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# **Principles and Guidelines for Duty and Rest Scheduling in Commercial Aviation**

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David F. Dinges, R. Curtis Graeber, Mark R. Rosekind,  
Alexander Samel, and Hans M. Wegmann

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May 1996



National Aeronautics and  
Space Administration

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David F. Dinges, University of Pennsylvania Medical School, Philadelphia, Pennsylvania  
R. Curtis Graeber, Boeing Commercial Airplane Group, Seattle, Washington  
Mark R. Rosekind, Ames Research Center, Moffett Field, California  
Alexander Samel, and Hans M. Wegmann, DLR-Institute of Aerospace Medicine,  
Cologne, Germany

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Space Administration

**Ames Research Center**  
Moffett Field, California 94035-1000

## Table of Contents

|                                                                                                     |    |
|-----------------------------------------------------------------------------------------------------|----|
| Preface .....                                                                                       | v  |
| Introduction .....                                                                                  | 1  |
| 1.0 General Principles .....                                                                        | 2  |
| 1.1 Sleep, Awake Time Off, and Recovery are Primary Considerations .....                            | 2  |
| 1.1.1 Sleep .....                                                                                   | 2  |
| 1.1.2 Awake time off .....                                                                          | 3  |
| 1.1.3 Recovery .....                                                                                | 3  |
| 1.2 Frequent Recovery Periods are Important .....                                                   | 3  |
| 1.3 Time-of-day/Circadian Physiology Affects Sleep and Waking Performance .....                     | 3  |
| 1.4 Continuous Hours of Wakefulness/Duty Can Affect Alertness and Performance .....                 | 4  |
| 1.5 Human Physiological Capabilities Extend to Flight Crews .....                                   | 4  |
| 1.6 Flight Crews are Made Up of Individuals .....                                                   | 4  |
| 1.7 Differences and Variability Preclude an Absolute Solution .....                                 | 4  |
| 2.0 Specific Principles, Guidelines, and Recommendations .....                                      | 4  |
| 2.1 Off-Duty Period .....                                                                           | 5  |
| 2.1.1 Definition: “off-duty” .....                                                                  | 5  |
| 2.1.2 Off-duty period (acute sleep and awake-time-off requirements) .....                           | 5  |
| 2.1.3 Off-duty period (recovery requirement) .....                                                  | 5  |
| 2.1.4 Off-duty period (following standard flight duty periods during window of circadian low) ..... | 5  |
| 2.2 Duty Periods .....                                                                              | 5  |
| 2.2.1 Definition: “duty” .....                                                                      | 5  |
| 2.2.2 Definition: “duty period” .....                                                               | 5  |
| 2.2.3 Duty period .....                                                                             | 6  |
| 2.3 Flight Duty Periods .....                                                                       | 6  |
| 2.3.1 Definition: “flight duty period” .....                                                        | 6  |
| 2.3.2 Definition: “window of circadian low” .....                                                   | 6  |
| 2.3.3 Standard flight duty period .....                                                             | 6  |
| 2.3.4 Extended flight duty period .....                                                             | 6  |
| 2.3.5 Extended flight duty period: restrictions and compensatory off-duty periods .....             | 6  |
| 2.3.6 Extended flight duty period: additional flight crew .....                                     | 7  |
| 2.3.7 Flight duty period (cumulative) .....                                                         | 7  |
| 2.4 Exceptions Due to Unforeseen Operational Circumstances .....                                    | 7  |
| 2.4.1 Reduced off-duty period (exception) .....                                                     | 8  |
| 2.4.2 Extended flight duty period (exception) .....                                                 | 8  |
| 2.5 Time Differences .....                                                                          | 8  |
| 2.6 Reserve Status .....                                                                            | 8  |
| 2.6.1 Definition: “airport standby reserve” .....                                                   | 8  |
| 2.6.2 Definition: “on-call reserve” .....                                                           | 8  |
| 2.7 Summary Overview: Guidelines and Recommendations .....                                          | 9  |
| 3.0 Other Industry Strategies .....                                                                 | 10 |
| 3.1 Education and Training .....                                                                    | 10 |
| 3.2 Scheduling Practices .....                                                                      | 10 |
| 3.3 Controlled Rest on the Flight Deck .....                                                        | 10 |
| 3.4 Operational Countermeasures .....                                                               | 10 |
| 3.5 Future Developments .....                                                                       | 10 |

## PREFACE

This document is intended to provide scientific input to the issue of duty and rest scheduling of flight crews in commercial aviation. It is available to any interested party that is addressing these complex issues.

