4.3 Extended Flight Time: Augmented Flight Crew

As described in Section 2.3.3, augmenting crews can allow for reduced time at the controls and opportunities for rest periods. In these cases, flight time can be increased beyond the recommended limit of 10 hours within each 24-hour period. All recommended guidelines in Section 2.3.3 for extended duty periods for augmented crews apply to extended flight time.

2.4.3.1 Extended Flight Time: 16-Hour and 18-Hour

Flight time can be extended when the flight crew has access to a dedicated sleep facility that can be used during scheduled sleep periods. Extensions up to 16 hours require a reclining seat that is separated and screened from the flight deck and passengers. Extensions up to 18 hours require a sleep facility permitting a supine position that is separated and screened from the flight deck and passengers.

2.5 Cumulative Limits

As described, daily and weekly (short-term) fatigue vulnerabilities are specifically addressed by the following:

- Daily (24-hour period) limits on duty periods and flight time;
- Minimum off-duty period for each 24-hour period; and,
- Off-duty recovery period per seven-day period.

A combination of daily duty and flight limits, and rest requirements (daily and weekly) help define weekly limits. Weekly limits also are influenced by the operational needs of the organization. An illustration in the appendix depicts a simple interpretation of how combining daily recommended maximum duty periods with minimum rest periods may look on a per week basis.

Operational experience suggests that there are safety benefits to observing monthly and yearly (long-term) limits in managing cumulative or long-term fatigue. These guidelines not only provide scheduling limits within a single operator but also provide an additional mechanism to ensure that limits are not exceeded when a flight crewmember works for more than one operator. Therefore, a joint responsibility between the operator and the pilot is required when observing these limits.

While scientific evidence specific to aviation is not sufficient to establish hard long-term limits, the industry has established recommended cumulative limits by applying general scientific principles. As a general guideline, the current industry standard is 100 cumulative flight hours per month and 1,000 cumulative flight hours per year.

Both short-term and long-term cumulative limits vary among operators. Therefore, it is important that operators consider their operational needs and practices when establishing company-specific cumulative limits.

2.6 Standby

Definition of *Standby*

Standby is a defined period of time at the airport, at the hotel or at home, during which a crewmember is required by the operator to be available to receive an assignment for a specific duty without an intervening rest period.

2.6.1 Standby Considerations

Flight crewmembers on standby provide a critical element in operational flexibility and the opportunity to meet unanticipated needs. Duty assignments should consider all of the following factors:

- Prior sleep and timing;
- Length of duty;
- Continuous hours of wakefulness relative to duty period; and,
- Circadian placement relative to duty period.

3.0 Fatigue Management

Fatigue management principles have been increasingly refined in the commercial aviation setting. These principles are being adapted to business aviation operations which, given the flexibility required in business aviation, can provide a significant contribution to overall safety when the principles are customized to meet the unique demands of each flight operation.

3.1 Two Foundational Principles of Fatigue Management

There are two core principles that form the basis of every fatigue management effort, regardless of the complexity of the operation:

> *The first is adherence to recommended duty and rest guidelines modeled on those found in this document. As noted, these guidelines are based on a combination of operational experience and scientific understanding.*
>
> *The second principle is operation-wide fatigue education and training that includes comprehensive, science-based educational content and training that applies these scientific principles to the specific fatigue challenges within the flight operation.*

Implementation of these principles may be sufficient for a non-complex flight operation that has, for example, predictable schedules into familiar locations with little variation.

3.2 Additional Elements for Active Fatigue Management

More complex operations require active fatigue management, a combination of the following elements drawn from commercial operations. Each operator must develop a fatigue management approach that addresses the fatigue challenges of its unique operation and, as noted, must train members of the operation according to those characteristics. Elements of a fatigue management approach can include:

3.2.1 Fatigue Countermeasures

These address fatigue challenges specific to the operation. Use of operational countermeasures varies widely in business aviation, based on many factors that include the characteristics of the operational environment, individual preferences and regulatory limitations. Listed below are a number of countermeasures reportedly common in business aviation. These are provided not as guidelines but to demonstrate the range of options available to manage fatigue in operations.

