INDEPENDENT PILOTS ASSOCIATION

June 18, 1996

HAND DELIVERED TO:

Mr. David Hinson
Administrator, Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, DC 20591

Re: FAA NPRM Concerning Pilot Flight and Duty Time
Docket #28081

Dear Administrator Hinson:

I am Robert Miller, a United Parcel Service (UPS) B-757/767 Captain and President of the Independent Pilots Association (IPA), a labor union that represents the 2,000 plus airline pilots who fly for UPS. As you know, our airline was formed in 1988 and is representative of U.S. carriers experiencing rapid growth in the overnight package air express industry. UPS pilots fly aircraft around the clock into and out of over 80 domestic airports and a growing number of international hubs including those in Mexico, Canada, East Asia, Europe, and South America.

On the whole, our pilot group reflects a high degree of aviation experience prior to coming to UPS. Nothing in our prior experience, however, has quite matched the rigors of pilot scheduling unique to a 24 hour a day operation that involves crossing of multiple time zones. As members of the FAA's Aviation Rulemaking Advisory Committee, we have voiced our concern for a number of years that current pilot flight and duty rules do not adequately insure the safe scheduling of pilots, particularly in operations such as ours.

What our experience suggests as true is now being verified scientifically by a body of learning and research concerning human sleep and circadian physiology. The IPA was heartened by the National Transportation Safety Board's recommendation, in the aftermath of the Guantanamo Bay crash, that the FAA undertake a review of existing pilot flight and duty rules to incorporate the best and most current in sleep and circadian learning. Upon publication of the NPRM, our Association determined to bring together a panel of leading experts in the field to produce an independent, scientific review the proposed rule.

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Attached to this letter is the work product of the panel entitled, "A Scientific Review of Proposed Regulations Regarding Flight Crewmember Duty Period Limitations," authored by the Flight Duty Regulation Scientific Study Group. The Study Group is comprised of ten leading experts, including the three co-chairs: Wallace A. Mendelson, M.D. of the University of Chicago; Gary S. Richardson, M.D., of Harvard Medical School; and Thomas Roth, Ph.D., of the Henry Ford Hospital in Detroit. The co-authors of the study are Ruth Benca, M.D., Ph.D.; Mary A. Carskadon, Ph.D.; Cynthia Dorsey, Ph.D.; Mark Mahowald, M.D.; Barbara Phillips, M.D., MSPH; James K. Walsh, Ph.D.; and Gary Zammit, Ph.D.

Importantly, the Study Group applauds, as do we, the FAA's efforts to incorporate the NASA research and circadian understandings into the NPRM. The most notable of these is the dependence of the proposed rule on total duty time, not just flight time. The NPRM is a serious attempt at improving the current set of antiquated regulations for which the Agency should be given full credit.

The NPRM, however, is not without room for important and needed improvements. The Study Group concerns include: 1) excessive duty durations; 2) the failure to address back side of the clock flying; 3) concern with certain aspects of the reserve component; and 4) a misplaced reliance on crew augmentation to increase time on duty. While not attempting to write a comprehensive regulation, the Study Group has made specific recommendations for revising the NPRM.

The membership of the IPA is composed of professional aviators, not medical experts. The analysis and recommendations of the Study Group do, however, comport with our experience as pilots flying schedules that, in our opinion, are inadequately regulated and too often prone to abuse. While thanking the FAA for the hard work that has gone into the NPRRM, we encourage the Agency to take this opportunity to carefully deal with the scientifically based recommendations that have been made.

Sincerely,

Capt. Robert M. Miller
President, IPA

RMM/bg

A Scientific Review of Proposed Regulations regarding Flight Crewmember Duty Period Limitations

Docket #28081

The Flight Duty Regulation Scientific Study Group[†]

Preparation of this document was supported by a grant from the Independent Pilots Association

Running title: Review of proposed flight duty regulations

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THE FLIGHT DUTY REGULATION SCIENTIFIC STUDY GROUP

Co-Chairs: **Wallace B. Mendelson, MD,** is the Director of the Sleep Research Laboratory and Professor of Psychiatry and the University of Chicago. He is an internationally recognized authority on sleep disorders, particularly insomnia, and on the pharmacology of sleep and wakefulness. He has been an officer on the executive boards of both the Sleep Research Society and the American Sleep Disorders Association, and participated in the formulation of national policy on the diagnosis and treatment of sleep disorders.

Gary S. Richardson, MD, is Associate Physician at Brigham and Women's Hospital in the Section on Circadian and Sleep Disorders Medicine, and an Instructor in Medicine at Harvard Medical School. He is an internationally recognized authority on circadian rhythms in human sleep and alertness, and has served as a consultant to the Department of Transportation and industry on the effects of shift work and sleep deprivation on human health and performance. He has been an officer on the executive board of the Sleep Research Society.

Thomas Roth, PhD, is Director of Research for the Henry Ford Health System in Detroit. He is also Director of the sleep disorders program and an internationally recognized authority on sleep, sleepiness and human performance. He is past president of both the Sleep Research Society and the American Sleep Disorders Association, and is Chairman of the Advisory Council for the Center for Sleep Disorders Research within the National Institutes of Health. Dr. Roth has served as a consultant to the Department of Transportation, National Highway Traffic Safety Association and NASA.

