AVIATION FATIGUE MANAGEMENT SYMPOSIUM: PARTNERSHIPS FOR SOLUTIONS

JUNE 17 – 19, 2008

Sheraton Premiere at Tysons Corner
8661 Leesburg Pike, Vienna, Virginia

PROCEEDINGS

PRESENTED BY
THE FEDERAL AVIATION ADMINISTRATION

Acknowledgements

The Federal Aviation Administration (FAA) thanks members of the aviation industry, representatives of employee groups, aviation operators, academic experts, members of the FAA staff, representatives of other government agencies and the National Transportation Safety Board for assisting with the organization of this symposium and for enthusiastic and constructive participation. The FAA also thanks the Institutes for Behavior Resources (IBR), Inc., CMP Meetings Services, and Science Applications International Corporation for planning, organizing, and supporting the symposium and IBR for preparing the proceedings of the symposium.

Invitation

Welcome to the FAA-sponsored symposium on managing fatigue in aviation. The FAA appreciates your participation and willingness to share and discuss information on fatigue physiology, management, and mitigation techniques. The participants in this symposium represent leading aviation industry professionals from around the world, as well as the best scientific knowledge regarding aviation fatigue currently available in the field.

While this event will cover many aspects of fatigue, it is not designed to solicit recommendations on FAA regulations or policies or reach consensus on any course of action. Rather, we hope that you will use this event to enhance your knowledge and awareness of fatigue and various fatigue-mitigation techniques for application in your working environments.

Many FAA employees have been asked to participate in this symposium based on their own personal and subject matter expertise. The opinions offered by these individuals are their own and should not be construed as an official FAA position on any particular issue. Please note that the presentations given during this event, as well as the symposium materials, will be available for review by the public upon conclusion of this event. If you have any questions or comments following this event, please feel free to contact the coordinators of this event, Mr. Rick Huss, Rick.Huss@faa.gov; Dr. Melissa Mallis, mmallis@ibrinc.org; and Dr. Steven Hursh, shursh@ibrinc.org.

Again, thank you for your active participation in this important event.

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II. INTRODUCTION

The Federal Aviation Administration (FAA) has recognized the need for leadership to begin dialogs to understand and address fatigue in the aviation industry. The issues are cross-cutting affecting flight crews, ground support personnel, maintenance personnel, and air traffic controllers. The solutions require the cooperative action of industry, employee groups, and the FAA. Making head way also requires a shared commitment to solve problems. That shared commitment must rest on a common understanding of the problem, a frank understanding of the barriers, and a collaborative approach to developing practical solutions.

The FAA set four primary objectives of the *Aviation Fatigue Symposium: Partnerships for Solutions*:

1. Energize the aviation community to solve aviation fatigue problems.

2. Provide attendees with the most current information on fatigue physiology, risk assessment and mitigation alternatives.

3. Develop a common understanding of fatigue issues, identify challenges that create the potential for fatigue, and discuss barriers that have historically prevented solutions to reduce fatigue.

4. Discuss the potential for collaborative alliances to develop and implement fatigue mitigation strategies.

The symposium was scheduled for June 17 to 19, 2008, at the Sheraton Premiere Hotel in Tyson's Corners, Virginia. The event was designed to accommodate from 250 to 300 attendees over a 2 ½ day period. Supporting the FAA in conducting the meeting was the Institutes for Behavior Resources, Inc. for development of content and speakers and CMP Meeting Services for meeting planning, logistics, and attendee support.

The audience of the meeting was broadly defined to include government agencies concerned with transportation fatigue (FAA, National Transportation Safety Board (NTSB), National Aeronautics and Space Administration (NASA), Federal Railroad Administration (FRA), Department of Defense (DOD), and others), commercial air carriers, major employee groups representing flight and ground support personnel, aircraft manufacturers, aviation associations, and the Flight Safety Foundation. The content of the meeting and the speakers were selected to address fatigue issues and concepts of interest to this diverse group of attendees.

The format for the meeting was designed to disseminate essential information about aviation fatigue, from the underlying biology to the operational impacts, and to stimulate discussion leading to seeds for future collaborative solutions. The meeting began with a morning of keynote speakers defining the fatigue issues and illustrating the importance of finding workable solutions. Following the keynotes were more technical descriptions of the fundamental biology of fatigue and how the conditions of aviation schedules could create performance deficits that can be operationally significant. Following this foundation material were parallel sessions with panel speakers addressing topics of particular interest to flight operations (track one) and ground support shift work operations (track two). Specific topics covered by the panel discussions were operational drivers of fatigue, description of fatigue risk management systems, operational evidence of fatigue, current state of fatigue mitigation for flight and shift work operations, and measures of effectiveness of fatigue risk management systems. Following the parallel sessions were breakout discussion groups that focused on specific areas of interest for either flight or shift work operations. These discussion groups had specific assignments to discuss fatigue challenges and drivers, historical barriers to reductions in fatigue, and potential avenues for future fatigue mitigation. Finally, on the third day, the discussion groups reported a summary of their discussions for the assembled audience, punctuated by a commentary on these reports by a panel of operational fatigue experts (see Appendix A for detailed agenda).

In order to encourage open discussion, the meeting was closed to the public and attendance was by invitation only. Every effort was made to extend invitations to major stakeholder groups. Letters of invitation were sent to the vice presidents of operations of the air carriers with an invitation to send key members of their organization concerned with safety and crew scheduling. Letters of invitation were also sent to employee representation organizations. Invitations were also sent to major aviation related associations. Finally, international fatigue experts were invited to attend and many were asked to serve as facilitators and subject matter experts in support of the discussion groups. Discussion group leaders were selected to ensure a balance of both management and labor representatives, as well as fatigue experts.

In preparation for the meeting, conference calls and mailings to the panel members and discussion group leaders were used to prepare topics and content of presentations and to facilitate smooth and fair conduct of the discussion groups. A discussion group guide was prepared to ensure that the groups covered an essential set of topics, conducted the discussions in a fair and balanced manner, and prepared reports that were clear and comprehensive relative to the goals of the meeting. Each discussion group was also assigned a note taker to assure that the substance of the discussions were captured and reflected in the report of the groups. Transcripts of the first and last day were maintained by the conference support contractor to assist with preparation of the meeting proceedings. The proceedings consist of summaries of all the talks, major discussion points of each talk, the resume of each speaker, and summaries of each panel. The proceedings also include all publicly releasable research findings and summaries of the discussion group findings.

III. KEYNOTE SESSION

"No Rumble Strips"

MR. ROBERT STURGELL

Acting Administrator
Federal Aviation Administration

June 17, 2008: Keynote Session

MR. ROBERT STURGELL: "Fatigue makes cowards of us all." That was Vince Lombardi's motto. He won 105 games that way. But while he very well may be the greatest football coach of all time, he's not going to score any points in this room.

We like to think that not getting enough sleep, working tired, being a little drowsy — that they're just all part of how Americans live. If you're like me, you think, "I'll catch up on Saturday." We don't like to think that fatigue can be linked to catastrophe, but there's some truth in that. I wish that our biggest worry were dropping a pass or missing a tackle. We know better.

In aviation, there are no rumble strips like there are on the trip back from the Outer Banks. In aviation, speaking generally, we don't understand the science of fatigue the way we need to. By "we," I mean all of us — all the players — the regulators, the industry, the academics, the controllers, the pilots, the dispatchers, flight attendants, technicians.

What we need is the knowledge to determine the right thing to do. The will is already there.

I think we all acknowledge that even with an outstanding safety record, we're not where we need to be when it comes to understanding and dealing with fatigue. This meeting aims to put us on a level playing field with what we know, with what we understand. We have international fatigue experts and eight countries here. At this conference, I want to look at new ways to manage fatigue for all personnel in this industry.