Break During Duty Day: For two-pilot crews, when the duty day includes a period of six hours or more on standby at an en route stop, pilots can obtain a maximum rest/sleep opportunity at a local hotel. In such cases, every two hours of hotel rest might be used to extend the duty day (but *not* flight time) by one hour (e.g., four hours rest permits a two-hour duty-day extension).

Pre-Departure Protected Rest: For crews anticipating a maximum-length duty day, consider scheduling pre-departure protected rest at a local hotel near the departure airport. Protected rest periods help to facilitate good quality sleep, by protecting sleep opportunities from potential disturbances (for example, due to calls from other personnel, or external noise). This helps to ensure that the duty day is initiated with little or no sleep debt. In some cases, preparation of the aircraft by a backup crew may afford additional mission flexibility.

Controlled Rest on the Flight Deck: Scientific data obtained during non-augmented, long-haul flight operations have demonstrated the effectiveness of a planned cockpit rest period of up to 40 minutes to promote performance and alertness. Controlled rest is just one operational strategy and is not an answer to all fatigue resulting from flight operations. Controlled rest is absolutely not intended as a substitute for additional flight crew or for appropriate rest facilities, or as support for extended duty. All possible strategies that maintain or improve safety should be considered. Sample operating procedures for controlled rest on the flight deck can be found in Appendix C to the *Fatigue Risk Management Systems (FRMS) Implementation Guide for Operators* (ICAO/IATA/IFALPA, July 2011).

It is important to note that current regulations in some countries, including the United States, do not sanction use of controlled rest on the flight deck for non-augmented crews.

Restorative Breaks: It is well known that performance can decline as a function of time spent on a given task. Breaks from continuous, prolonged performance of a required task, such as monitoring, are important to maintain consistent and appropriate levels of performance. Both restorative breaks and adequate sleep, which includes recovery sleep, are important to help sustain optimal performance. Therefore, restorative breaks introduced in this section mean brief periods of time during a duty period in which the pilot disengages from the task at hand. Periodic restorative breaks — taken one pilot at a time on about an hourly basis — should be an integral part of in-flight crew activities. In-seat restorative breaks can include short periods of relaxation or stretching. More active restorative breaks can be as simple as standing up and stretching limbs.

3.2.2 Policies and Practices

These can be developed to manage and mitigate day-to-day crewmember fatigue resulting from specific operational demands. Examples of these mitigations include:

Preflight Planning: For augmented crews, specific preflight planning of the in-flight duty/rest cycle is important. Crewmembers should communicate how rested they are and how they feel physiologically prior to departure because sometimes crewmembers' planned sleep is shortened before reporting for duty due to circumstances beyond their control. The chief pilot (or pilot-in-command) can adjust assignments of pre-established times of flight deck duty and rest in order to effectively mitigate fatigue. Priority should be given to the landing crewmembers with consideration for optimum timing in relation to circadian rhythm and recovery from sleep inertia (i.e., the feeling of grogginess or sleepiness upon awakening). Duty/rest periods for cabin crewmembers should be included in this planning.

Pre-Positioning Crews: When operational needs exceed recommended guidelines, it is recommended that relief crews be pre-positioned at appropriate locations along the route. Pre-positioning should be planned to allow for travel contingencies and should provide opportunity for circadian adaptation and recommended rest prior to commencing duty.

Protected Sleep Opportunities: It is important that flight crew sleep opportunities be protected, for example, from calls by scheduling managers, responsibilities for flight planning and noise caused by hotel staff.

3.2.3 Fatigue Reporting Mechanism

This is needed for hazard reporting as well as cases of a crewmember requesting relief from duty. The fatigue reporting system should include a method for collecting and analyzing fatigue reports, and a mechanism for providing feedback to members of the flight operation. Crewmember reports about fatigue risk and associated performance changes, in addition to scheduling information, allow the operator to evaluate specific operational requirements that may be more fatigue inducing than others. They also provide a foundation for ongoing refinement of fatigue mitigation strategies.