The global aviation industry requires 24-hour activities to meet operational demands. To address this challenge, a scientific working group with expertise relevant to these demands met to develop principles and guidelines for duty and rest scheduling in commercial aviation.

**Scientific Working Group Methodology.** First, the group identified areas of scientific knowledge relevant to flight safety. This included identifying areas where relevant data were available and also areas where no scientific data currently exist. Based on current scientific knowledge, general principles directly related to aviation operational considerations were established. With the general principles as a basis, specific principles, guidelines, and recommendations for duty and rest scheduling in commercial aviation were developed. There was no intention to create regulatory policy. This was beyond the scope of the scientific working group. Although the group is aware of current operational practices, it adhered to the preset guideline of requiring scientific data relevant to specific recommendations. The group noted that there may not be a single solution to the challenges posed by the 24-hour demands of the aviation industry. Therefore, other industry strategies are suggested to complement the duty and rest scheduling guidelines. Throughout this process, input was obtained from individuals with extensive operational experience and familiarity with these issues.

**Scientific Basis for Principles and Guidelines.** The scientific working group was composed of scientists actively involved in examining these issues in aviation settings. The group intends to produce two documents based on their work. This first document is intended to be concise, to be focused on operational considerations, and to provide scientific input to this complex issue. The second document will follow and will provide the specific scientific references that support the principles and guidelines outlined here. This second document will be longer and will focus on the scientific considerations related to these issues. It is planned that an initial draft of this second document will be available within approximately 12 months.

**Implementation.** It is acknowledged that implementation of these principles and guidelines may require additional considerations. These considerations include economic, legal, cost/benefit, and other factors. It was beyond the scope of the scientific working group to address these issues, and they are left to appropriate operational and regulatory expertise for deliberation.

The scientific working group met as individuals and not as representatives of any organization or of a particular position on any issue. Therefore, the views and opinions expressed in this document are those of the scientific working group and do not necessarily reflect those of any organization.

In alphabetical order, the scientific working group included: David F. Dinges, Ph.D., R. Curtis Graeber, Ph.D., Mark R. Rosekind, Ph.D., Alexander Samel, Ph.D., and Hans M. Wegmann, M.D. To refer questions about this document to the scientific working group, please use either of the following points of contact:

Mark R. Rosekind, Ph.D.  
NASA Ames Research Center  
Mail Stop 262-4  
Moffett Field, CA 94035-1000  
(415) 604-3921 (Office)  
(415) 604-3729 (Fax)

Hans M. Wegmann, M.D.  
DLR-Institute of Aerospace Medicine  
Linder Hoehe  
D-51147 Koeln  
Germany  
49 2203 601 1 ext. 3667 (Office)  
49 2203 696 372 (Fax)

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Ames Research Center

## **INTRODUCTION**

### **Twenty-four Hour Requirements of the Aviation Industry**

The aviation industry requires 24-hour activities to meet operational demands. Growth in global long-haul, regional, overnight cargo, and short-haul domestic operations will continue to increase these round-the-clock requirements. Flight crews must be available to support 24-hour-a-day operations to meet these industry demands. Both domestic and international aviation can also require crossing multiple time zones. Therefore, shift work, night work, irregular work schedules, unpredictable work schedules, and time zone changes will continue to be commonplace components of the aviation industry. These factors pose known challenges to human physiology, and because they result in performance-impairing fatigue, they pose a risk to safety. It is critical to acknowledge and, whenever possible, incorporate scientific information on fatigue, human sleep, and circadian physiology into 24-hour aviation operations. Utilization of such scientific information can help promote crew performance and alertness during flight operations and thereby maintain and improve the safety margin.

### **Challenges to Human Physiology**

Throughout aviation history, operational capabilities and technology have evolved dramatically, while human physiological capabilities have not. Flight operations can engender fatigue, sleep loss, and circadian disruption and these physiological factors can result in decreased performance and reduced alertness during operations. Over the past 40 years, scientific knowledge about sleep, circadian physiology, sleepiness/alertness, and the performance decrements associated with these factors has increased significantly. Scientific research has extended its examination of these factors to operational environments, including field and simulator studies. These studies have confirmed the presence in aviators of performance-impairing fatigue resulting from the sleep loss, circadian disruption, and workload engendered by current flight and duty practices.

Humans are central to aviation operations and continue to perform critical functions to meet the 24-hour requirements of the industry. Therefore, human physiological capabilities, and limitations, remain crucial factors in maintaining safety and productivity in aviation.

### **Principles Based on Scientific Knowledge**

Though research on fatigue, sleep and circadian physiology, and shift work schedules has generated an extensive body of scientific knowledge, the application of this information to the requirements of operational settings is relatively new. While acknowledgment of this scientific information is increasing, its transfer to operations (e.g., scheduling, regulatory considerations, personal strategies, countermeasures) offers the greatest potential for its benefit. Current federal regulations and industry scheduling practices rarely acknowledge or incorporate such knowledge. The primary purpose of this

document is to outline scientifically-based principles that can be applied to the duty and rest scheduling requirements of the aviation industry.

## **Shared Responsibility**

There is no one absolute or perfect solution to the demands of duty and rest scheduling in aviation. It is critical that safety be acknowledged as a shared responsibility among all the industry participants. Each component of the aviation system should be examined for avenues to incorporate scientific information and to apply guidelines and strategies that will maximize performance and alertness during flight operations. Regulatory considerations, scheduling practices, personal strategies, and technology design are specific components of the industry that could be subject to such an examination.

Each of these components is complex and presents unique challenges. This document is focused on scientifically-based principles and guidelines for duty and rest scheduling. However, it is acknowledged that regulatory action involves many considerations, such as legal, economic, and current practice. It is the intent of this document that relevant scientific information be considered in the regulatory domain.

## **“Safe” can be Difficult to Quantify**

Determining a “safe” operation is a complex task. Aircraft accidents are such rare occurrences that they may not provide the best outcome variable to estimate safe operations. The aviation industry and flying public demand a high margin of safety and redundancy. Among modes of transportation, the aviation industry’s reputation for safety is well-deserved. As many segments of the industry increase their activities, as technology enables longer flights, and as overall growth continues, the challenge will be to maintain, and where possible, improve the safety margin. The fatigue factors addressed in these principles can create a vulnerability for decrements in performance and alertness that can reduce the safety margin. Guidelines designed to specifically address these factors can help to minimize this vulnerability.

## **Objectives**

The primary objective of this document is to provide empirically derived principles and guidelines for duty and rest scheduling in commercial aviation. In the first section, scientifically-based principles related to operational issues posed by the aviation industry are outlined. In the second section, the principles are applied to guidelines for duty and rest scheduling in commercial aviation, with specifics provided where appropriate and available. In the third section, a brief overview of other potential industry strategies to address these issues is provided.

## **1.0 GENERAL PRINCIPLES**

### **1.1 Sleep, Awake Time Off, and Recovery are Primary Considerations**

**1.1.1 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 provides for optimal levels of performance and physiological alertness during wakefulness. On average, this is 8 hours of sleep in a 24-hour period, with a range of sleep needs greater than and less than this amount. Losing as little as 2 hours of sleep will result in acute sleep loss, which will induce fatigue and degrade subsequent waking performance and alertness. Over days, sleep loss—any amount less than is required—will accrue into a cumulative sleep debt. The physiological need for sleep created by a deficit can only be reversed by sleep. An individual who

has obtained required sleep will be better prepared to perform after long hours awake or altered work schedules than one who is operating with a sleep deficit.

**1.1.2 Awake time off**– Fatigue-related performance decrements are traditionally defined by declines in performance as a function of time spent on a given task. Breaks from continuous performance of a required task, such as monitoring, are important to maintain consistent and appropriate levels of performance. Therefore, awake time off is introduced here to describe time spent awake and free of duty. Thus both awake time off and sleep are needed to ensure optimum levels of performance.

**1.1.3 Recovery**– Recovery from an acute sleep deficit, cumulative sleep debt, prolonged performance requirement, or extended hours of continuous wakefulness is another important consideration. Operational requirements can engender each of these factors and it is important that a recovery period provide an opportunity to acquire recovery sleep and to re-establish normal levels of performance and alertness.

Required sleep and appropriate awake time off promote performance and alertness. These are especially critical when challenged with extended periods of wakefulness (i.e., duty) and circadian disruption (i.e., altered work/rest schedule). Recovery is important to reduce cumulative effects and to return an individual to usual levels of performance and alertness.

## **1.2 Frequent Recovery Periods are Important**

More frequent recovery periods reduce cumulative fatigue more effectively than less frequent ones. For example, weekly recovery periods afford a higher likelihood of relieving acute fatigue than monthly recovery periods. Consequently, guidelines that ensure minimum days off per week are critical for minimizing cumulative fatigue effects over longer periods of time (e.g., month, year).

## **1.3 Time-of-day/Circadian Physiology Affects Sleep and Waking Performance**

There is a 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 24-hour 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 circadian (*circa* = around, *dies* = day) pattern of wakefulness and sleep is programmed for wakefulness during the day and sleep at night. The circadian clock repeats this pattern on a daily basis. Certain hours of the 24-hour cycle, that is 0200 to 0600, are identified as a time when the body is programmed to sleep and during which performance is degraded. Time-of-day or circadian effects are important considerations in addressing 24-hour operational requirements because circadian rhythms do not adjust rapidly to change.

For example, an individual operating 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 that cannot be compensated 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 day that counteracts the ability to sleep. Thus, circadian disruption can lead to acute sleep deficits, cumulative

sleep loss, decreases in performance and alertness, and various health problems (e.g., gastrointestinal complaints). Therefore, circadian stability is another consideration in duty and rest scheduling.

#### **1.4 Continuous Hours of Wakefulness/Duty Can Affect Alertness and Performance**

Extended wakefulness and prolonged periods of continuous performance or vigilance on a task will engender sleepiness and fatigue. Across duty periods, these effects can accumulate further. One approach to minimize the accumulation of these effects is to limit the duty time (i.e., continuous hours of wakefulness during operations). Acute effects can be addressed through daily limitations while cumulative effects can be addressed by weekly limitations. There is more scientific data available to support guidelines for acute limitations than to determine specific cumulative limitations. Nevertheless, cumulative limitations (weekly and beyond) remain an important consideration for minimizing accumulation of fatigue effects.

#### **1.5 Human Physiological Capabilities Extend to Flight Crews**

Fatigue has its basis in physiological limits and performance deficits reflect these physiological limits. Flight crews' human physiology is not different from that of other humans. Therefore, it must be expected that the same fatigue-producing factors affecting performance and alertness in experimental subjects, physicians on-call, shift workers, military personnel, and others also affect flight crews. It follows that scientific findings relevant to human physiological capabilities and performance deficits from fatigue, sleep loss, and circadian physiology extend to flight crews.

#### **1.6 Flight Crews are Made Up of Individuals**

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, and considerations of required sleep and recovery time for an individual. Individual differences can vary as a function of age, sleep requirement, experience, overall health, and other factors. Individuals can also vary in their participation in off-duty activities that engender fatigue during a subsequent duty period (e.g., commuting across long distances immediately prior to starting a duty period).

#### **1.7 Differences and Variability Preclude an Absolute Solution**

It must be acknowledged that the aviation industry represents a diverse range of required work demands and operational environments. Sections 1.5 and 1.6 highlight the diverse situations and individuals that are encompassed by generalized guidelines. This further illustrates that guidelines and regulations cannot completely cover all personnel or operational conditions and that there is no single absolute solution to these issues.

### **2.0 SPECIFIC PRINCIPLES, GUIDELINES, AND RECOMMENDATIONS**

The following are specific principles, guidelines, and recommendations to address the 24-hour duty and rest scheduling requirements of the aviation industry. These principles and guidelines, based on the General Principles introduced in section 1.0, are intended to provide a consistent margin of safety across aviation operations. Therefore, they are intended for application to minimum flight crew complements of two or more. Similarly, they are intended for consistent application across Part 121 and Part 135 operations. There is no scientific basis to differentiate between these operations. These



specific principles and guidelines also apply across all flying duty of flight crew members required to perform Part 91 or military flight operations before or after scheduled commercial operations.

In order to provide specific guidelines, it is necessary to define the terms used in these guidelines. Altering these definitions may invalidate the principles that follow.

## **2.1 Off-Duty Period**

**2.1.1 Definition: “off-duty”**– A continuous period of uninterrupted time during which a crew member is free of all duties.

**2.1.2 Off-duty period (acute sleep and awake-time-off requirements)**– The off-duty period should allow for three components. The first critical component of the off-duty period is an 8-hour sleep opportunity. The general principles clearly describe that an acute sleep deficit and a cumulative sleep debt can degrade performance and alertness. Also, it should be recognized that an appropriate “spin down” time may be required to fall asleep. The second component is awake time off, an opportunity to break from the continuous performance of required tasks. The third component is the other activities necessary during an off-duty period. These other necessary activities can include transportation to and from layover accommodations, hotel check in/out, meals, shower, and personal hygiene. Therefore, the off-duty period should be a minimum of 10 hours uninterrupted within any 24-hour period, to include an 8-hour sleep opportunity, awake time off, and time for other necessary activities. (In the case of extended flight duty period, see section 2.3.5.)

**2.1.3 Off-duty period (recovery requirement)**– The general principles outline the importance of recovery to minimize the cumulative effects of sleep loss and fatigue. Two consecutive nights of usual sleep is a minimum requirement to stabilize sleep patterns and return waking performance and alertness to usual levels. Two consecutive nights of recovery sleep can provide recovery from sleep loss. 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 7-day period.

**2.1.4 Off-duty period (following standard flight duty periods during window of circadian low\*)**– Extensive scientific research, including aviation data, demonstrate that maintaining wakefulness during the window of circadian low is associated with higher levels of performance-impairing fatigue than during daytime wakefulness. Therefore, flight duty periods that occur during the window of circadian low have a higher potential for fatigue and increased requirement for recovery. It is recommended that if two or more flight duty periods within a 7-day period encroach on all or any portion of the window of circadian low, then the standard off-duty period (36 continuous hours within 7 days) be extended to 48 hours recovery.

## **2.2 Duty Periods**

**2.2.1 Definition: “duty”**– Any task a crew member is required by the operator to perform, including flight time, administrative work, training, deadheading, and airport standby reserve.

**2.2.2 Definition: “duty period”**– A continuous period of time during which tasks are performed for the operator; determined from report time until free from all required tasks.

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\* For definition of “window of circadian low,” see section 2.3.2.

**2.2.3 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. (In the case of additional flight crew, see section 2.3.6.)

## **2.3 Flight Duty Periods**

**2.3.1 Definition: “flight duty period”**– The period of time that begins when a crew member is required to report for a duty period that includes one or more flights and ends at the block-in time of the final flight segment. At a minimum, this period includes required pre-flight activities and flight time.

**2.3.2 Definition: “window of circadian low”**– The window of circadian low is best estimated by the hours between 0200 and 0600 for individuals adapted to a usual day-wake/night-sleep schedule. This estimate of the window is calculated from scientific data on the circadian low of performance, alertness, subjective report (i.e., peak fatigue), and body temperature. For flight duty periods that cross 3 or fewer time zones, the window of circadian low is estimated to be 0200 to 0600 home-base/domicile time. For flight duty periods that cross 4 or more time zones, the window of circadian low is estimated to be 0200 to 0600 home-base/domicile time for the first 48 hours only. After a crew member remains more than 48 hours away from home-base/domicile, the window of circadian low is estimated to be 0200 to 0600 referred to local time at the point of departure.

**2.3.3 Standard flight duty period**– To reduce vulnerability to performance-impairing fatigue from extended hours of continuous wakefulness and prolonged periods of continuous performance requirements, cumulative flight duty per 24 hours should be limited. It is recommended that for standard operations, this cumulative flight duty period not exceed 10 hours within a 24-hour period. Standard operations include multiple flight segments and day or night flying.

**2.3.4 Extended flight duty period**– An extended cumulative flight duty period should be limited to 12 hours within a 24-hour period to be accompanied by additional restrictions and compensatory off-duty periods. This limit is based on scientific findings from a variety of sources, including data from aviation, that demonstrate a significantly increased vulnerability for performance-impairing fatigue after 12 hours. It is readily acknowledged that in current practice, flight duty periods extend to 14 hours in regular operations. However, the available scientific data support a guideline different from current operational practice. The data indicate that performance-impairing fatigue does increase beyond the 12-hour limit and could reduce the safety margin.

**2.3.5 Extended flight duty period: restrictions and compensatory off-duty periods**– If the cumulative flight duty period is extended to 12 hours then the following restrictions and compensatory off-duty periods should be applied.

*A. Cumulative effects: maximum cumulative hours of extension.* Over time, extended flight duty periods can result in cumulative effects of fatigue. To support operational flexibility and still minimize the potential for cumulative effects, it is recommended that extended flight duty periods can be scheduled for a cumulative total of 4 hours within a 7-day period. For example, there could be two 2-hour extensions of the standard 10-hour flight duty period ( $2 \times 2 = 4$  hr) or four 1-hour extensions ( $4 \times 1 = 4$  hr).

*B. Flight duty periods during window of circadian low.* As described in Section 2.1.4, the window of circadian low (as defined in Section 2.3.2) is associated with higher levels of

performance-impairing fatigue. Therefore, it is recommended that in a 7-day period, there be no extended flight duty period that encroaches on any portion of the window of circadian low.

*C. Restricted number of landings during window of circadian low.* If an extended flight duty period contains a single continuous block-to-block flight period greater than 10 hours that encroaches on any portion of the window of circadian low, then it is recommended that flight crew members be restricted to no additional landings following the flight.

*D. Recovery: compensatory off-duty period.* To promote recovery from the acute fatigue associated with an extended flight duty period, additional off-duty time is recommended. The subsequent 10-hour required off-duty period should be extended by the time duration of the flight duty period extension. For example, an extended flight duty period of 11.5 hours would be accompanied by the subsequent off duty period being extended to 11.5 hours.

**2.3.6 Extended flight duty period: additional flight crew–** Additional flight crew afford the opportunity for each flight crew member to reduce the time at the controls and provide for sleep during a flight duty period. Consequently, with additional flight crew and an opportunity for sleep, it would be expected that fatigue would accumulate more slowly. In such circumstances, flight duty periods can be increased beyond the recommended limit of 12 hours within each 24-hour period. For each additional flight crew member who rotates into the flight deck positions, the flight duty period can be extended by 4 hours as long as the following requirements are met: 1) each flight crew member be provided one or more on-duty sleep opportunities; and 2) when the extended flight duty period is 14 hours or longer, adequate sleep facilities (supine position) are provided that are separated and screened from the flight deck and passengers. Controlled rest on the flight deck is not a substitute for the sleep opportunities or facilities required for additional flight crew members.

If an extended flight duty period is increased according to the above requirements, the maximum flight duty period limit supersedes the 14-hour duty period limit (section 2.2).

**2.3.7 Flight duty period (cumulative)–** A 24-hour cumulative flight duty period limit, a minimum off-duty period per 24 hours, and a specified off-duty recovery period per 7 days focus specifically on short-term vulnerabilities and considerations. To minimize fatigue that is not compensated by short-term recovery and to reduce excessive accumulation across longer periods of time, cumulative flight duty period limitations are recommended. There is not sufficient scientific data to provide specific guidance in this area. However, the general principles apply. For example, when determining cumulative flight duty limitations, shorter time frames should be considered. Therefore, in addition to 30-day and yearly cumulative flight duty period limitations, a 2-week limit should also be set. Also, these cumulative flight duty period limitations should be adjusted downward across the longer time period. Rather than just multiplying the 2-week cumulative flight duty period limitation to calculate the 30-day and yearly amounts, the 30-day amount should be decreased a percentage from the 2-week amount. The yearly cumulative flight duty period limitation should be decreased a percentage from the 30-day amount. This will further reduce the potential for long-term accumulation of fatigue factors.

## **2.4 Exceptions Due to Unforeseen Operational Circumstances**

Exceptions allow the flexibility needed to respond to unforeseen circumstances beyond the control of the operator that occur during operations. They are not intended for use in regular practice. These exceptions must not be scheduled.

**2.4.1 Reduced off-duty period (exception)**– To support operational flexibility, it is recognized that due to circumstances beyond the control of the operator, it may be necessary to reduce an off-duty period to 9 hours. This reduction would occur only in response to an unforeseen operational requirement. In this situation, the subsequent off-duty period should be extended to 11 hours.

**2.4.2 Extended flight duty period (exception)**– To support operational flexibility, an extended flight duty period can be increased by up to a maximum of 2 hours due to unforeseen circumstances beyond the control of the operator. The subsequent required off-duty period should be increased by the time by which the flight duty period is increased.

## **2.5 Time Differences**

In general, the longer a flight crew member is away from the home-base/domicile time zone, the more recovery time is needed for readjustment back to home-base/domicile time. Therefore, it is recommended that for flight duty periods that cross 4 or more time zones, and that involve 48 hours or more away from the home-base/domicile time zone, a minimum of 48 hours off-duty be allowed upon return to home base/domicile time.

## **2.6 Reserve Status**

Flight crew members on reserve status provide a critical element to operational flexibility and the opportunity to meet unanticipated needs. It is important that flight crew members on reserve status obtain required sleep prior to a flight duty period.

**2.6.1 Definition: “airport standby reserve”**– A reserve flight crew member required to be available (on standby) at an airport for assignment to a flight duty period.

An airport standby reserve flight crew member should be considered on duty and the previous duty period guidelines apply.

**2.6.2 Definition: “on-call reserve”**– A reserve flight crew member required to be available to an operator (away from the airport) for assignment to a flight duty period.