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1. Introduction

This document is intended to provide a review of the proposed flight-duty regulations for flight crewmembers as defined by the Federal Aviation Administration (FAA) in the Notice of Proposed Rule-making (NPRM) (1). The Flight-Duty Regulation Scientific Study Group (the "Study Group") was organized in response to a request by the Independent Pilots Association (IPA) for a scientific review of the NPRM, including a detailed determination of the extent to which the proposed regulations adequately address the problems of fatigue and sleep deprivation in flight crew, and the extent to which they appropriately utilize available scientific information, both that expressly cited in the NPRM and the larger body of scientific literature regarding the origins of human fatigue in sustained operations.

The Study Group consists of members of the scientific community with research interests in the fields of human sleep and circadian physiology, and sleep disorders medicine. While some of the members of the Study Group have participated in an advisory or review capacity in the evaluation of extended duty limitations in other work settings, including other transportation sectors, none of the members has had previous involvement in the development of these flight-duty regulations or in the NASA research projects cited as providing the specific foundation for the current NPRM. Thus, it is the intent of the Study Group that this document will constitute a new and independent review, incorporating the perspectives provided by regulatory efforts in other industries and by research performed in other related areas.

Another important principle guiding our review and assessment of the proposed regulations requires express statement at this point. It is the position of the Study Group that the success of any attempt to regulate duty schedules to guarantee adequate rest depends jointly upon the provision of adequate opportunity for rest within the schedule, and upon the responsible cooperation of the regulated individual. However, personal behavior cannot practically be regulated. Experience with attempts to provide improved rest opportunities in other settings demonstrates that time provided for sleep is often used for other things, effectively defeating the intent of the original provision. The solution to this limitation is a continued emphasis on education of the regulated group regarding the nature of the problem and their role in its solution. However, the Study Group feels strongly that the possibility of compromise of allocated rest time should not relieve regulatory authority of the responsibility for insuring that adequate time is provided for rest.

Finally, it is also important to state in this introduction that, despite its evident limitations, the proposed NPRM represents unambiguously important and valuable progress. The Study Group unanimously feel that the FAA is to be applauded for persisting in this effort, and for producing a set of proposed regulations that attempt to incorporate current understanding of human sleep physiology. To our view, this incorporation is not as complete as it can or should be, and the issues identified in this review are meant as suggestions for improvement in the proposed regulations. It is our hope that many of the important adjustments can be included in the final set of rules produced by this effort, whereas other issues clearly represent deficits in the current scientific database. These will require additional research attention before they can be addressed in future rule-making efforts.

The goal of providing safe travel 24 hours a day requires optimum crew alertness and performance at all times. Since human alertness is highly dependent on the complex regulatory system governing sleep and wakefulness, we will begin this review by summarizing current understanding of the physiologic systems regulating sleep and wakefulness, and the factors that contribute to human fatigue. In subsequent sections, we will 1) summarize the adequacy of the proposed changes in flight duty regulations (1) in addressing the relevant aspects of human physiology, and 2) summarize areas where we believe that the proposed regulations can and should be revised and expanded to better address these issues with the goal of optimization of aircrew alertness and air travel safety.

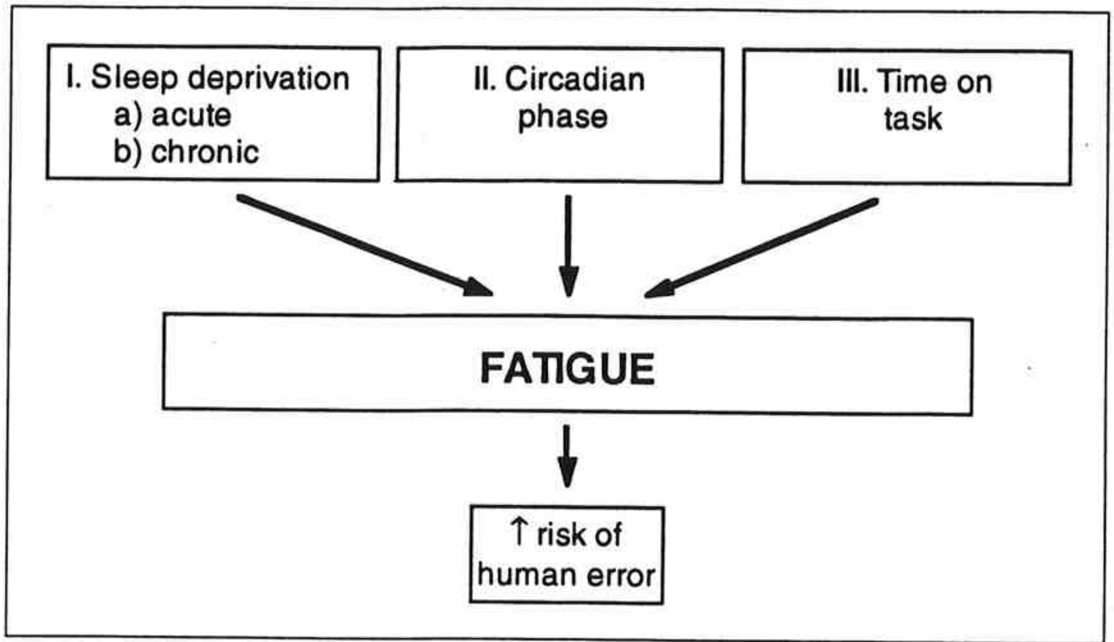

Figure 2-1: Schematic representation of the physiologic factors contributing to human fatigue in sustained operations

2. Scientific Background

2.1. A working definition of fatigue

Much of the literature cited in support of the proposed modifications to the FAA regulations variably use the terms "fatigue" and "sleepiness" to describe the physiological condition arising from inadequate prior sleep and/or the condition that occurs when wakefulness is forced during phases of the circadian cycle appropriate to sleep. The implication of this usage is that these terms are interchangeable, whereas a closer evaluation indicates that they are not, and confusion of the two terms impairs the discussion of the physiologic basis of performance errors and the appropriate focus for interventions. Sleepiness has a precise definition:

> "Sleepiness, according to an emerging consensus among sleep researchers and clinicians, is a basic physiological state (like) hunger or thirst. Deprivation or restriction of sleep increases sleepiness, and as hunger or thirst is reversible by eating or drinking, respectively, sleep reverses sleepiness."*

By contrast, the term "fatigue", as it is used in the human performance context, does not have a precise physiologically-based definition. Instead, fatigue is used in a broader sense to describe deterioration in human performance, arising as a consequence of several potential factors, including sleepiness. When the intent is to prevent human error, it is necessary to go beyond the broad definition and identify the specific physiologic components which then become the target for intervention. This review will reserve the term fatigue for the general condition in which performance is impaired, and will identify and focus upon three contributors to human fatigue, the control and limitation of which is necessary to the optimization of performance of crew members in air flight. (Figure 2-1).

* From Roth, T., *et al.*, Daytime sleepiness and alertness. In *Principles and Practice of Sleep Medicine*, M.H. Kryger, T. Roth, and W.C. Dement, Eds. 1989, W.B.Saunders: Philadelphia. p. 14-23.

2.2. Homeostatic regulation of sleep

As suggested, the most prominent among potential causes of fatigue is a decline in human alertness (or an increase in sleepiness) occurring as a consequence of sleep deprivation. Sleep deprivation can be thought of as an inadequate fulfillment of the homeostatic need for sleep(2), either over the short term ("acute sleep deprivation"; Figure 2-1) or gradual sleep deprivation over the longer term ("chronic sleep deprivation"; Figure 2-1).

The homeostatic mechanism is reflected in common sense observation that an individual who does not get adequate sleep prior to performing a task will be sleepy, and performance of the task will be impaired. In designing appropriate schedules to determine what is "adequate sleep", several factors need to be considered: 1) although the average amount of sleep needed for daily alertness is typically a little less than eight hours, there is tremendous individual variation. Thus what may be sufficient for one individual may not be enough for another; 2) The effectiveness of sleep in maintaining daytime alertness changes across the lifetime, and declines in older age (3). This suggests that in older crew members the need for adequate pre-flight sleep is particularly important: 3) Complete recovery from operating with an inadequate amount of sleep ("sleep deprivation") does not occur after a single sleep period (4, 5). Two or three sleep cycles are usually required before normal levels of alertness are achieved following sleep deprivation. 4) There is evidence that sedatives including sleeping pills or alcohol have profoundly greater effects, and may have longer duration of action, in a person who has had inadequate sleep (6). Thus the duration of time needed for safe performance following use of such compounds may be prolonged in a person who took them in a state of sleep deprivation.

2.3. Circadian modulation of sleep, sleepiness and performance.

The second factor in determining the levels of sleepiness is the phase of the human circadian clock (Figure 2-1). Circadian rhythmicity is the term used to describe diurnal variations in physiologic functions that derive from time-keeping systems within the organism. Circadian rhythms are apparent in the physiology of virtually all plants and animals, and this ubiquity suggests that internal time-keeping was an important adaptation to the 24-hour variation in the external environment (7). In mammals, including humans, circadian rhythms are controlled by sophisticated neural clocks located at the base of the brain that use photic information from the retina to orient physiologic rhythms with respect to external time. In diurnal ("day-active") species such as the human, the circadian clock is oriented so that alertness, metabolic activity, and various other functions increase by day to facilitate the physical activity and behaviors exhibited at those times (8). By night, alertness is decreased and metabolic activities are commensurably reduced to facilitate sleep and conserve metabolic energy. Laboratory studies of the influence of the circadian clock typically rely on continuous body temperature measurements to track the clock's influence on metabolism. Core body temperature is remarkably rhythmic in humans when it is measured in conditions carefully designed to eliminate outside influences.

The circadian rhythm of body temperature has a peak between the hours of 4 and 6 PM in the evening, and a trough approximately 12 hours later at 4 to 6 AM. While the exact position of these reference points may vary from individual to individual, in healthy adults, they are remarkably consistent within a relatively narrow range. Studies of human performance as a function of time of day have demonstrated clear circadian rhythms in several different types of performance functions. For the most part, this variation mirrors the circadian variation in sleepiness (*i.e.* minimum in performance capacity in the early morning hours (between 4 and 6 AM) coincident with minimum body temperature and maximum sleepiness) (9). These data are consistent with the generally accepted hypothesis that important circadian variation in performance is a secondary consequence of the circadian variation in sleepiness.

Further, an extensive body of laboratory data has established that human circadian clocks rely upon light-dark variation to orient circadian rhythmicity relative to external time (10). A dependence of this effect on the intensity of the light means the external sunlight exposure typically dictates the orientation of an individual's circadian clock. Studies of the relationship between circadian orientation and light-dark cycles have progressed to the point where it is now possible to make reasonable estimates of the effect of transmeridian travel, with the consequent alterations in light-dark exposure, on internal circadian orientation and the dependent rhythms in alertness and performance (11).

Studies of the circadian system lead to several conclusions relevant to extended-duty paradigms such as those in aviation: 1) Attention only to the needs of the homeostatic system will not result in adequate alertness. Thus a crew member who works in the early morning hours of 4 - 6 AM will not necessarily be as alert as one working during daylight hours, even if both had been off-duty for the same amount of time prior to work. 2) When flight plans involve transmeridian travel, duty requirements may lead the crew to need to function at times in which the body's propensity is to sleep; 3) When crew land at transmeridian destinations, their internal circadian systems may be out of phase with those of the new local environment (12). Thus they may be in their own internal sleep phase when it is daytime at the new destination.

Further, several factors need to be considered in designing schedules that allow for these circadian processes. The first is that there is a great deal of individual variation in the ability to adapt to changing schedules of this type (13). In addition to this individual variability the ability to adapt to changing shift schedules declines with age. Hence older crew members are more likely to experience difficulty adjusting to new time periods of sleep and waking. Second, the ability to adjust to new time schedules depends on the direction of transmeridian travel. In general, short-term changes of four or more time zones in eastward travel are more difficult to adapt to than equivalent westward travel. The implication of this is that recommendations for adequate rest may need to be tailored specifically for the direction of travel. Third, recovery sleep itself is influenced by the time of the circadian day (14). Thus a 10 hour period for recovery sleep in a new time zone will not initially be as effective in restoring alertness as an equivalent recovery period in the home time zone. Fourth, the use of hypnotic medication (sleeping pills) may improve sleep in adverse phases of the circadian cycle, but the relationship of this improved sleep to subsequent performance is complex and still under study (15). Finally, one environmental factor-- the amount and timing of exposure to sunlight (or equivalent bright artificial light)-- can greatly influence the ability to adapt to new sleep and waking schedules (16). Thus exposure to sunlight, or the use of appropriately timed artificial light, may be useful in helping an individual receive adequate sleep. Conversely, inappropriate exposure to bright light may inhibit that individual's ability to receive adequate rest.

2.4. Time on task

The third factor that can contribute to fatigue is the duration of time spent working without significant interruption ("time-on-task; Figure 2-1). Evidence suggests that a complex relationship exists between task efficiency, as measured by the probability of error, and time spent working on the task. In studies of manufacturing settings, the probability of error begins at a relatively high level at the beginning of the shift ("re-familiarization"), rapidly declines to optimal levels within a few hours, then steadily increases over the remainder of the (typical) eight-hour shift ("task fatigue"). Studies of longer shift durations consistently suggest the rate at which performance deteriorates may increase for durations beyond 8 hours and this has been an important factor in efforts to limit maximal shift duration in a variety of settings (17).

Time-on-task effects are the least studied and least understood of the factors contributing to human fatigue. For example, unlike sleep deprivation which can only be reversed by sleep, performance deterioration associated with prolonged task duration appears to be task specific, reversing with time away from the task, even if the time is spent with other waking activities. But important data about the nature of this effect, particularly as it might relate to complex tasks such as those performed by flight crews, is not yet available. It is not clear, for example, whether inherently variable tasks can modulate the rate at which performance deteriorates. Further, there are important methodological issues that have not all been addressed in available studies of time-on-task effects. For long task durations, *i.e.* 8 or more hours, sleep deprivation and circadian phase effects will necessarily vary significantly over the course of the task, confounding interpretation of performance changes. Studies systematically varying circadian and sleep deprivation (homeostatic) influences to isolate the time-on-task effects have not yet been performed. Pending collection of such data, ideally specific to flight crew job requirements, available time-on-task data nonetheless raise significant general concerns about sustained shift durations, particularly those greater than 10 hours.

An additional important factor in the determination of time on task effects is task intensity. Fatigue generally accumulates faster in high intensity tasks than in low intensity tasks, suggesting that maximum task durations should be adjusted according for task intensity. However, in practice, task intensity can be very difficult to measure. Within aviation, this principle has been used to justify adjustments of maximum shift duration as a function of the number of landings on the widely accepted premise that landings are the most intensive aspect of aviation.

2.5. Interactions

Beyond their direct relationship to human fatigue and the probability of error, each of the physiologic axes identified above also interacts with the others to potentiate adverse effects. Thus, the extent of sleepiness and performance impairment produced by moderate sleep deprivation is greater at 4 AM than it is at 4 PM. Similarly, the rate at which time-on-task effects on performance accumulate depends both on the circadian phase at which the task is performed, and on the extent of prior sleep deprivation on the part of the person performing it. The importance of the circadian system in modulating both alertness and the ability to sleep results in another important interaction. In addition to the direct adverse effect on alertness and performance, work on the "back side of the clock" over a number of successive nights results in chronic sleep deprivation as a consequence of impaired ability to sleep during the day. This sleep deprivation can then potentiate the performance impairment on later night shifts.

These interactions have made it difficult to isolate the physiologic contributors to fatigue in the laboratory and assess their relative magnitude and importance; for example, how much sleep deprivation is equivalent to work at the circadian nadir? Without more data on this issue, the only effective strategy for intervention requires addressing each of the three axes as completely as possible.

2.6. Shift-work

The focus of this effort on the scheduling of flight crews occurs in the context of general concern about extended duty, night work, and consequent sleep deprivation in a large number of occupations with public safety implications (18). A growing number of US. workers are called upon to routinely work other than regular daylight hours. It is estimated that some twelve million people in the United States now fit this broad definition of shiftworker (19). A number of strategies have evolved to provide for extended duty and nighttime coverage of the growing variety of service and manufacturing settings that require continuous staffing. The most common of these is the "rotating" shift schedule in which crews of workers work successive shifts for one or more weeks at a time. The shifts typically are days (8 AM to 4 PM), evenings (4 PM to midnight) and nights (midnight to 8 AM). While rotating shifts of this kind, varying slightly with regard to starting time and direction of rotation, probably the most common implementation for continuous coverage, a number of other approaches have been used as well. As a consequence, specific data regarding the impact of a given shift schedule, or even specific shift durations, on human performance, sleepiness, or other human factors are not always available. It is also important to realize that generalization from research results regarding a specific schedule to all shift work is rarely justified.

It is recognized that night-work can be deleterious to workers' safety and productivity in part because of the increased risk of performance errors during the early morning hours (between 4 and 6 AM). While various shift work schedules may be capable of modulating this risk to a greater or lesser degree, recent work on the importance of sunlight to human circadian function (see above) has established that this nighttime vulnerability to error persists even in shiftworkers with years of night work experience. It is important to realize that an individual working nights is at risk for significant sleepiness for two distinct reasons: First, work during the early morning hours (between 4 and 6 AM) is associated with the previously-described circadian increase in sleepiness and sleepiness mediated performance errors. In addition, an individual working successive nights is forced to obtain sleep during the daylight hours at a time when the circadian pre-disposition to sleep is minimal (20). As mentioned, sleep under these circumstances is typically fragmented, sleep state architecture is distorted and the restorative nature of sleep (per hour of sleep attempted) is reduced. Thus, over time, the night shift worker accrues cumulative sleep deprivation which when added to the circadian sleep effects can produce profound impairment. A consequence of this is that the unifying aspect of successful strategies for combating the increase in performance errors by shift-workers on the night shift is to maximize the amount of sleep obtained, compensating as much as possible for the inefficiency of daytime sleep through sleep extension, napping *etc.*, and preventing the accumulation of significant chronic sleep deprivation.

2.7. Fatigue and safety in flight operations

While the problems of sleep deprivation and night-work are certainly not unique to aviation, there can be little doubt regarding the significance of the problem that crew fatigue poses for the aviation industry. Laboratory simulator studies have demonstrated that compliance with current flight-duty regulations and work schedules does not protect against significant sleep deprivation and unacceptable levels of fatigue in flight crews (21). A growing number of field studies have documented that crews are experiencing serious sleepiness during flight operations, and NASA's Aviation Safety Reporting System (ASRS) identified 221 incident reports (over an eight year period) in which crew fatigue contributed to problems during flight operations (1). Finally, the National Transportation Safety Board (NTSB) has identified crew fatigue as a material contributing factor in more than one recent accident. Together, these findings indicate that fatigue is a significant safety issue in the aviation industry, and that the current regulations regarding limitations on flight-duty schedules are an important factor in the genesis of that fatigue.

One important challenge posed by the NPRM is the identification of outcome measures to be used to determine the impact of revised regulations. While available measures have adequately documented the presence of a problem, they would appear to be inadequate for the task of assessing change over a two or three year span immediately following implementation of new flight-duty regulations. The relative rarity of aviation accidents studied by the NTSB makes this measure too insensitive to detect changes that might reasonably be expected to occur in response to small proactive interventions such as a two hour reduction in maximum duty time for example. At the same time, the potential bias inherent in the ASRS database makes these data too subjective. The Study Group feels strongly that an important priority for the immediate future should be the identification and validation of proxy measures of crew fatigue that can be used to effectively monitor the impact of this and future revisions without relying on catastrophic outcomes as the only accepted dependent measure.

3. Summary of proposed guidelines

The FAA cites the NASA technical memorandum "Principles and Guideline for Duty and Rest Scheduling in Commercial Aviation" (22) as the primary source in the preparation of the NPRM (1), although there are important differences between the NASA recommendations and the final NPRM document. The NPRM guidelines address duty period, flight, time, and rest requirements. Secondarily, they discuss reserve periods as well as cumulative duty periods for a week and a month.

There are two important general features of the proposed guidelines. The first is the predication of duty limitations on total duty instead of just flight time. Specific regulations of duty durations specify separate upper limits for total duty time (without an intervening period of rest) and for total flight time within the longer duty segment. The second important general change is the consolidation of regulations for various types of flight operations covered by Part 121 (covering domestic, flag and supplemental flight operations) and elimination of differences between relevant parts of the Part 121 regulations and the Part 135 regulations (covering commuter and on-demand flights). This results in simplification and greatly improved consistency in flight regulations.

TABLE 3-1: SUMMARY OF PROPOSED REGULATIONS

	Description	
1. Flight duty duration	**Crew size**	**Max.duration (duty/flight)**
	1	14/8
	2	14/10
	3	16/12
	3[1]	18/16
	4[1]	24/18
2. Minimum rest duration	**Crew size**	**Min. duration (hours)**
	1	10
	2	10
	3	14
	3[1]	18
	4[1]	22
3. Flight time limits	**Time frame**	**Max. flight time (hours)**
	Per week	32
	Per month	100
	Per year	1200

[1]*With facilities for sleeping in flight*

The new regulations are intended as "...a preventative measure designed to address the potential safety problems associated with fatigue-based performance decrements...by requiring certain scheduling limitations and minimum rest periods." Before assessing the extent to which the proposed regulations accomplish this goal, it is necessary to stipulate their specific provisions. An abbreviated summary of the relevant sections of the NPRM follows (see Table 3-1).

3.1. Revised Flight-Duty Durations

Under the proposed regulations, the base duration of the duty period (2 pilot crew) would be 14 hours. This would include 10 hours of flight time. Importantly, depending on crew size, availability of on-flight sleeping quarters, and operational delays, this can be extracted to 26 hours of duty time and 20 hours of flight time. Increasing crew to three pilots raises duty period to 16 hours, availability of sleep opportunity to 18 hours, and 4 person crews to 24 hours. Any one of these limits can be increased by 2 hours for unplanned operational delay.

3.2. Rest Period

The basic unit of rest, associated with the basic 2 person crew, 14 hour duty period, is 10 hours. Depending on the duration of the duty period, the requirement of the rest period could be as long as 24 hours. It must be recognized that these rules are for the subsequent rest period. Regulations do not specify minimum rest for subsequent duty. Thus, it is possible to have a 10 hour rest period during daytime hours followed by a 26 hour duty period. All rest period requirements can be reduced by up to 1 hour because of operational delays that can increase duty duration by up to 2 hours.

3.3. Stand-By Assignments

Reserve time in this proposal is a period of time when a flight crew member is not on duty but nonetheless must be able to report upon notice (*i.e.* greater than one hour), for a duty period. The guidelines explicitly reject relating amount of time of notice to time of day. Rather, it relates amount of time of advance notification to the maximum duration of the subsequent duty period. With less than 4 hours of notice, only a 6 hours duty period is allowed. As notification period goes to ten or more hours, a full duty period, up to 26 hours depending on circumstances, is allowable. An alternative to this standby schedule is maintaining a constant 6 hour protected time (by request) for each 24 hours of reserve time. During this time, the certificate holder may not contact the crew member to place them on duty. This 6 hour period must be assigned before the crew member begins the reserve time assignment. The duty period must be completed in 18 hours within the reserve time and must be in accordance with the general guidelines.

3.4. Cumulative Limits

The cumulative limits for flight hours are set at 32 hours for any 7 day period, and 100 hours for any calendar month. The yearly period is set by multiplying the monthly requirement by 12 (*i.e.* 1200 hours).

4. Evaluation of proposed regulations

It is important to reiterate and emphasize the Study Group's position that the proposed regulations as defined in the current NPRM on the whole represent an important advance over existing flight-duty regulations. The principal improvement lies in the new dependence of the regulations on total duty time, rather than just flight time, in setting limits on maximum work duration. As reviewed above, this is a much more physiologically sound approach, reflecting the importance that all work time has in the generation of fatigue.

The Study Group did, however, find several specific aspects of the proposed regulations that should be improved upon and/or appear to deviate from the FAA's stated intention "...to incorporate (whenever possible) scientific information on fatigue and human sleep physiology into regulations on flight crew scheduling." (1). Adjustments to the final regulations should address each of the issues identified below.

In comparing the proposed regulations to the stated goals outlined in the introduction to the NPRM and to available data in the scientific literature, the Study Group identified two important general issues.

4.1. Excessive duty duration

While regulation of the maximum duration of total duty time (rather than just flight time) represents an important improvement from the perspective of the limits of human physiology, the actual duration of the proposed work periods substantially exceeds what can reasonably be justified by scientific data on human performance and fatigue. In light of substantial evidence indicating that work durations in excess of 12 hours are associated with a significant increase in the probability of human error independent of circadian phase and prior sleep wake history (13, 23), there can be little scientific justification for baseline work durations of 14 hours, let alone the greater durations permitted under operational delay conditions. The specific duty and time limitations are the same as those specified in the NASA recommendations (22), although there are potentially important differences between the NASA recommendations and the NPRM in the definition of flight time. While the NASA document recognizes the importance of limiting maximum shift duration (Section 1.4; p 4), it provides no evidence in support of the statement that 14 hours within a 24-our period is sufficient limitation (Section 2.2.3), nor was the Study Group able to identify research to suggest that these shift durations might be acceptable in the unique aviation setting. In this regard, it is important to note that these duty periods are significantly longer than those being applied in a range other work settings where regulatory attention has been focused on the problem of fatigue-related performance decrements, including most other transportation sectors.

Absent research data to the contrary, the only relevant findings suggest that performance deteriorates significantly for shift durations greater than 12 hours, and the recommended limits for duty time in the NPRM are not consistent with the implications of those findings. As outlined above, it is not clear whether the variability of task inherent in the flight-duty assignment, *i.e.* shorter durations of flight time within the context of the longer duty schedule, might mitigate the deterioration in performance associated with shifts of equivalent duration in other work settings, however scientific endorsement of the safety of these shift durations must await empirical confirmation of such an effect.

Similarly, the extraordinary duty durations under circumstances where crew number is augmented and/or arrangements for sleep during flight are provided are inadequately justified by available scientific data. It is certainly not clear, based on a review of the studies published by NASA or any other group to date, that augmenting the crew results in a material increase in tolerance for sleep deprivation that would justify an increase in shift duration of the specified magnitude. Other concerns of the Study Group pertain to the specific arrangements for sleep for augmented crews in extended duty durations. The Study Group is very concerned about the adequacy of sleeping arrangements that will be provided in these situations so that crew members can obtain some sleep while relieved by the extra crew. To our review, provision of such facilities addresses only one of several important concerns about the impact of extended duty arrangements. It remains to be determined whether adequate sleep can and will be obtained under operational conditions. While available data on cockpit napping have demonstrated that brief naps have a clearly beneficial effect over the short term on crew alertness (24), published studies have not yet shown that this improvement is sufficient in magnitude and duration to allow a significantly sleep-deprived crew member to return to duty. The second half of this concern is that several studies in other contexts have demonstrated that simply providing the opportunity for sleep in the extended-duty setting does not guarantee that such sleep will actually be obtained. Without express stipulation about the amount and scheduling of rest/sleep to be obtained by crew members, it is our concern that the revised regulations sanction extraordinarily long extended duty arrangements without providing any reasonable likelihood that adequate sleep will be obtained.

Finally, the provisions for rest do not appear adequate to compensate for the clearly heroic demands of duty durations of up to 26 hours. Rest allowances are adjusted for the rest periods following extended duty, not for the rest period preceding it. Thus for crewmembers moving among assignments of varying duration, it is possible to be called upon to work very long shift durations of 24 - 26 hours after limited (as few as 9 hours; "reduced rest"), with no stipulation that this time be provided at a circadian phase conducive to sleep.

In summary of this first concern, the Study Group does not feel there is adequate scientific justification for duty durations greater than 12 hours. Nor is the Study Group confident that compensatory arrangements of extra crew, sleeping quarters in flight, and extended rest provide adequate protection from the extreme fatigue associated with very long work schedules permitted under the proposed regulations.

4.2. No adjustment for "back side of the clock"

Our second major concern is that the proposed regulations make no effort to adjust prescribed limits on work duration or rest duration based on the time of day at which those activities are scheduled. This is the most disappointing omission, and particularly difficult to understand in light of the express predication of the revised regulations on the NASA-Ames database, a body of research that has done much to characterize the dependence of sleep and performance in the aviation setting on human circadian phase. Based both on the NASA studies and the larger body of scientific evidence developed in this area, there can be no doubt about the importance and relevance of circadian physiology to the modulation of human performance and the tendency to human error, and to the ability to obtain sleep and thereby reverse performance decrements arising as a consequence of sleep deprivation.

It is clear that application of circadian physiology to this regulatory effort raises several practical issues. First, regulations that account for time-of-day in provisions for work duration and rest are necessarily more complicated than the proposed set, particularly when transmeridian travel is taken into account. Second, it may prove difficult to develop consensus definitions for the circadian periods of maximal sleepiness and maximal alertness, as well as the precise extent of the adjustments of work and rest duration, respectively, that would be required during those windows. While the Study Group does not feel it is qualified to address detailed issues of practicality, our response to this concern would be that flight duty regulations that adequately account for circadian modulation in the capacity for sleep and in human performance have been used in the United Kingdom for 6 years (since May, 1990), and by account appear to be working well. The Study Group is aware of no qualitative reason why adjustments such as those incorporated in the UK regulations could not be used in the US as well.

4.3. Interactions

While the Study Group feels that each of the identified issues warrants specific modifications of the proposed regulations, the interactions between the two relevant physiologic axes, as reviewed above, greatly compound the concern. With inadequate restrictions on work duration and no compensation for circadian phase, the regulations permit "worst case scenarios" that are well outside scientifically supported limits. For example, without adjustments of rest period duration for circadian phase incompatible with sleep, it is possible to have a routine 14 hour night shift, followed by a rest period of ten hours from 12 noon to 10 PM, *i.e.* precisely coincident with the circadian phase at which sleep is least possible ("the forbidden zone"), followed by a 26 hour shift (assuming operational delay). As stated, provision of in-flight time for sleep can not be assumed to adequately protect against the performance decrements that marathon duty of this kind will inevitably produce.

Similarly, much of the concern about shift duration stems from the absence of any adjustment of duration for the time of day. While future studies could demonstrate that a succession of 14 hour flight-duty day shifts allow maintenance of acceptable performance limits, it is very unlikely that a succession of 14 hour night shifts will be similarly validated. Unless maximum shift durations are kept well within human performance limits, *i.e.* less than 12 hours*, some adjustment for the compounding effects of time-of-day needs to be included.