3.2.4 Fatigue Management Tools

These should be both strategic and tactical for a multi-layered approach. For example, operators can include a number of the following tools:

- Flight Risk Assessment Tool that includes fatigue factors commonly found in the flight operation;
- Flight crew surveys that focus on specific types of trips, use of countermeasures, etc.;
- Use of biomathematical models to assess the potential fatigue levels of various trip scenarios, the effectiveness of crew prepositioning or augmenting strategies, and insights for layover and recovery planning; and,
- Objective data collection in cases in which scheduled duty periods exceed recommended guidelines and additional empirical information can help design mitigations and countermeasures.

3.2.5 Process for ongoing review

This covers fatigue-related risks and the effectiveness of the fatigue management effort.

3.3 Fatigue Management Guidance

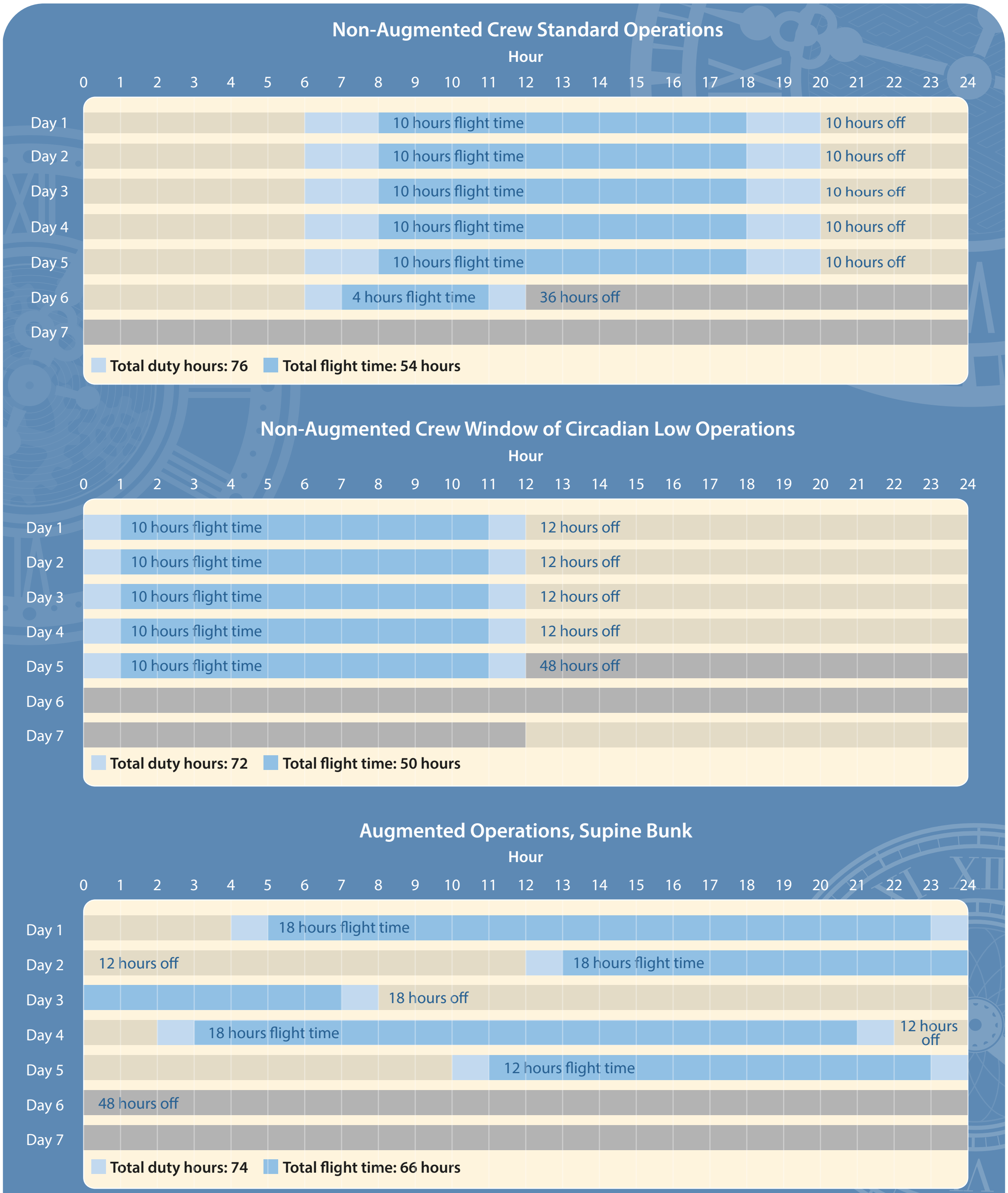
ICAO, the International Business Aviation Council and Flight Safety Foundation currently are collaborating on further detailed guidance, above and beyond the content of this document. This work will include describing new elements and their appropriate application in a business aviation setting.