Specifically, let's provide the most current information on fatigue physiology, management and mitigation alternatives. Let's share information and perspectives among aviation industry decision makers. Let's discuss the science regarding fatigue management. Let's hear fatigue mitigation initiatives and best practices.

Perhaps we can get agreement in the form of proposals for data collection — agreements for studies, for oversight, for steering.

And while we're at it, I encourage you to leave your day job at the door. Think outside the box. Specifically, black ones.

So, where are we? We know that adequate sleep is only half of it. We know time of day of sleep affects performance just as much. Right Even small restrictions on sleep can lead to a sleep debt that causes continuous degradation in performance.

As we move forward, we need to define what is an acceptable level of fatigue risk and what levels of fatigue must be minimized. We need to come to agreement on what studies or data would be needed to provide those definitions.

I'm not talking necessarily about adopting prescriptive criteria for fatigue risk abatement. All options will be considered. I think we need to address all levels of fatigue and put appropriate mitigations in place — mitigations that are proportionate to the risk. Endurance shouldn't be a Vince Lombardi thing. This isn't a test of how close we can get to the edge.

In closing, let me remind us all that we share in this issue together. And it's not just at the organizational level. Every person in every line of work bears the personal responsibility to report for work rested. All modes of the transportation system depend on that. Everyone knows that fatigue affects memory, attention to detail, communication ability, decision making. It affects our situational awareness. We've all long thought — and Richard Sumwalt and Dr. Dinges are about to tell us — that while fatigue may have not been called out by name, it's been there lurking in many of the accidents we've faced over the years.

We're trying to do something innovative here with a topic that generates a lot of emotion and anecdotal claims. My hope is that the conversations we're about to have will bring some clarity to the issue and help us decide where to go using a data-driven approach. This isn't a venue for arguments about economics, now, the rules only address sleep opportunities. and it's not about contract negotiations. But it is a chance for us to give a boost to safety where one is needed. Thanks for being here.

Biography

Bobby Sturgell was named FAA Acting Administrator on September 14, 2007. He had been FAA's Deputy Administrator since 2003.

As Administrator, Sturgell regulates commercial and private aviation in the United States. He leads the 43,000 FAA employees who operate and advance the safety of the world's largest air traffic control system and most complex network of airports. He also oversees the agency's day-to-day operations, capital programs and modernization efforts.

Before joining FAA, Sturgell was the senior policy advisor at the National Transportation Safety Board (NTSB). He was the focal point for analysis and coordination of NTSB's safety recommendations, policies, programs and safety initiatives.

Sturgell came to the federal sector after flying for United Airlines, where he was a flight operations supervisor and line pilot. He flew the B-757 and B-767 on domestic and international routes. Sturgell also practiced aviation law in Washington, D.C.

A former naval aviator, Sturgell was an instructor at Top Gun, the Navy's Fighter Weapons School. He has flown the F-14, F-18, F-16 and A-4. Sturgell is a graduate of the U.S. Naval Academy and the University of Virginia, School of Law. He retired from the Navy as a commander. Sturgell, his wife Lynn and son reside in the Washington, D.C., area.

"Reduce Aviation Accidents and Incidents Caused by Fatigue: It's Time to Act! "

MR. ROBERT SUMWALT

Vice Chairman
National Transportation Safety Board

June 17, 2008: Keynote Session

MR. ROBERT SUMWALT: Thank you. And thank you for that nice introduction. It really is an honor for the NTSB to be invited at this venue, and I'd like to congratulate the FAA for pulling this together. I think that this is such an important topic, and we definitely appreciate your commitment to making it happen.

And, also, as I've come to realize, you can have a wonderful symposium, but if people don't come then you don't have much of a symposium at all. So I'd like to look out into the audience, and it really warms my heart to see that we have 300 people from around the industry who have gathered, gathered to learn more about fatigue, to look for common solutions. And as the title of this symposium is, to form a partnership for solutions. So congratulations to all of you for being here.

I put a fair amount of thought into the title of the discussion this morning. What should I title this? The first part of it, "Reduce Aviation Accidents and Incidents Caused by Fatigue," that's right off of the Safety Board's most wanted list. That is the verbiage right here on this list. We've been saying that for a long time. But the second part of the title, "It's Time to Act," that's what I came up with because it is time to act.

We have been dealing with trying to resolve fatigue in aviation for a long time, and what we do at the Safety Board is we put a red mark on our most wanted list next to this recommendation, which means that the recipient of the recommendation is moving at an unacceptable pace. And the recipient happens to be the FAA. But you know what? The FAA really is in sort of a bind. And it's not my position to try and apologize for other federal agencies, but the fact is, by the Administrative Procedure Act of 1946, federal agencies are bound to go through a rule-making process. They have to publish a notice of proposed rule-making. They have to solicit public comment.

The FAA formed an advisory rule-making advisory committee on fatigue in 1995, and it didn't appear that there was going to be an industry consensus on fatigue. And so that sort of puts the recipient of our recommendation in a bind because, by law, they have to do something, they have to solicit the input. They're trying to achieve consensus. But if the industry can't achieve consensus, than the regulator can't put forth the regulations.

So what I'd like to do is challenge everybody to come together for a partnership for solutions. Let's spend the next three days looking for solutions. Let's put the past behind us, and let's move forward.

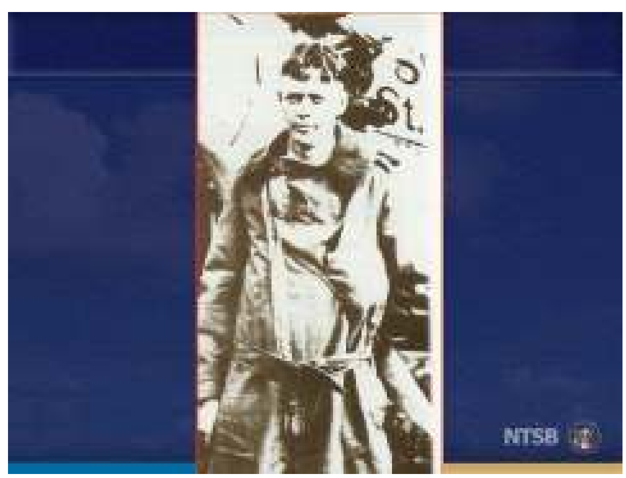
I'd like to start by talking about my stamp collection. I have sort of a strange stamp collection. I started collecting stamps as a child and, over the years, my stamp collection has gotten a little more strange. But I collect airmail that never made it to where it was going from the 1920's and the 1930's because the airmail was in a plane crash.

So let's look at a few of my stamps. Here's one here from 1926, and, ironically, this was on the inaugural service of airmail between Chicago and the Twin Cities. And what happened? The plane crashed. And it's hard to see that green stamp that is right there, but it says, "Mail delayed by accident in Mendota, Minnesota in which pilot Elmer Lee Partridge was killed."

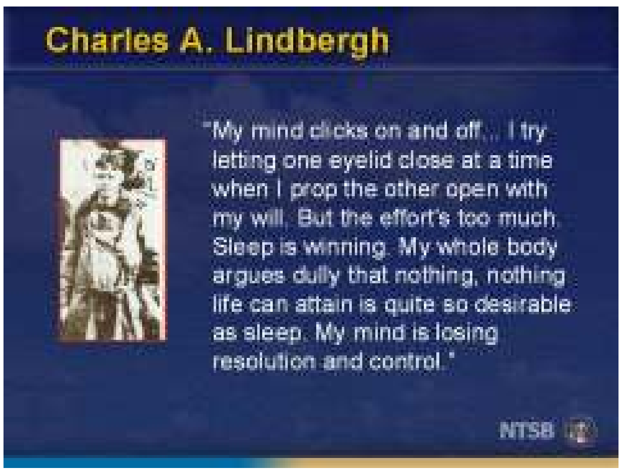
And here's another one and another one and another one. Here's one from 1930. And yet another. And I've got several more, but I just wanted to show you some of my stamp collection.

But of all of the crash stamps that I've collected over the years, this is one that I don't have, and this is one that I would absolutely love to have. There's only one of these known to exist. You see, this one is from 1926. It was on a flight between St. Louis and Chicago. The pilot bailed out at 14,000 feet. I think he had iced up and bailed out. Obviously, the plane crashed. The pilot went over to the wrecked plane and recovered as much of the mail as he could possibly get. He got about 60 pounds of mail and then went and got on a train and took it to Chicago. Remember the mail must get through. But this is the only remaining one of those that exists, and there's a stamp on there that says "arrived in damaged condition," and then the pilot wrote "due to airplane crash," and he signed it. He signed it with an "L," and that "L" was Charles Augustus Lindbergh.

What I think is just as interesting, it was only five or six months later, it was May of the next year, that Lindbergh made his famous flight across the Atlantic as a solo pilot.



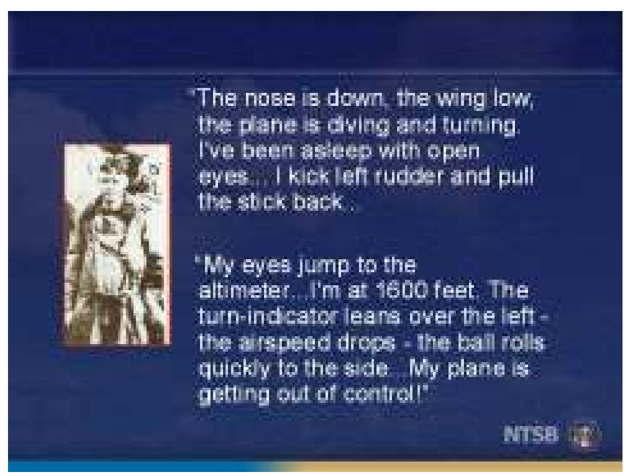
And I don't know how many of you have ever read the book "The Spirit of St. Louis." How many of you have read that book? A fair number. All throughout the book, Lindbergh punctuates the book with quotations talking about how tired, how fatigued he was. For example, "My mind clicks on and off. I try letting one eyelid close at a time when I prop the other open with my will. But the effort is too much. Sleep is winning. My whole body argues dully that nothing, nothing life can attain is quite so desirable as sleep. My mind is losing resolution and control."



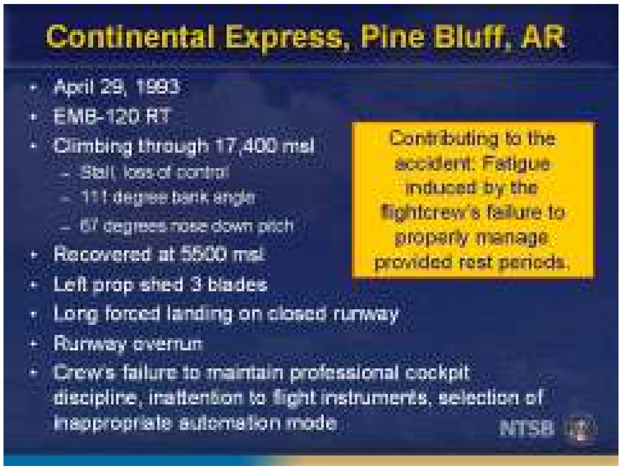
This isn't just something that went away with Charles Lindbergh. This is something that we've experienced for the last 80 years of aviation. In fact, let's look at the paper from a week ago, from this time last week. Pilots falling asleep.

There's three points I'd like to make this morning. The first is fatigue is real and it does affect safety.

Let's look at a few examples. Well, let's go back to Charles Lindbergh. "The nose is down, the wing is low, the plane is diving and turning. I've been asleep with open eyes. I kick the left rudder and pull the stick back. My eye has jumped to the altimeter. I'm at 1600 feet. The turn indicator leans over to the left. The air speed drops, the ball rolls quickly to the side. My plane is getting out of control."



When I read this, I'm reminded of an accident the Safety Board investigated a number of years ago. This airplane was a Continental Express in Pine Bluff, Arkansas back in 1993.



It was an EMB-120. The pilots were climbing through 17,000 feet. They had allowed the speed to decay. The airplane had picked up some ice as they had climbed through the clouds. And with the decayed speed, the airplane stalled at a speed that they didn't expect it to. They were talking to the flight attendant. They were doing other things. They weren't adequately monitoring the airplane. The airplane got away from them. But the amazing thing is that they stalled, they lost control, they got it into a 111-degree bank angle, 67 degrees, nose down, and they finally recovered at 5,500 feet. Imagine what the dry cleaning bill would have been after that ride.

The left prop shed three blades during the process, and the crew made a forced landing on a closed runway. They ran off the runway. And the Safety Board found that the crew's failure to maintain professional cockpit discipline and inattention to the flight instruments and selection of inappropriate automation mode were certainly the causal factors in the accident. But the Safety Board also found that contributing to the accident was fatigue induced by the flight crew's failure to properly manage provided rest periods.

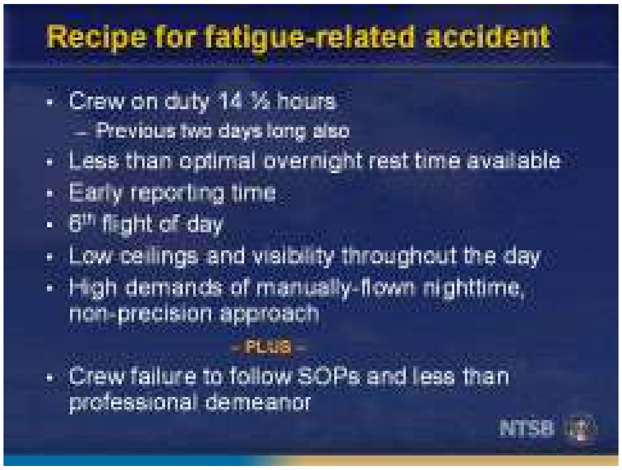
You see, it was day three of a trip. They had had short layovers on the first night of the trip. But on the second day of the trip, the crew got in at 11:30 in the morning. They didn't have to report to duty until about 5:00 or 5:30 the next morning. Now, granted, that is early, but they had, according to the Safety Board, ample layover opportunities, but the crew did not take advantage of their layover rest. You see, they stayed up until 11 or 12 watching TV, reading, whatever, and they had to get up at 4:00 in the morning.

So we did find that fatigue was a contributing factor, and this accident occurred at a time of day that is normally associated with fatigue. And so that was a contributing factor, and it underscores a couple of things: that there's not a lot of difference between Charles Lindbergh's plane going out of control and this one here; and that fatigue is a problem and it is something that we need to do something about.

But it also makes a point that I believe it was Bobby made--that there is a personal responsibility. You can have the best flight and duty time limitations in the world, but if people don't exercise that professional responsibility it's not very good. Let's move on.

This airplane was an accident, a fatal accident, 13 fatal.

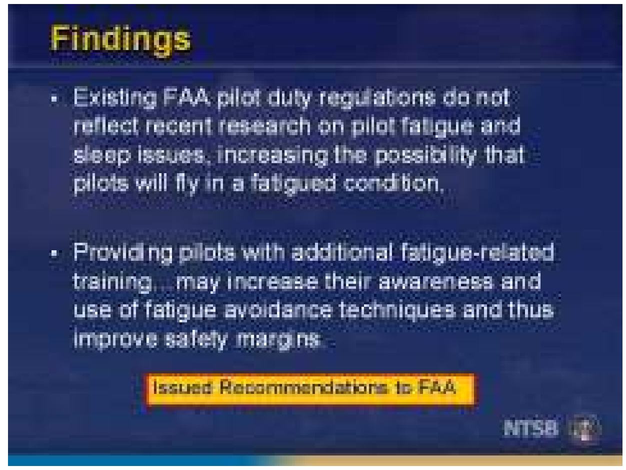
There was a jet stream operated by Corporate Airlines, doing business as American Connection, back in 2004. The crew was conducting a nighttime non-precision approach into Kirksville, and they hit the ground. If you ask me, when we go back and look at the factors involved in this accident, this was a recipe for a fatigue-related accident. Let's look at a few of the ingredients.



First, the crew had been on duty for 14 1/2 hours, and their two previous days had also been very long. They had less than optimal overnight rest time the night before the trip. They had to wake up early. The captain got up at 4:00, and the first officer got up at 4:30. It was the sixth flight of the day. They had been doing approaches and low ceilings and low visibility all throughout the day, and this would have been their final landing. It was now late at night. And just think about this: the high demands associated of manually flying a dive-and-drive non-precision approach when you're tired.

And these were the ingredients. And now we come in and we add in something else, something that I hate to talk about, but it happened; and that is the crew's failure to follow SOPs and their less-than-professional demeanor. When we tie all of those together, we get the perfect storm. We've got a recipe for a fatigue-related accident, and, unfortunately, we had 13 fatalities, two serious injuries.

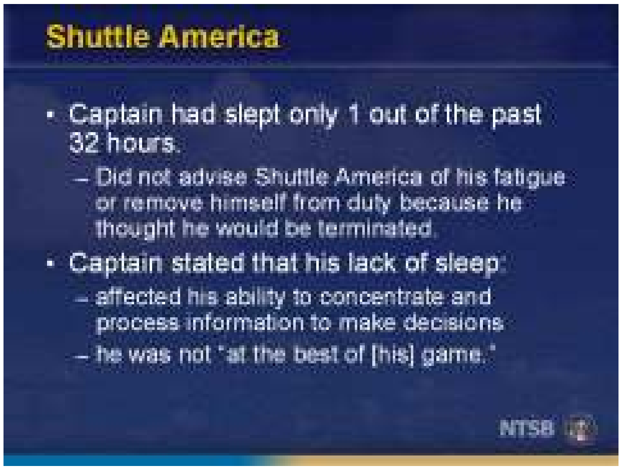
The Safety Board found that the existing FAA flight and duty time limitations don't reflect the recent research on pilot fatigue and sleep issues, which, of course, increases the possibility that pilots will fly while they're fatigued. And we also said that providing pilots, providing crew members, with fatigue-related training may increase their awareness and therefore, help pilots to avoid flying when they're fatigued.



We came out, and we made recommendations on each of these findings. Dr. Jana Price will speak on the NTSB panel later this morning and talk specifically about our recommendations.

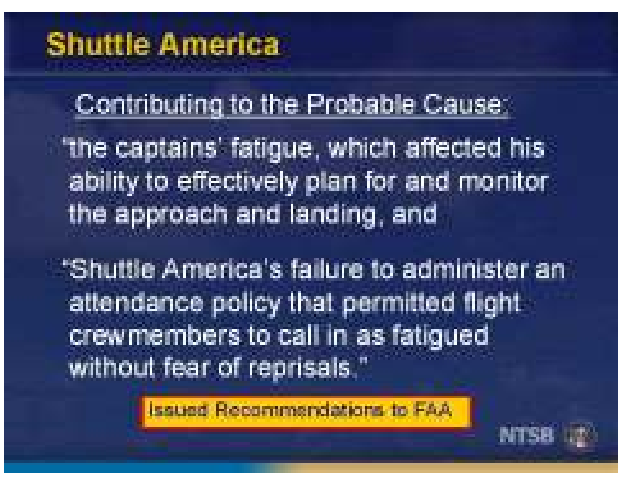
Another flight that the Safety Board deliberated just in mid-April, this accident occurred in February of `07, an Embraer 170 at Cleveland, runway overrun, no fatalities fortunately.

But what we found, what our investigators found, is that the captain had slept only one out of the past 32 hours, and he did not advise Shuttle America of his fatigued state, nor did he attempt to take himself off of the trip because he had been notified by his company that he had used an excessive number of sick calls and that if he used more he could be subjected to discipline, including termination.



And the captain said that his lack of sleep affected his ability to concentrate and to process information and to make decisions and that he was not at the best of his game.

The probable cause was something along the lines of the captain's faulty decision to continue this approach. But contributing to the probable cause was the captain's fatigue, which affected his ability to effectively plan for and monitor the approach and landing, and also the company, Shuttle America's failure to administer an attendance policy that permitted crew members to call in as fatigued without fear of reprisals.



Once again, we made recommendations to address each of these areas, and Dr. Price will be discussing those in her presentation.

Let's just look, without even getting into them, let's just look at a few other fatigue-related accidents. Here's one that the Board deliberated a week ago today.

And here's another one.

And another one, five fatal on a Part 91 repositioning flight on a Learjet.

And another one, 11 fatalities, 45 serious injuries.

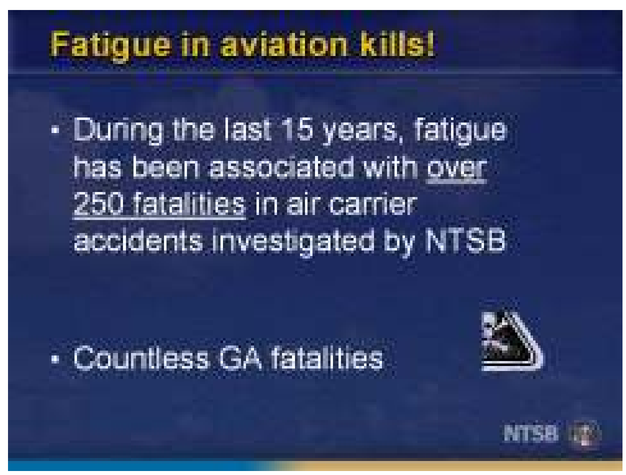
Here's one, 228 fatalities, 26 serious injuries.

And yet another one.

And there are more.

The point I want to make is that fatigue is serious and it has serious implications. In fact, as Dr. Brenner from the Safety Board will say in his part of their panel, in the last 15 years fatigue has been associated with over 250 fatalities in air carrier accidents investigated by the Safety Board. 250 fatalities. There are countless other general aviation accidents, but the numbers are just countless.

So that's my first point. Fatigue is real, and it does have serious safety consequences.



The second point is that the Safety Board has had a longstanding concern about fatigue.

We've issued, since 1972, 117 fatigue-related safety recommendations in all modes of transportation.

Thirty-four of those are related to aviation, and they apply to the flight crew, mechanics, air traffic controllers; and they've been issued to a number of organizations and governmental entities.

Fatigue has been on the Safety Board's most wanted list since the very inception of this list in 1990, and today's most wanted list has seven, seven aviation fatigue-related recommendations that concern air traffic control, maintenance, and flight crew.

We believe in a comprehensive approach to addressing fatigue.

Yes, we think that we do need flight duty time limitations that are based on fatigue research, circadian rhythms, and sleep and rest requirements. And we've been saying that now since the Kirksville accident.

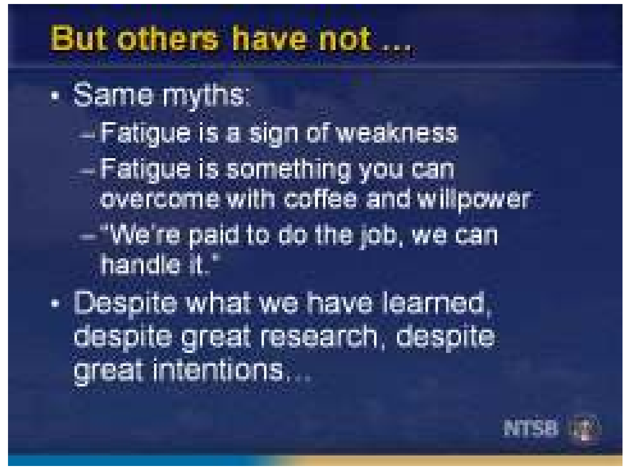
But we also say, and we just came out with this recommendation last week, we approved this recommendation last week. The Board also believes in fatigue management systems or, as it is called also and you'll hear a lot of discussion about that later during this symposium, these fatigue risk management systems. What are they?

We'll let the panel after lunch discuss it. But, basically, it's a comprehensive tailored approach to address fatigue in the workplace. The Safety Board believes that both of these are needed to fully address the issue of fatigue in aviation.

I want to make the point that just because we might have a fatigue management system, it does not mean that we don't need good flight and duty time limitations. We need to have both. We need good structure in place by good flight and duty time limitations. And then the fatigue risk management, or the FRMS, is just another part of that. But the fatigue management system should not be looked at to replace the flight and duty limitations.

You know, I did have a great career flying for the airline. And as I look back, I see that some things have changed. I think really it's amazing how the airplanes have changed over the years. Some things have changed, but then others have not.

The same myths exist today that existed when I entered that airline cockpit in 1981, like fatigue is a sign of weakness. Fatigue is something that you can overcome with coffee, a shower, and some willpower. Or how about this one? We're paid to do the job, and we can handle it.

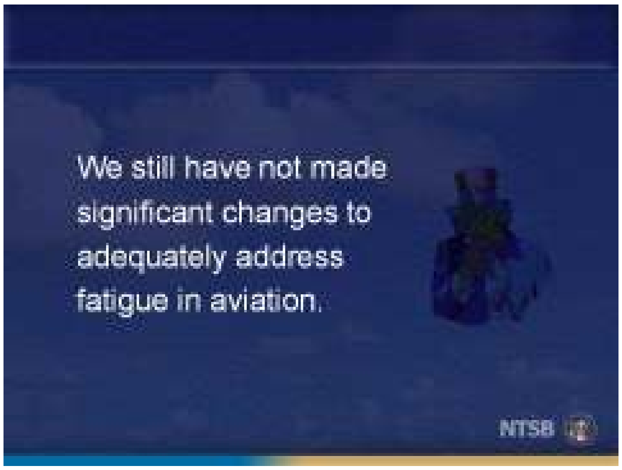


When I left the airline in 2004, I went to run a Fortune 500 flight department. When I got there, there was no flight operations manual at all. And this was the company that I went to work for. We changed that, but no flight operations manual meant that there were no flight duty time, no duty restrictions because the chief pilot had the attitude that we are paid to do the job and we will do it. It was a can-do attitude that, if we can't do the job, the company will find somebody that can. They'll sell the airplanes, they'll start chartering, they'll go to fractional ownership, whatever; so we need to be able to do the job for our company.

Well, within a few months, we had a flight operations manual, and we did have flight and duty time limitations. And, occasionally, it would irk some member of senior management that the new manager would call up -- by the way, the chief pilot left shortly after I got there -- it would irk some in senior management that this new guy would call them up and say, "Look, we can't fly the trip as scheduled. You can leave later, you can come back earlier, but we will not exceed our duty day." They didn't like that.

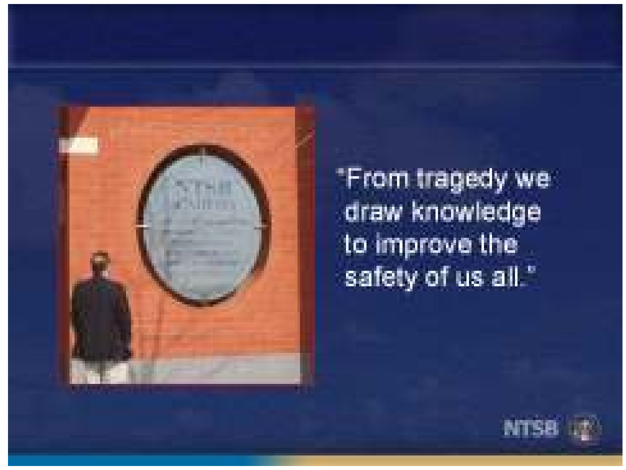
But, unfortunately, it sort of all came home to me after I joined the Safety Board. I had been at the Board about five months when somebody called me early on a Friday morning to tell me that the former chief pilot had been killed in a plane crash. He was pushing limits trying to get back into the home airport under very low IFR, and he was at the end of a 16-hour duty day.

So despite what we've learned, despite great research, despite great intentions, we still have not made significant changes to adequately address fatigue in aviation, which leads to my third and final point.



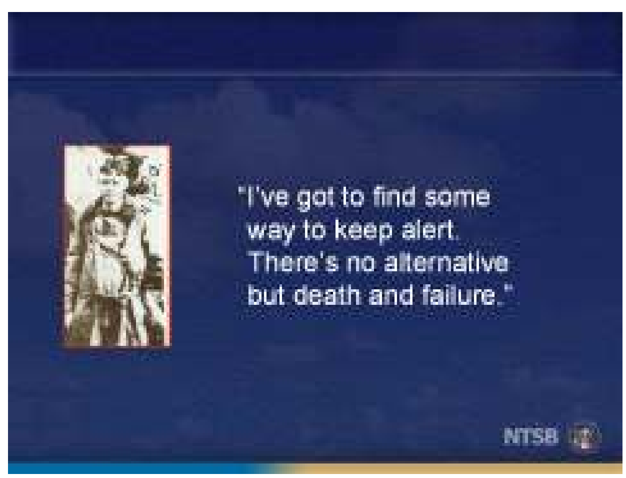
It is time to implement workable solutions.

Outside of the NTSB's training center, we have a plaque, and I usually like to pause and read that plaque before I walk into the building. It says, "From tragedy, we draw knowledge to improve the safety of us all."



And that is what we do at the NTSB. We take tragedy; we try to learn from it to improve the safety of us all. But we can't change it. We don't have the congressional authority to go out and change rules. All we can do is make recommendations and try to urge people to come together to, as the title of this symposium is, to form a partnership for solutions. If it's going to happen, it's going to happen within the four walls of this room.

Back to Lindbergh--we'll close on a quote from Lindbergh. Lindbergh says, "I've got to find someway to keep alert. There's no alternative but death and failure."



And with respect to Mr. Lindbergh, I'm going to propose that death is certainly not an alternative. We've had over 250 deaths due to fatigue in air carrier operations of accidents investigated by the Safety Board over the past 15 years. Death is not an alternative, and I dare say that anyone in this room wants to accept failure as an alternative.

I challenge you to take the knowledge from this symposium, come together and form workable solutions, and let's solve this thing once and for all. Thank you very much.

Biography

Robert L. Sumwalt was sworn as the 37th Member of the National Transportation Safety Board on August 21, 2006. His term of office will run until December 31, 2011. President Bush has also designated him as Vice Chairman of the Board for a two-year term.

Prior to coming to the Board, Mr. Sumwalt was Manager of Aviation for the SCANA Corporation, a Fortune 500 energy- based company.

Mr. Sumwalt was a pilot for 24 years with Piedmont Airlines and then US Airways, logging over 14,000 flight hours and earning type ratings in five aircraft before retiring from the airline in 2005. He has extensive experience as an airline captain, airline check airman, instructor pilot and air safety representative.

Mr. Sumwalt worked on special assignment to the US Airways Flight Safety Department from 1997 to 2004, where he was involved in the development of numerous airline safety programs, including an enhanced crew awareness program and a windshear training program. From 2002 to 2004, he served on the US Airways Flight Operations Quality Assurance (FOQA) Monitoring Team.

Mr. Sumwalt served as a member of Air Line Pilots Association's (ALPA) Accident Investigation Board from 2002 to 2004, and also worked with ALPA's Aviation Weather Committee on improving the quality of weather products available to pilots. He has chaired ALPA's Human Factors and Training Group and was a co-founder of that organization's Critical Incident Response Program, which provides guidance to airline personnel involved in traumatic events such as accidents.