On-call reserve status should not be considered duty. However, it is important that the flight crew member has an opportunity to obtain sleep prior to an assigned flight duty period. Two specific principles should be applied. The flight crew member should be provided a: 1) predictable and 2) protected 8-hour sleep opportunity. “Predictable” indicates that the flight crew member should have prior information (24 hours notice is recommended) as to when the 8-hour sleep opportunity can be obtained within the 24-hour on-call reserve time. The 8-hour sleep opportunity should not vary by more than 3 hours on subsequent days to ensure circadian stability. “A protected 8-hour sleep opportunity” should be protected from interruption by assignment to a flight duty period. Any approach that meets the requirements of these two principles could be utilized.

## 2.7 Summary Overview: Guidelines and Recommendations

Figure 1 provides a summary overview of the guidelines and recommendations discussed in this document.

|             | Off-Duty Period                                                   |                                                                                                                                                                                                     |                                                                                               | Duty Period      |                                                                                    | Flight Duty Period                                                                                                                                                                                                                                                                |                                             |                                                                                                                                                                                                |                                            |
|-------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
|             | Per 24-hr period                                                  | Per week                                                                                                                                                                                            | Other                                                                                         | Per 24-hr period | Weekly, Monthly, Annually                                                          | Per 24-hr period                                                                                                                                                                                                                                                                  | Per week                                    | Monthly, Annually                                                                                                                                                                              |                                            |
| Scheduled   | 1) 10 hrs.<br>2) 10+ hrs (following extended flight duty period). | 1) At least 36 continuous hours, to include 2 consecutive nights of recovery sleep, in a 7-day period.<br>2) 48 continuous hours in a 7-day period (following flight duty period in circadian low). | 48 continuous hours upon return home following flight duty period across multiple time zones. | 14 hrs.          | There is not sufficient scientific data to provide specific guidance in this area. | 10 hrs.                                                                                                                                                                                                                                                                           |                                             | There is not sufficient scientific data to provide specific guidance in this area; however, cumulative flight duty period limitations should be adjusted downward over increasing time frames. | Standard                                   |
|             |                                                                   |                                                                                                                                                                                                     |                                                                                               |                  |                                                                                    | 12 hrs (requires restricted landings, maximum cumulative hours, compensatory off-duty time).<br><br>For each additional flight crew member, flight duty time can be increased by 4 hrs (requires sleep opportunity for each crew member, and for FDPs > 14 hrs, a bunk facility). | Maximum of 4 cumulative hours of extension. |                                                                                                                                                                                                | Extended                                   |
| Unscheduled | 9 hrs (subsequent off-duty period increased to 11 hrs).           |                                                                                                                                                                                                     |                                                                                               |                  |                                                                                    | Extended FDP can be increased by up to 2 hrs (subsequent off-duty period increased by an equal amount).                                                                                                                                                                           |                                             |                                                                                                                                                                                                | Exceptions Due to Unforeseen Circumstances |

Figure 1. Summary overview of guidelines and recommendations.

### **3.0 OTHER INDUSTRY STRATEGIES**

A general principle previously stated is that addressing issues of fatigue, sleep loss, and circadian disruption in the aviation industry is a shared responsibility. These principles and guidelines for duty and rest scheduling are intended to provide scientific input to the regulatory process that addresses these issues in aviation. However, there is no single solution to the challenges posed by the 24-hour demands of the aviation industry. To highlight this shared responsibility, several other industry strategies for addressing these issues will be described. These are intended to complement the recommendations listed above.

#### **3.1 Education and Training**

An important first step for the industry is to become informed about the extensive knowledge now available regarding fatigue, sleep, and circadian physiology as it relates to performance and aviation operations. This knowledge can then be incorporated into daily operations. The information can be useful in providing specific recommendations for personal strategies to manage performance and alertness in flight operations. Education and training modules to meet this need are available and currently implemented successfully within the industry.

#### **3.2 Scheduling Practices**

The scientific information available can be particularly useful in guiding rational and physiologically-based scheduling practices. Scheduling is a complex and multi-determined process. However, it is possible and essential to include scientific data on human physiology as a factor for consideration. Obviously, priorities need to be established, and cost/benefit considerations are critical. There are examples of successful integration of scientific information on fatigue into schedule construction.