The Study Group recognizes that worst case scenarios are not likely to be representative of typical flight crew shift durations. However, it is opinion of the Study Group that no reliable protection against such potentially dangerous extremes of scheduling can be had without express adjustments of duty time and rest time for the dictates of the circadian clock, and significant reductions in the maximum length of the duty period.

4.4. Reserve Time

The Study Group has separate but related concerns about the proposed regulations regarding Reserve Time. As reviewed above, two distinct approaches for the protection of rest time within the reserve window are permitted. In the first, termed "variable notice", the maximum length of a duty assignment decreases with the length of the advance notice provided. In the alternate arrangement, termed "protected window", crew members on reserve are assigned a pre-identified six hour window during which they cannot be called. In this specification, the proposed regulation is notably different from the recommendation of the NASA group which called for an eight hour protected period. The window is the same during each successive day on reserve.

The Study Group is concerned that the variable notice arrangement is based on the unproved supposition that sleep deprivation resulting from a short-notice call can be adequately compensated for

* Twelve hours is felt to be the maximum safe shift duration in many shiftwork settings, e.g. nursing. However, there are data demonstrating an increase in performance errors between 8 and 12 hours of shift duration, suggesting to some that the appropriate maximum shift duration in safety-sensitive shiftwork settings should be 8 hours (17).

by reducing the duration of work required. At its extreme, this arrangement would allow a pilot to work for up to 6 hours with effectively no notice, *i.e.* advance notice equivalent to the time required to report to the place of assignment. Presuming worst case timing in which the crew member was called immediately prior to the habitual daily sleep period, continuous wakefulness of more than 22 hours (presuming an eight-hour habitual sleep period) by the end of the 6 hour shift. There is no reason to believe that the reduced shift duration adequately compensates for the performance impairment associated with acute sleep deprivation of this kind.

The Study Group prefers the protected window arrangement, as specifically defined in the NPRM, because the greatest possible extent of sleep deprivation is limited to 18 hours (presuming that the crew member using protected time for sleep). For protected windows during the day, and particularly those during the circadian window of maximal alertness, six hours would not appear to be sufficient to allow adequate rest on repetitive basis.

One major improvement and important safeguard in the current NPRM reserve arrangements is the requirement that a normal rest period precede each reserve assignment. Specific concerns about either reserve arrangement are mitigated by this protection, which should serve as an adequate safeguard against extremes of sleep deprivation, even if subsequent duty assignments occurring during either reserve arrangement are adversely timed.

5. Recommendations

The Study Group concludes that the proposed flight-duty regulations represent an important advance in the effort to define physiologically sound limits that minimize fatigue and optimize flight crew performance and aviation safety. Criticisms of the specific regulations reviewed above are not meant to be construed as a preference for the status quo. Instead, the Study Group urges expedient implementation of the proposed regulations, with the following modifications:

5.1. Recommended revisions to the proposed regulations:

5.1.1. Maximum duty durations should all be adjusted downward to levels in accordance with available data on the relationship between shift duration and degradation of performance. Circadian variation in susceptibility to this degradation should be accommodated with reduced maximums for shifts that include the time of peak circadian sleepiness (4 – 6 AM).

5.1.2. Minimum rest periods should be adjusted upward for sleep periods that include the time of peak circadian alertness (4 – 6 PM).

5.1.3. The provision allowing extension of duty maximums up to 24 hours (26 with operational delay) in augmented crews and in assignments that include facilities for in-flight sleep should not be implemented until scientific evidence is available demonstrating that in flight arrangements preserve alertness at acceptable levels, *i.e.* at levels equivalent to that on the routine shift durations.

5.1.4. Reserve time arrangements should be adjusted so that protected windows during the time of peak circadian alertness are extended to compensate for decreased efficiency of sleep during that time.

5.2. Recommendations for future revisions:

Several of these issues illustrate the need for additional data, and even with adjustments recommended here, specific limits on duty duration and minimum rest duration will represent quantitative implementations of solutions for which there is currently only qualitative scientific support. Therefore, the Study Group also recommends this set of recommendations be viewed as the first step in a continuous process. Specifically,

5.2.1. NASA, in its capacity as independent scientific resource, should be commissioned to gather additional data on this issue with the following priorities;

5.2.1.1. Identification and characterization of a suitable surrogate outcome measure that can substitute for actual accidents and self-reported incidents as a measure of fatigue in flight crews. This proxy measure will then be assessed to continuously monitor the extent of fatigue and the impact of this and future regulatory adjustments.

5.2.1.2. Determination of the impact of duty period duration on performance, independent of sleep deprivation and circadian phase effects. The impact of varying percentages of flight time within a duty period should also be assessed.

5.2.1.3. Determination of the impact of varying workload on performance, with particular attention to the role of landings and sustained flight.

5.2.1.4. Assessment of the protective effect of augmented flight crews and provision of facilities for in-flight sleep on crew alertness with the intent of determining the extent to which duty and flight durations can be safely extended.

5.2.2. An independent scientific panel should review the data collected by NASA on a regular basis with the intent of providing a comprehensive and detailed set of recommended revisions to the regulations within three years from the time at which these recommendations are ultimately implemented.

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