A trained accident investigator, Mr. Sumwalt participated in several NTSB investigations including the crash of USAir flight 427 in 1994 near Aliquippa PA, and USAir flight 861 near Birmingham Alabama in 1998. He also participated in the Transportation Safety Board of Canada's investigation of the accident involving Swissair flight 111 off the coast of Nova Scotia in 1998.

From 1991 to 1999, Mr. Sumwalt conducted aviation safety research as a consultant to NASA's Aviation Safety Reporting System, studying various issues including flight crew performance and air carrier de-icing and anti-icing problems.

Mr. Sumwalt has co-authored a book on aircraft accidents and he has written extensively on aviation safety matters, having published over 85 articles and papers in aviation trade publications and he has broad experience in writing aircraft operations manuals and airline and corporate aviation policy and procedure guidelines. He has been a regular contributor to Professional Pilot magazine.

In 2003, Mr. Sumwalt joined the faculty of the University of Southern California's Aviation Safety and Security Program, where he was the primary human factors instructor.

In recognition of his contributions to the aviation industry, Mr. Sumwalt received the Flight Safety Foundation's Laura Taber Barbour Award in 2003 and ALPA's Air Safety Award in 2004.

Since joining the Board, the Vice Chairman has served as the Member on-scene for the November 30, 2007 collision between an Amtrak passenger train and a standing Norfolk Southern freight train in Chicago, Illinois. He was also on-scene Member for the November 1, 2007 liquid propane pipeline rupture and explosion in Carmichael, Mississippi. Additionally, he launched with the Go Team to Sanford, Florida to the scene of an accident that occurred on July 10, 2007, in which a twin-engine Cessna 310R airplane impacted homes in a residential area. He was also the on-scene Member for the October 20, 2006 derailment of a Norfolk Southern train in New Brighton, Pennsylvania, Vice Chairman Sumwalt also accompanied the NTSB Go-Team to Lexington, Kentucky for the on-site investigation of the August 27, 2006 crash of Comair flight 5191.

Mr. Sumwalt is a graduate of the University of South Carolina.

“Fatigue: Where Biology Meets Technology"

DAVID F. DINGES, PH.D.

Professor and Chief
University of Pennsylvania School of Medicine

June 17, 2008: Keynote Session

Abstract
Modern humans have created technologies that challenge the limitations placed on all species by time and space. Commercial aviation technologies are some of the more remarkable achievements that have accelerated human contact and figuratively shrunk the planet. But the brain structures that made the technologies capable of routinely transporting tens of millions of people through Earth’s atmosphere are not the only brain structures relevant to the safe operations of modern aircraft. In all human brains are the ancient biological imperatives of sleep and circadian timing that have ubiquitous and profound influences over human alertness, cognitive performance and related goal-directed behaviors. These endogenous neurobiological drives in humans contribute to fatigue and its risks to performance in personnel involved in commercial aviation -- especially in transmeridian and long-haul aviation.

Although there have been considerable efforts to use scheduling and human redundancy (e.g., crew relief/rotation) to manage fatigue risks in commercial aviation, there remains untapped potential for fatigue management based on new scientific data on fatigue causes and mitigation, and on novel technologies to management fatigue risks. The integration and validation of such information and technologies could form the basis for a dynamic fatigue risk management system that can be adapted to changing operational needs and idiosyncratic factors that contribute to risk. Fatigue occurs in the brain (e.g., when sleep pressure is elevated) and is manifest in behavior (e.g., reduced vigilance) that can increase risk of an adverse event. A system approach based on integrated components that are scientifically valid and operationally practical might emphasize prevention, prediction, detection and intervention to dynamically manage fatigue and risk. Prevention refers to behaviors and technologies that reduce risks in advance.

Related to prevention is prediction of risks (e.g., via operational databases to identify higher risk scenarios; technologies that can model human vulnerability to fatigue or to risk, and potentially indicate where to mitigate the causal link between fatigue and risk). Detection of fatigue (or risk) refers to behaviors and technologies in the work environment that can reliably indicate the presence of fatigue (or risk). Finally, intervention refers to countermeasures used operationally to mitigate fatigue, or performance deficits, or risks. For all four of the components of a putative fatigue risk management system, there are likely to be three levels of discovery and development:

(1) what may be useful immediately; (2) what is knowable in the near-term; (3) and what may be achievable in the far-term. The empirical development and validation of system components requires both sound evidence of positive benefits that exceed current practices, and evidence that there are no unwanted consequences to safety, costs or personnel. It should include the best available information on the biology of fatigue and its risk mitigation with novel technologies. Identifying these components will require standards of evidence, creativity, and a willingness to be decisive. The flexibility that may be achievable in such an evidenced-based system has the potential to accommodate more frequent changes in commercial aviation while managing risk.

Major points

- The integration and validation of new scientific information on human fatigue and its mitigation, and on technologies mitigating fatigue could form the basis for a dynamic fatigue risk management system that can be adapted to changing operational needs and idiosyncratic factors that contribute to risk.

- A system approach based on integrated components that are scientifically valid and operationally practical might emphasize prevention, prediction, detection and intervention to dynamically manage fatigue and risk.

- The empirical development and validation of system components requires both sound evidence of positive benefits that exceed current practices, and evidence that there are no unwanted consequences to safety, costs or personnel. It should include the best available information on the biology of fatigue and its risk mitigation with novel technologies.

Biography

David F. Dinges is a Professor and Chief of the Division of Sleep and Chronobiology, and Director of the Unit for Experimental Psychiatry in the Department of Psychiatry, and Associate Director of the Center for Sleep and Respiratory Neurobiology at the University of Pennsylvania School of Medicine. He is also Adjunct Professor in the School of Biomedical Engineering, Science and Health Systems, Drexel University.

During the past three decades his research has been supported by NIH, NASA, NSBRI, DOD (AFOSR, ONR), DOT (FAA, FMCSA, NHTSA), DHS (TSA), foundations and some private companies. He has advised both federal and private entities in the U.S. and abroad on scientific evidence for regulatory policies regarding duty hours and fatigue management. As a behavioral neuroscientist, his research focuses on physiological, neurobehavioral, and cognitive effects of fatigue from work schedules, sleep loss, disturbances of circadian biology, and stress, and the implications of these unmitigated effects on health and safety. He has conducted extensive scientific work on development and validation of behavioral, technological, and biological interventions for these effects. Examples of his contributions to behavioral understanding human sleep need and sleep deprivation include his work on the cumulative effects of chronic sleep restriction, on differential vulnerability to the cognitive effects of sleep loss, on the benefits of prophylactic/power napping, on the impact of split-sleep schedules, and on circadian contributions to restricted sleep schedules. Examples of his contributions to technological prediction and detection of sleepiness and fatigue include his work with others to advance and improve mathematical models of performance risk from fatigue, development and validation of the psychomotor vigilance test (PVT), and laboratory, simulator and field studies of the validity (or lack of validity) of various fatigue monitoring technologies. Examples of his contributions to biological mitigation of fatigue include his studies of caffeine and wake-promoting medications.

In addition to his extensive laboratory research—which includes some of the largest laboratory controlled studies ever conducted on sleep loss effects in healthy humans—he has conducted research in commercial cockpit simulators and aircraft, in truck cab simulators and over the road, and in space analog environments under the ocean and in space flight. Dr. Dinges currently leads the Neurobehavioral and Psychosocial Factors Team for the NASA funded National Space Biomedical Research Institute (NSBRI). He is a member of the NIH NINR Council. He has been President of the U.S. Sleep Research Society and of the World Federation of Sleep Research and Sleep Medicine Societies, and served on the Board of Directors of the American Academy of Sleep Medicine and the National Sleep Foundation. He is currently Editor-in-Chief of SLEEP, the leading scientific journal on sleep research and sleep medicine in the world. He has received numerous awards, including the 2004 Decade of Behavior Research Award from the American Psychological Association, and the 2007 NASA Distinguished Public Service Medal.