A common theme of all fatigue management approaches is a shared responsibility among all parties involved in the flight operation, including management, flight crew, cabin crew, schedulers, managers and maintenance personnel. Aviation professionals who have a clear understanding and constant awareness of fatigue risks make better-informed decisions at both the organizational and individual levels, yielding safety benefits for the operation along with personal health and safety benefits for every individual.

Appendix

The following charts depict a simple interpretation of combining daily recommended maximum duty periods with minimum rest periods (from Tables 1 [p. 5] and 2 [p. 6]) on a per week basis, then use basic arithmetic to calculate the weekly limits. However, keep in mind that simple calculations using daily guidelines to construct weekly cumulative limits do not consider operational conditions, workload and safety standards of a flight operation.

It must be recognized that operational demands can introduce additional fatigue, requiring active fatigue management strategies, which sometimes include reducing weekly limits. This additional complexity should not be overlooked, especially when approaching maximum duty limits, whether on a daily or weekly basis.



Note: The charts are derived from maximum duty times found in Table 1 (p. 6) and Table 2 (p. 7).

Source: Flight Safety Foundation and National Business Aviation Association

Table 1

Recommended Guidance for Non-Augmented Crews

24-Hour Period

Type of Operation	Duty Period (maximum hours)	Flight Time (maximum hours)	Off-Duty Period (minimum hours)
Standard[1]	14	10	10 **Weekly:** Minimum of 36 continuous hours, including two consecutive nights, in seven-day period
WOCL[2]	12	10 Restricted landings (see Section 2.4.2)	12 48 continuous hours in 7-day period following multiple WOCL duty periods
Extended[3]	14	12 Restricted landings and compensatory time off duty (see Section 2.4.2) **Weekly:** Maximum of 4 cumulative hours of extension	12
WOCL	No extensions recommended		48 continuous hours in a 7-day period following multiple WOCL duty periods
Multiple Time Zones			48 continuous hours off duty on return home following a duty period crossing multiple time zones

Notes

1. *Standard operations* are defined as operations that do not encroach on the WOCL and are not extended operations.
2. *Window of circadian low (WOCL) operations* are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL, or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).
3. *Extended operations* are defined as any operation with a duty period longer than 14 hours or flight time longer than 10 hours. Extended operations can involve duty/rest cycles longer than 24 hours.

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration

Table 2

Recommended Guidance for Augmented[1] Crews

24-Hour Period[2]

Type of Operation	Duty Period (maximum hours)	Flight Time (maximum hours)	Off-Duty Period (minimum hours)
Reclining seat available for rest	18	16	12
Supine bunk available for rest	20	18 Each flight crewmember to have maximum sleep opportunity with a minimum of 4 hours total	12 Maximum of two consecutive duty periods with 18 hours off duty after the two consecutive duty periods
WOCL[3]	No extensions recommended		
Multiple time zones			48 continuous hours off duty on return home following a duty period crossing multiple time zones

Notes

1. *Augumented crew* is a flight crew that comprises more than the minimum number required to operate the aeroplane so that each crewmember can leave his or her assigned post to obtain in-flight rest and be replaced by another appropriately qualified crewmember.
2. Augmented operations can involve duty/rest cycles longer than 24 hours.
3. *Window of circadian low (WOCL) operations* are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL, or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration