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NATIONAL TRANSPORTATION SAFETY BOARD
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Human Performance - Addendum 1

(11 pages)

American Airlines flight 1420
Little Rock, Arkansas
June 1, 1999

DCA99MA060

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

August 30, 2000

Human Performance

Human Performance Group Chairman's Factual Report Addendum 1

A. ACCIDENT

Operator:	American Airlines (Flight 1420)
Location:	Little Rock, Arkansas
Date:	June 1, 1999
Time:	2351 central daylight time[1]
Aircraft:	McDonnell Douglas, MD-82, N215AA
NTSB Number:	DCA99MA060

B. HUMAN PERFORMANCE GROUP

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[1] All times are central daylight time based on a 24-hour clock, unless otherwise noted.

C. SUMMARY

On June 1, 1999, at 2351, a McDonnell Douglas MD-82, N215AA, operated by American Airlines as flight 1420, overran the end of runway 4R and collided with the approach light stanchion at the Little Rock National Airport (LIT), in Little Rock, Arkansas. The captain and 10 passengers sustained fatal injuries; the remaining 134 passengers and crewmembers sustained various injuries.

D. DETAILS OF THE INVESTIGATION

Dr. David Dinges, from the University of Pennsylvania School of Medicine, had been scheduled to testify as an expert witness on fatigue and associated human performance issues at the public hearing held for this accident in Little Rock, January 26-28, 2000. Because of inclement weather in the Little Rock area on January 27, Dr. Dinges was unable to travel to the site of the hearing and present his testimony. As a result, the Human Performance Group decided to interview Dr. Dinges as a group activity at a later date.

On April 28, 2000, an interview was conducted with Dr. Dinges in his office at the University of Pennsylvania School of Medicine. Present were group members Evan Byrne, and Tom Nesthus. Tom Chidester participated in the interview via telephone from his office in Dallas. Group member Mike Leone was prevented from participating due to an acute illness.

Following the interview, a draft summary was prepared by Evan Byrne and reviewed and approved by all group members participating in the interview. The revised draft was then sent to Dr. Dinges for review and comment. The interview summary is contained in this addendum.

Submitted by:

[redacted]

8/30/00

Evan A. Byrne
Chairman, Human Performance Group

Date

Name: David Dinges, Ph.D.
Interviewed by: Human Performance Group (Chidester via phone; Leone absent)
Date: 28 April 2000
Time: 1330 EDT
Location: University of Pennsylvania

Dinges is a Professor of Psychology in the Department of Psychiatry at the University of Pennsylvania School of Medicine. He is also the Chief of the Division of Sleep and Chronobiology. He has been in this position for 5 years. He holds a Ph.D. in general experimental physiological psychology. He is not a pilot. He directs the Unit for Experimental Psychology. The lab receives funding from NIH, NASA Headquarters, NASA Ames Research Center, NHTSA, the USAF Office of Scientific Research, and others. The lab examines research questions related to alertness and performance capabilities in people who have to work long or unusual hours. Current studies examine the biological limits of human performance as they relate to fatigue and stress; past research focused on fatigue, sleep loss, circadian rhythms, and countermeasures such as napping.

Dinges said he generally uses the term fatigue to refer to an individual's difficulty maintaining a certain level of performance as a function of time. He said that to the extent that wakefulness occurs in time, many of the same phenomena that have been documented in the fatigue literature are also observed in sleep-deprived subjects. He said it is important to note that fatigue is a biological state.

Dinges was asked to describe how human performance is affected when someone is fatigued. He said that:

- Performance on cognitive tasks shows somewhat more variability -- both between and within subjects.

- There is a tendency for vigilance decrements to occur when a task requires monitoring or detecting signals. This is associated with general difficulty overall in sustaining attention as time on task increases.

- Short-term and working memory errors increase. It can be somewhat more difficult to remember what was done and what was not done.

- Cognitive slowing occurs on self-paced tasks. If the person can control the pace of work they will slow down, and slow the pace of the work, to maintain accuracy and hold performance up as they get tired or fatigued. However, if the task is work paced -- thereby preventing the maintenance of accuracy at the expense of speed -- errors can be increased.

- There tends to be a loss of time perception, which may be associated with cognitive slowing -- and people begin to fail to appreciate whether their actions are timely enough.

- There is perseverance on ineffective solutions, a tendency to keep trying the same old solution even if it doesn't work. People have difficulty coming up with a new way of solving a problem when fatigued.