"Fatigue: Where Biology Meets Technology"

DAVID F. DINGES, PH.D.

Professor and Chief, Division of Sleep & Chronobiology
University of Pennsylvania School of Medicine

June 17, 2008: Keynote Session

Text of Presentation

DR. DAVID DINGES: Let me begin by thanking Mr. Sumwalt and the organizers, Drs. Steven Hursh and Melissa Mallis, for asking me to speak. I appreciate the significance of this meeting and the very important work you are going to do for the next few days and throughout this Fatigue Symposium, by discussing issues that have been at times intractable and mired in adversarial relationships. But I would urge you to do what the symposium organizers asked and rise above the disagreements to focus on novel solutions.

The previous presenter spoke of Charles Lindbergh's historic solo nonstop crossing of the Atlantic in May of 1927. I would add that from the perspective of fatigue, Lindbergh's flight was paradoxical. He reported extensively in his flight logs of that auspicious journey that he struggled for many hours to remain awake as he flew, that he had difficulty attending to the compass and holding the plane on course due to loss of alertness, and his fatigue worsened to the point that he became disoriented and believed he could land on the ocean (as published in the *Spirit of St. Louis,* Charles A. Lindbergh, NY: Scribners, 1953). Yet reports of the flight — including those of such renowned scientific journals as *Science* and *Scientific American*, made no mention of Lindbergh's incredible struggles with sleepiness and fatigue during the historic crossing. The extent of Lindbergh's fatigue during the flight and the risks it posed to his survival only became clear when he published the *Spirit of St. Louis* more than 25 years after the event. The world remembers him for his heroic act, but his fatigue nearly brought a premature end to his achievement. The risks posed by fatigue continue to this day to be important concerns in commercial aviation.

The brains of all pilots and all professionals involved in ensuring safe commercial aviation contain the genetically programmed neurobiology that put all humans to sleep each day and that time our 24-hour cycles of sleep and waking. There is extensive scientific evidence on the brain mechanisms that control our vigilance states across a day, and on the nature of performance changes and unreliability when we attempt to override our need for sleep and its biological timing. The high-tech, high-mobility, high-consumption lifestyles we create put us in conflict with our biological heritage.

Despite the challenges of fatigue-related performance risks from jet lag, night work and sleep loss, global commercial aviation safely transports hundreds of millions of people each year, thanks to a long line of safety-related improvements in aviation and operational technologies (see Figure 1). However, as the demand for more flexibility in transportation industries grows, federal agencies are faced with fundamental questions. The first is whether there is some way to reduce the need for sleep? The scientific answer to this question is a firm "no". Finding ways to reduce sleep need has remained an intractable scientific problem, and no chemical or biotechnological substitute for sleep has been found.

This leads to a second question. If there is no way to eliminate sleep need, is there some way to anticipate and prevent performance risks due to fatigue? I would suggest that there is reason for optimism relative to this question. Unobtrusive, objective ways to detect fatigue in human operators have begun to be the focus of considerable research on technologies that validly and reliably predict, detect and/or prevent performance risks due to fatigue. The idea of using technology to do this in commercial aviation may cause concern or incredulity in those over 50 years of age, but I believe the concept is obvious and even attractive to many under that age. Whether it is or not, the development and application of these technologies is inevitable. The generation coming into power over the next 10-20 years grew up immersed in technology. They accept human-machine interaction in nearly all aspects of life. In their minds, the computer should be sentient-like, in that it should read human intentions, anticipate human actions, and do other things that enhance human capability. Those expectations will bring the emergence of ever-more sophisticated human-machine interfaces, which will undoubtedly change the nature of human work in all transportation modes, including commercial aviation. Fatigue is an area where such human-machine interfaces can have a profound effect by preventing, predicting, detecting and mitigating fatigue-related risks (Figure 1).

The following three concepts provide a framework for thinking about how technologies for fatigue management might be integrated into commercial aviation.

1. The integration and validation of new scientific information on human fatigue and its mitigation, and on technologies that predict and detect fatigue could form the basis for a dynamic fatigue risk management system that can be adapted to changing operational needs and idiographic factors that contribute to fatigue risk.

2. A system approach based on integrated components that are scientifically valid and operationally practical might emphasize prevention, prediction, detection and intervention to dynamically manage fatigue and risk (Figure 1).

3. The empirical development and validation of system components requires both evidence of positive benefits that exceed current practices, and evidence that there are no unwanted consequences to safety, costs or personnel. It should include the best available information on the biology of fatigue and its risk mitigation with novel technologies.

Perhaps the most compelling argument for the development of fatigue management technologies in commercial aviation is the fact that no matter what scheduling limits are placed on commercial aviation, the circadian and sleep-dependent nature of fatigue ensures it will occur in some operations—such as night flights and transmeridian flight schedules. However, this fact opens up the possibility of predicting when fatigue will occur, using mathematical models validated on sleep and circadian dynamics relative to performance (Mallis et al., 2004; Dinges, 2004). While advances in aviation technology (e.g., avionics, jet engines) and operational technology (e.g., tracking of aircraft and weather) have given air travel a good safety record, people (flight crews, maintenance personnel, air traffic controllers) remain at the heart of a safe air transit system. In this sense, the safety of commercial aviation remains human-centered. Fatigue management is designed to prevent, detect, and reduce fatigue as a risk factor in a human-centered, safety–sensitive industry. However, fatigue management technology should be more than quality of seats and bunks for crew rest in airplanes (Figure 1), which along with regulated duty-hour limits have been low-tech approaches to managing fatigue in flight crews.

Criteria for identifying human-centered technologies that predict and/or detect fatigue in flight operations have been detailed, but first and foremost is the requirement that they meet systematic scientific validity (Dinges & Mallis, 2001). This should include double-blind testing of the accuracy of a given technology relative to a gold-standard performance-based measure of fatigue, and assurance that it is accurate when

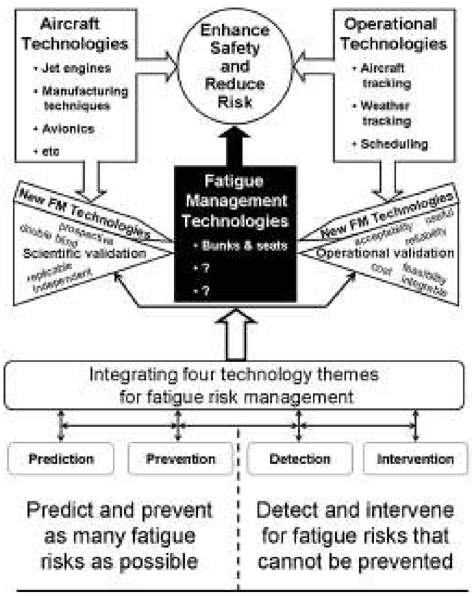


Figure 1. *Key elements of a Dynamic Fatigue Risk Management System. Fatigue management (FM) technologies have lagged behind aircraft technologies and operational technologies in efforts to enhance safety and reduce risk in commercial aviation. It is now possible to develop the former to aid in prevention of fatigue, prediction of when fatigue is most likely, detection of fatigue during operations, and interventions to reduce fatigue or its risks when it occurs.*

used in every person. This necessitates swift elimination of invalid approaches. One cost-effective strategy to getting to the most valid technologies is to leverage what has already been discovered by research supported through other federal agencies. The biology of fatigue is common to all occupations, and some discoveries in other transportation modalities can be applied to aviation.