#### **3.3 Controlled Rest on the Flight Deck**

Scientific data obtained during flight operations have clearly demonstrated the effectiveness of a planned cockpit rest period to promote performance and alertness in nonaugmented long-haul flight operations. Controlled rest is a single operational strategy and is not an answer to all fatigue engendered by flight operations. It is absolutely not intended as a substitute for additional flight crew, appropriate rest facilities, or as support for extended duty. All possible strategies that maintain or improve the safety margin should be considered.

#### **3.4 Operational Countermeasures**

A variety of other strategies for use during flight operations should be examined and utilized where appropriate. This includes the design and use of technology to promote performance and alertness during operations. Varying work demands or other creative uses of flight deck automation could be developed to maintain alertness and performance. Several activities in this area are underway with some successful applications currently in use.

#### **3.5 Future Developments**

There are a number of other possibilities that are in different stages of development. Provocative laboratory studies of several countermeasures are often cited. However, validation of their effectiveness and safety in operational settings is still needed prior to widespread implementation. Research continues and may provide further findings on countermeasures relevant to regulatory, scheduling, personal strategies, and technology approaches to manage alertness in aviation operations.

**REPORT DOCUMENTATION PAGE**Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

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| <b>1. AGENCY USE ONLY (Leave blank)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                 | <b>2. REPORT DATE</b><br>May 1996              | <b>3. REPORT TYPE AND DATES COVERED</b><br>Technical Memorandum             |  |
| <b>4. TITLE AND SUBTITLE</b><br><br>Principles and Guidelines for Duty and Rest Scheduling in Commercial Aviation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                 |                                                | <b>5. FUNDING NUMBERS</b><br><br>505-64-53                                  |  |
| <b>6. AUTHOR(S)</b><br><br>David F. Dinges, R. Curtis Graeber, Mark R. Rosekind, Alexander Samel, and Hans M. Wegmann                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                 |                                                |                                                                             |  |
| <b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b><br><br>Ames Research Center<br>Moffett Field, CA 94035-1000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                 |                                                | <b>8. PERFORMING ORGANIZATION REPORT NUMBER</b><br><br>A-961924             |  |
| <b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b><br><br>National Aeronautics and Space Administration<br>Washington, DC 20546-0001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                 |                                                | <b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b><br><br>NASA TM-110404 |  |
| <b>11. SUPPLEMENTARY NOTES</b><br><br>Point of Contact: Mark R. Rosekind, Ames Research Center, MS 262-4, Moffett Field, CA 94035-1000; (415) 604-3921                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                 |                                                |                                                                             |  |
| <b>12a. DISTRIBUTION/AVAILABILITY STATEMENT</b><br><br>Unclassified — Unlimited<br>Subject Category 51                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                 |                                                | <b>12b. DISTRIBUTION CODE</b>                                               |  |
| <b>13. ABSTRACT (Maximum 200 words)</b><br><br>The aviation industry requires 24-hour activities to meet operational demands. Growth in global long-haul, regional, overnight cargo, and short-haul domestic operations will continue to increase these round-the-clock requirements. Flight crews must be available to support 24-hour-a-day operations to meet these industry demands. Both domestic and international aviation also can require crossing multiple time zones. Therefore, shift work, night work, irregular work schedules, unpredictable work schedules, and time zone changes will continue to be commonplace components of the aviation industry. These factors pose known challenges to human physiology, and because they result in performance-impairing fatigue, they pose a risk to safety. It is critical to acknowledge and, whenever possible, incorporate scientific information on fatigue, human sleep, and circadian physiology into 24-hour aviation operations. Utilization of such scientific information can help promote crew performance and alertness during flight operations and thereby maintain and improve the safety margin.<br>The primary objective of this document is to provide empirically derived principles and guidelines for duty and rest scheduling in commercial aviation. In the first section, scientifically-based principles related to operational issues posed by the aviation industry are outlined. In the second section, the principles are applied to guidelines for duty and rest scheduling in commercial aviation, with specifics provided where appropriate and available. In the third section, a brief overview of other potential industry strategies to address these issues is provided. |                                                                 |                                                |                                                                             |  |
| <b>14. SUBJECT TERMS</b><br><br>Fatigue, Circadian rhythms, Duty and Rest, Scheduling                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                 |                                                | <b>15. NUMBER OF PAGES</b><br>15                                            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                 |                                                | <b>16. PRICE CODE</b><br>A03                                                |  |
| <b>17. SECURITY CLASSIFICATION OF REPORT</b><br>Unclassified                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>18. SECURITY CLASSIFICATION OF THIS PAGE</b><br>Unclassified | <b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> | <b>20. LIMITATION OF ABSTRACT</b>                                           |  |