- There is a willingness to take some risks. In the literature, for example in the Cambridge Cockpit Study, the more tired aviators became, as reported by Hockey and Bartlett, the more likely they were to cut some corners and to in general accept some lower standards in their accuracy and performance. This is probably a product of people prioritizing what they view as important and giving up or slacking off on the other things viewed as less important -- from a cognitive energy conservation model.

- There is a tendency to not pick up peripheral events or to pay less attention to peripheral events. Peripheral events are defined in context and are often dependent on what the person is doing, what they see as their priority task, what problems they are confronted with at what rate, etc.

- An individual's reaction time can slow.

- The above factors can combine to produce a loss of situational awareness, which can involve a neglect of routine actions, and a failure to plan adequately for future actions.

Dinges said that the tasks used to conduct research on performance impairments and fatigue as a function of work duration tend to be the building block elements of more complex real world tasks. For example, Dinges said that if someone were trying to visually identify an airport or runway from a cockpit at altitude he would consider that as a kind of vigilance task requiring divided and sustained attention demands. He said that because of the nature of the tasks used in experimental studies on fatigue, it is difficult to make a broad statement that all tired pilots would show the types of performance changes he previously described. However, he said that in his review of ASRS reports in which fatigue is cited, he notes that many of the reports show behavior consistent with findings derived from laboratory studies using simpler tasks.

Dinges was asked whether there are changes in behavior that are specific to fatigue. He said that when he examines the literature he observes similarity between fatigue-related performance impairments and those that result from alcohol intoxication, concussive head blow, or severe stress, or hypoxia. For example, increased variability in performance is common to hypoxia and to fatigue -- resulting from a destabilization of the internal or endogenous ability to direct performance in an efficient manner with an appropriate priority. To that extent, it is at times difficult to know how much a particular outcome is expressly due to fatigue. He said that when studying fatigue in the laboratory, scientists remove other factors such as stress, alcohol, hypoxia, etc. He said that as a result the behaviors observed -- the tendency to slow, to make short-term/working memory errors, instability of state, and vigilance decrements -- do appear to be clearly related to fatigue.

Dinges was asked about the origin of the vigilance decrement observed with fatigue. He said there was no definitive origin identified. However, preliminary evidence shows it generally centers around inputting and maintaining attention to the task. He said structures from the sensory organ to the brain's cortex are involved, and that delays are incurred in both input and processing times. He said it is important to note that it is cognitive, or brain-based fatigue that is responsible for this (in contrast to muscle fatigue or what is commonly referred to as physical fatigue). He said there is evidence from research where people are kept awake from 2 to 40 hours that the eyelid starts to close more frequently. He said that even if there is arousal produced by other systems in the brain, a tired person could still make mistakes. The reason for this has not been determined. He said that there is published evidence that both auditory and visual vigilance tasks are affected by fatigue. He said that based on his research on people who are kept awake or are asked to work at a time when they are normally asleep, the visual system may be slightly more sensitive than the auditory system to fatigue impairment. One reason may be that the visual system processes information at multiple levels and is more complex relative to the auditory system; and the fact that there is a peripheral gate (eyelid) that shuts off input to the visual system.

Dinges spoke about allocation of resources from the framework of cognitive psychology. He said motivated, committed, professional people allocate resources to things they see as important when they are tired and have to get a job done. For example, if detection of a signal is important, even if a person is tired and their vigilance should be impaired, they will try to maintain performance by putting extra resources, extra compensatory effort, into that task or modality. As a result, the person may not perform as well on other concurrent activities. It is more difficult for a fatigued person to allocate cognitive resources to multiple channels; and they have to expend more available cognitive resources to what they see as the most critical task at a given moment.

Dinges was asked about how time-since-awakening contributes to fatigue-related impairment. He said this has been an issue historically since hours of service in various industries were established. He said early models of performance were based on the premise that the longer people worked the more likely they were to be impaired. He said a problem with that model was that it did not predict error rates or accident rates accurately. He said in the 1950's and 1960's there was an advancement of knowledge involving circadian rhythms and sleep research, which resulted in the recognition that impairment is not singularly a function of how long someone works but also what circadian phase they are in and how much sleep they have obtained. For example, working at night makes an individual more vulnerable to vigilance errors or accidents earlier than if the same work is conducted during the day. He said that getting less sleep makes an individual more vulnerable to performance failures sooner. Because of these factors, Dinges said it is difficult to talk about simple rules for how tired or how impaired people might get as a function of how long they work.

Dinges said that generalizations could be made if discussion is limited to a person who has received a full amount of sleep (without any sleep disorder) and works a diurnal work cycle (working during the day, afternoon, and possibly into the evening) that avoids the circadian nadir. He said that most of the research done in this area has focused on industrial operations not aviation. He said Dr. Roger Rosa in the US and others in Europe have examined accident and injury rates as a function of continuous hours of work. A study from Sweden reported that the rates were stable for the first 9 hours of work but after 16 hours of work they tripled. Rosa has done studies showing a three-fold increase in accident rate for 16 hours of work. Dinges noted that there are studies showing that accidents by bus drivers in Poland are highest during the first 3 hours of work in the morning. He said there are factors other than time of continuous work that determine what goes wrong in the workplace. For example, the amount of activity or exposure on the roadway and in the workplace is a major determinant of accidents. As a result, what is often seen when accidents are plotted as a function of time of day (even for dayshifts) is that they peak about mid-day, when exposure is greatest and then decline. He said these types of studies attempt to adjust their data to control for exposure and when this is done it appears that accidents begin to rise sometime after 9 hours of work in some studies; and they rise after 10 or 12 hours of work in other studies. He said the specific increase (the amount of increase) typically appears to be study- and population-specific. However, in general, accidents and injuries do go up as a function of continuous hours of work, especially after 12 hours on duty. Dinges said this suggests that fatigue is going up at the same time. However, the intermediate process that leads to the errors is somewhat more difficult to clearly identify but people often report being tired when working long shifts.

Dinges said the characteristics of the human circadian system for a diurnally-entrained person (one who sleeps at night and works during the day) presents an added complexity to drawing conclusions between accidents/incidents and continuous hours of work. He said the circadian system promotes a physiologic alertness reaching its peak a few hours before a person goes to bed. This peak makes a person faster, think quicker, and do better; and this can be observed even in sleep deprivation studies where subjects who have been kept awake all night demonstrate worse performance in the morning, improve during the day, and achieve their best performance for the day after a sleepless night in the evening (a few hours prior to their habitual bedtime).

Dinges said that if someone stays awake past their circadian peak and it happens to be an extension of a work schedule there exists a combination of fatigue risk factors (how long the person is awake and the descending slope in the circadian system's maintenance of alertness). Dinges offered the example of being in the 10th hour of work during the circadian peak and working 14-16 hours total in which the last hours of work would be at time when the circadian system is <u>not</u> actively promoting alertness. He said in these situations performance can deteriorate very rapidly.

Dinges said that using that kind of information in any one accident or event is difficult unless there is an indication of where the person was in his endogenous circadian cycle, which can be tricky to estimate without some information regarding habitual timing of sleep and wakefulness. He said knowing that the person had a very stable sleep/wake cycle makes the task easier. He said a stable sleep/wake cycle could be used as a surrogate estimate of when the individual is likely approaching the peak and trough in his circadian rhythm.

Dinges said he reviewed the material provided regarding the crash of AAL1420.[2] He said that circadian problems in accidents are typically thought of as occurring after midnight but this accident occurred just before midnight. However, based on the captain's daily routine, Dinges said that the captain might have had an additional physiological fatigue load on him about the time of the accident. He said the data suggest that if the captain went to bed the night before the accident at his habitual time of 2130-2200 hours he received a good dose of sleep. Dinges said that it appeared that the captain's habitual bedtime was steady and he was not a caffeine user. He said what is relevant, insofar as the circadian system is concerned, is that the accident happened a couple hours after the captain's usual bedtime. He said this would suggest that the captain's circadian system was already in its downward phase. He said that the captain could have gone from feeling pretty good and being more alert when he left

[2] Dinges was provided with the following documents: (1) NTSB Specialist's factual report of investigation DCA99MA060 by Albert G. Reitan of a typed transcript of the cockpit voice recorder from 1119:44 to 1150:48; (2) Transcript of Proceedings (second interview with First Officer Origel), Los Angeles, CA, July 22, 1999; (3) NTSB Exhibit No. 14A, Human Performance Group Chairman's Factual Report; (4) NTSB Exhibit No. 14B, Human Performance Group Chairman's Factual Report Attachment 1: Interview Summaries. (5) NTSB Exhibit No. 2A, Operational Factors Group Chairman's Factual Report; (6) NTSB Exhibit No. 2B Operational Factors Group Chairman's Factual Report, Attachment 1: Interview Summaries.

Dallas to having an increased physiologic fatigue level as he got closer to Little Rock. Consequently, Dinges noted that one key factor in the accident scenario was that the captain was being asked to perform a landing task at a time of night when he would normally be asleep. Dinges said he would not be concerned if the accident had occurred only a couple of minutes past the captain's normal bedtime—but in this case it was a couple of hours past his bedtime, which was significant.

Regarding the Captain's circadian phase at the time of the crash, Dinges felt that total wake time may have contributed to vulnerability to error. He noted that the captain had worked a considerable period of time on the day of the accident and had been up for 16 or more hours. He said that 16 hours of continuous wakefulness really is the limit that anyone would suggest is safe to perform within. Dinges said that this prolonged wakefulness, coupled with the fact that the accident occurred at night approximately 2-2.5 hours past the captain's habitual bed time, make it highly likely that the Captain was fatigued at the time of the crash. He emphasized that fatigue was apparently one of a number of things that might have been relevant to performance errors made by the Captain. Dinges said that after reviewing the CVR transcript, what seemed evident to him was that the way things were being prioritized by the Captain during the final minutes of the flight, fit with what is known about fatigued performance. There appeared to be a focus outside of the cockpit (toward the storm and the airport), with a priority to land the plane on the target runway.

Dinges said that there are published studies that demonstrate that "larks", or morning-type people, do not perform well when they get into the circadian zone of when they are habitually asleep. He said these studies show that larks have difficulty adapting to nightshift work, and they are much more likely to make mistakes after long shifts when they are in the night zone. Dinges said there is reason to believe that based on the literature for larks and owls that the timing of the accident for the Captain, being well past his normal bedtime, may have been challenging for him.

Dinges said he reviewed the CVR record to examine the nature of the crew's performance. He said he saw evidence of time pressure (to complete the flight and to avoid the storm). Dinges noted that such time pressure would create a work-paced environment, and would have the effect of eliminating the flight crews' option to slow performance to maintain accuracy. In addition, the frequent and changing radio reports from ATC during approach and landing also demanded attentional resources and added to the work-paced nature of the performance demands. Time pressure and frequently changing wind information would make effective performance even more difficult in a fatigued pilot, and therefore increase the likelihood of errors in the Captain. In addition, Dinges commented that in his opinion the crew was paying significant attention outside the cockpit to the storm and to the visual identification of the airport and runway during the approach. This prioritization and the cognitive resources allocated to it could lead to the potential to overlook other cockpit tasks.

Dinges said that there were a number of instances where something was said and the captain asked for it to be repeated. He said this appeared to be a sign that the Captain in particular was having cognitive allocation problems focusing because of the multiple attentional demands that were required during approach and landing, and the pace of the information coming in.

Dinges said that the presence of distracting sounds makes a task more difficult for a fatigued person. He said a fatigued person will tend to ignore these sounds even if they are warnings.

Dinges said he did not want to suggest that the crew was so exhausted that they could not problem solve. He said he saw evidence of adaptive performance in the CVR record based on the fact the crew selected a different runway to land with a headwind rather than a tail wind.

Dinges said he would suspect from a biological standpoint that there was a fair amount of stress involved at this time in addition to fatigue. Dinges said that it was important to recognize that the fatigue in this situation was not drowsiness where someone falls asleep on the job. He said that although he felt the Captain was fatigued, he did not think either pilot was feeling sleepy, primarily because of the stressful nature of the approach and landing. He said instead he saw this situation as a difficult and demanding situation that was at the performance limits of what could be expected for these people at this time of day under these conditions.

Dinges said that he doesn't believe that the Captain felt tired in Dallas because of his desire to get somewhere and complete the trip. He said that it is not unusual and is frequently observed in laboratory studies. Dinges said he felt the Captain was motivated, committed and professional, but he was also tired, especially during the approach and landing. Dinges said that the performance of the flight crew during approach and landing, including both the accuracy of landing the airplane on the correct runway and the apparent failure to arm the spoilers (and stop the airplane in a timely manner after landing) were responses consistent with ASRS reports related to fatigue that he has reviewed.

Dinges was asked about how fast someone could adapt to a 2 hour time zone change from west to east. He said that a 2-hour change usually takes 3 or 4 days, assuming the person makes an effort to change to the new time zone. To adjust to the new zone the person needs to go to bed earlier by a couple of hours and try and wake up earlier. He said when someone goes westward the change in time zones is easier to adapt to because it results in a phase delay instead of a phase advance. He said adaptation to westward changes might occur a day sooner. Dinges said that if a person does not try to adapt to the new time zone but tries to remain on their home time zone, adaptation will occur eventually over a week or two because the person will be exposed to morning light earlier.

Dinges said that in the studies on sleep deprivation that they conduct participants are generally extremely familiar with the cognitive tasks and performance is stable. He said they observe deficits in performance with sleep deprivation on very familiar tasks. The deficits can take the form of increased variability in performance. He said with increasing fatigue, tasks that have learning curves show a shift in the learning curve in that performance doesn't improve as fast, it may level off sooner, or it can decrease if fatigue is severe. Dinges said there is an argument that novel tasks don't show these effects because of the novelty component and because a person is on the steepest portion of the learning curve the first few times they perform the tasks. As a result, people can get better over time even if they are becoming more fatigued over time.

Dinges said that in his knowledge of the scientific literature on fatigue, giving people breaks can help reduce fatigue, but the effects are modest and short-lived if the break does not involve sleep. He said one of the primary determinants of fatigued performance is how long a person has been awake; another is the circadian system. He said that in addition there is how long you have to work on something before you get a break. He said that with short breaks performance would show less cumulative deterioration. He said that giving short breaks does not guarantee nonfatigued performance but that the deficits will not be as large as they would be if a person had worked continuously over the same period.

Dinges said that in terms of age effects and fatigued performance, the scientific literature tends to show a slight but generally statistically significant overall cognitive slowing across the adult work years. He said there is no loss of cognitive ability. He said this means that older people can become more sensitive to work paced tasks because when they cannot slow the task down they are more prone to make errors. He said the literature is controversial in terms of whether older people are more likely to be affected by fatigue. He said there are studies that suggest that the elderly are more impaired when they stay awake longer -- but there are also studies to suggest that they are less physiologically sleepy. However, he said that in the age range from 30-50 years, there doesn't appear to be much variation in susceptibility to fatigue related impairments.

He said that people's judgments of their own fatigue can range from very accurate to very inaccurate. He stated that judgments are extremely sensitive to contextual variance, meaning that who asks the question, what the implications of the answer are, what the expectation of the reporter is, and a host of other variables, including stimulation in the environment will determine the individual's response. He said that if a motivated and capable person trying to do a professional job, particularly under time pressure, is asked if they are tired they will generally tend to respond that they're okay if they view getting to the end point as the successful conclusion of the job. He said a person in this situation will be reluctant to tell you they're tired and they may not even feel tired because they're up, they want to get this done, and they've allocated their energy to it. He said that in his studies people will often start out saying they are tired but eventually will change to saying they are not tired even though it is at the time when they have a low performance capacity. Dinges said that subjective reports of fatigue can be a sensitive barometer, but can also be erroneous particularly when people are trying to get their jobs done professionally. He said they see the greatest amount of error in self-reports when people believe that their jobs are to be professional and "professional" means being alert. Dinges said that is why so many agencies support research in laboratories like his -- because self reports fail so often, there is an urgent need for more behavioral and/or biological markers of when people are becoming impaired before it's too late. Dinges said that by the time a motivated person realizes they are impaired from fatigue, it is often too late.

Dinges said it is very hard for people to detect fatigue in someone else. He said if he kept people awake for 4 days and then let them shower or clean up and then stand for a photo or video it would be difficult to identify them as tired when they were mixed in with people who were not sleep deprived. He said even asking someone if they are tired in a social context is a powerful transient stimulus for humans -- so that is often why people tell us they feel great, and then they do the task and they're terrible and they say they don't understand why. He said self-report does not predict the likelihood of having an accident, or performance error.

Dinges said that his laboratory's original fatigue-countermeasures research focused on prophylactic naps and the efficient use of caffeine. He said the research concluded that cockpit napping would be a beneficial countermeasure but he said it was not being used operationally in the U.S. He said his laboratory's research now is searching for early warning signs of fatigue. He said these experiments involve are trying to develop ways to identify whether someone is becoming drowsy. He said it might be possible to develop technology to do this for situations such as a long boring flight with nothing happening. However, he said that in the case of the Little Rock accident, the flight situation appeared to be dynamic with lots of things happening (e.g., time pressure, detecting the airport, monitoring the storm's position, completing checklists, configuring and maneuvering the airplane) and to detect fatigue in that situation may require a different kind of technology. He said that kind of technology would likely have to involve behavioral monitoring of pilots -- how they are allocating their efforts, what they are looking at or not looking at, etc. He said that biological monitoring of things like heart rate would not be specific enough. He said that ultimately such a system would provide feedback to pilots that they are misallocating resources or not doing things in the right sequence. He said that knowledge and research relevant to the development of such operator aids still has a way to go.

Dinges said there are ways to make many of the regulated industries safer in terms of reducing the potential for fatigue related accidents and incidents. He said improvements are not limited to the absolute work rules provided by the regulators but can include companies developing risk management systems that consider operator schedules. He said that regardless what is done with technology, people should not be working in safety sensitive occupations with a biological impairment such as fatigue. He said that it is discouraging to see the extent to which various transportation modes use the regulations to determine how to extend the duty day through various extra factors (e.g., using inclement weather as a reason to have pilots work longer hours—which can have the effect of increasing the chances that a tired pilot will be attempting a more difficult performance). He said that individual transportation operators, such as pilots, also have a responsibility to manage fatigue. He said that for example pilots who live in Florida and commute to California and then fly Pacific routes are putting themselves in an impaired state by starting with a 3-hour circadian phase shift when they come to work.

Dinges said that when people are fatigued, there is evidence that they can persevere on ineffective solutions. He said that Jim Horn (published in Harrison and Horn, 1999) has data that sleep deprived subjects persevered on ineffective solutions in a set of complex economics tasks. These subjects also had a reduced ability to update their plans.

Dinges said that self-reports of fatigue impairment may be affected in the same way that self report is inaccurate for impairment due to hypoxia or alcohol. He said these states may reduce the ability of the brain's self-monitoring executive function that tracks how well one is performing.

Dinges said that his review of the CVR in AAL1420 left him with the impression that the crew experienced a loss of situational awareness in space and time. He said that relative to space, they were so focused on maintaining situational awareness outside the airplane (toward the storm, airport and runway) that they may have lost sight of things inside the cockpit relevant to prepare for landing. He said that relative to time, they were so focused on getting the airplane on the runway in a timely manner, that they may have lost sight of what was going to happen after they touched down.

Dinges said that in general, when people are fatigued, they are likely to make a bad decision about the next thing they will do. He said the reason for this is unknown and there isn't a great deal of information about it. He said it is assumed to be a failure of the individual to consider their options. Dinges said that time pressure can also lead to bad decisions.

Dinges said that based in part on the fact the crew requested an airplane swap in DFW, there appeared to be a motivation to complete the duty cycle. He said the question is, would a tired person be more likely to want to get done and therefore go ahead than someone who wasn't fatigued? He said they have not manipulated that variable in the laboratory. However, he said that in experiments where they test people for a long time, if the end is in sight there is a tendency for people to ask us if they skip a meal or save time in another way to get to the end of the experiment. He said he thinks that what may be happening is related to the allocation of resource energy and compensatory effort in that if it is getting late, and the goal is seen as achievable, tired people may tend to push to get there—taking shortcuts if they can. He said this is seen in trucking in that a driver's desire to get home may lead him to not stop at a rest area when tired. He said that experiments on this are rare and findings come primarily from anecdotes.

Dinges said his primary concern was not the length of the crew's duty day but that the Captain was shooting the approach 2 hours past his normal bedtime He said completing the planned duty day would have helped if the flight could have been completed in what was the captain's normal duty/working day; and that there is no question that this would have been preferable to working 2 hours after when one might normally be asleep.

Dinges was asked about the length of duty days whether 12, 14, or 16 hours. He said that he would prefer that extensions to 14 and 16-hour duty days not occur unless there is mitigation of the increased risk of performance failure, like augmentation crews on long haul flights or the appropriate use of countermeasures. He said that in the absence of risk mitigation it is difficult to embrace the notion that we should permit individuals in safety sensitive occupations to be putting in hours that exceed 12, and if we do go to 14 hours, there should be frank acknowledgement of the risk - and some sort of effort to mitigate it.

Dinges was asked if there is any test for judging whether any schedule sequence is more or less likely to produce fatigue and push human performance limits. He said he did not know of a specific test or algorithm that is validated to do that in an absolute sense. He said there is aggressive work in a number of labs to develop such algorithms. He said these types of tests will exist sometime and at present his laboratory is providing data to collaborators at Harvard for development of such a scheduling mathematical model. He said the fact that there is not a test to evaluate schedules for their potential to incur fatigue is one of the reasons that companies should operate within the limits of the regulatory schemes. He said there is risk beyond those boundaries and the current boundaries are the only ones that exist until we get better at making micro-predictions of where risk is likely to be elevated in any given schedule. However, Dinges said the sleep and transportation safety fields have identified risk factors in schedules. These include watching out for time zone changes, for long duty days and for short rest cycles.