A scientifically valid fatigue management technology should then undergo operational validity, which refers to the extent to which a technology is feasible, reliable, and acceptable by operators in an operational environment. For example, it is obvious that a scientifically valid fatigue-detection technology must be deployable in an aircraft cockpit if it is intended to be used by pilots. Pilots must also perceive the feedback from the technology to be useful to them in managing their fatigue. The technology must work reliably, and have both high sensitivity (i.e., detect fatigue) and high specificity (i.e., detect primarily fatigue). Finally, to be used, it must be as unobtrusive as possible.

Fatigue management technologies that have potential for use in commercial aviation include the following: (1) technologies that predict the occurrence and severity of fatigue and as such can be used to create schedules that are more fatigue-management friendly; (2) technologies that help deliver education on fatigue management and optimal countermeasure use to individuals; (3) technologies in the workplace (on the operator or embedded in the work system) that detect when an individual is showing signs of fatigue; and (4) intervention technologies that help people be more alert and free of fatigue. In the following I discuss two of the more promising areas for fatigue management technologies—those that predict fatigue and those that detect fatigue.

Fatigue prediction technologies. Human performance (e.g., alertness, attention, working memory, problem solving, reaction time, situational awareness, risk taking, etc.) is dynamically controlled by the interaction of waking biological processes sensitive to time awake, sleep quantity, and circadian phase

(Durmer & Dinges, 2005; Van Dongen & Dinges, 2005). Although the effects of time awake and sleep duration can be modeled as near-linear processes within and between days, the circadian interaction with these processes makes the prediction of performance nonlinear. For example, when remaining awake for 40 hours, it is a counterintuitive fact that fatigue and performance deficits are worse at 24 hours than at 40 hours awake. The circadian system also influences the duration of recovery sleep that is possible to achieve, and the circadian system is slow to adapt to sleep in new time zones (see Figure 2). It is this nonlinearity that makes inadequate and imprecise many work-hour limits based solely on a linear model of fatigue (i.e., the longer one works the more fatigued one will become). This nonlinearity in the brain's performance capability over time is the reason that developing mathematical models that predict performance is increasingly regarded as essential.

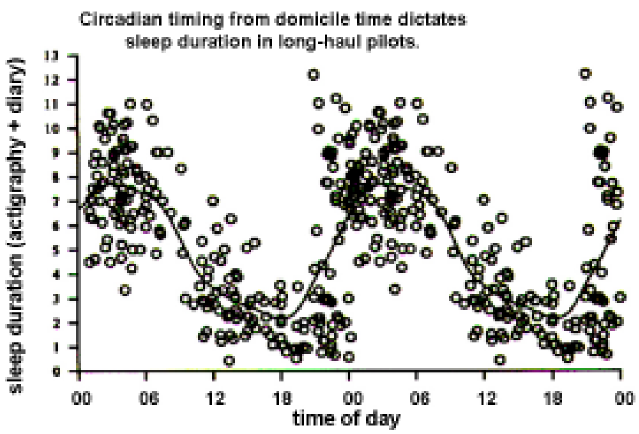


Figure 2. *Sleep durations in N = 21 long-haul commercial flight crew members flying four the middle 4 consecutive transmeridian Pacific flight legs (out of 8 legs) from the USA. Each point is a single sleep episode on layover. All four layover periods were between 21 and 29 hours. Sleep duration is double-plotted as a function of clock time in each crewmember's home. The data show that layover sleep duration was longer (>6 hours) when sleep in the layover city occurred between midnight and 9 a.m. at the crewmember's permanent home. In contrast, shorter sleep durations (<6 hours) occurred in the layover city when sleep was taken between 10 a.m. and 10 p.m. at the crewmember's permanent home. These data suggest that long-haul crews do not make a substantial circadian adjustment to the time zones they fly into, but instead experience sleep durations that more closely reflect circadian entrainment in their permanent homes. This is one major reason why fatigue management is important in long-haul commercial aviation. Data from a study by Rosekind et al. (1994).*

Mathematical models of fatigue prediction are the fatigue management technologies that have received the most attention in the past 15 years thanks to interest and support from DOD (Jewett et al., 1999), NASA and DOT (Neri, 2004). These models will again be the focus of an International Conference on Fatigue Management in Transportation Operations on March 24-26, 2009, in Boston (http://depts.washington.edu/uwconf/fmto/).

Based on the dynamic interaction of human sleep homeostatic drive and circadian rhythms, some of these mathematical models have advanced to the critical point of integrating individual differences into the modeling predictions for a more accurate estimate of the timing and magnitude of fatigue effects on individuals (Van Dongen et al., 2007), which should facilitate more precise use of countermeasures (e.g., naps, recovery sleep, caffeine intake).

Fatigue Detection Technologies. There are three scientifically-based reasons why objective fatigue detection technologies are needed in safety-sensitive operations such as commercial aviation. (1) Humans are often unable to accurately estimate how variable or uneven their alertness and performance have become due to inadequate sleep or working at night. When fatigued they tend to estimate their alertness based by their best responses and ignore their worse responses. (2) Performance deficits from fatigue accumulate over days to high levels when recovery sleep is chronically inadequate (Van Dongen et al., 2003; Belenky et al., 2003). Awareness of these cumulative deficits appears to be less accurate as performance declines (Van Dongen et al., 2003). (3) While everyone eventually develops performance deficits from fatigue, some people do so very rapidly while others take much longer, and these differences appear to be stable characteristics of people (Van Dongen et al., 2004) and therefore they may reflect biological differences among them (e.g., Viola et al., 2007). There are currently no reliable biomarkers for one's performance vulnerability to fatigue, making detection of fatigue a primary goal.

Fatigue detection technologies have been of interest to DOT for some time. A decade ago, the National Highway Traffic Safety Administration (NHTSA) and Federal Motor Carrier Safety Administration (FMCSA) had my laboratory systematically evaluate the validity of the "most promising" fatigue detection technologies, which included brain wave (EEG) measures, eye blink devices, a measure of slow eyelid closures (called PERCLOS), and a head position sensor. In a number of highly controlled, double-blind experiments, we evaluated the extent to which each technology detected the alertness of subjects over a 40-hour period, as measured by lapses of attention on the Psychomotor Vigilance Test (PVT)—a well validated and highly sensitive measure of the effects of fatigue on neurobehavioral alertness (Dorrian et al., 2005). Only PERCLOS reliably and accurately tracked PVT lapses of attention in all subjects, outperforming not only all the other technologies, but also subjects' own ratings of their fatigue and alertness (Dinges et al., 1998; 2002).

Subsequently, a group of technologies that included an infrared-based PERCLOS monitor, were evaluated in an over-the-road study of commercial drivers, to determine whether feedback from fatigue detection technologies would help truck drivers maintain their alertness in actual working conditions (Dinges et al., 2005a). The details of this study are extensive and need not be reviewed here, but suffice it to say that the infrared PERCLOS monitor did not perform well due to environmental factors (ambient light) and operator behavior (head turning to view mirrors). However, we are now developing a technique for NASA that involves optical computer recognition (machine vision) of the human face to identify expressions of stress and fatigue (Dinges et al., 2005b; Dinges et al., 2007). This system has a number of advantages. It requires no sensor or conspicuous technology, it can track the face as it moves in 3-dimensional space, and it can process information online in real time.

In the over-the-road study of the effects of feedback from fatigue-detection technologies on commercial drivers, we expected that when the technologies signaled a driver was drowsy it would result in the driver taking countermeasures, including stopping to rest or nap. However this rarely happened. On the other hand, we did find that the drivers felt the fatigue detection devices (and the PVT test they performed in the middle and at the end of each trip) informed them of their fatigue levels and prompted them to acquire more sleep on their days off duty. Both the debrief interviews Dr. Jerry Krueger did with the drivers, as well as the actiwatch data we acquired on the drivers confirmed that they increased their sleep by an average of 45 minutes on days off duty (Dinges et al., 2005a). This is a remarkable and unexpected outcome, and it suggests another purpose for fatigue detection technologies in the workplace—namely to urge operators to sleep more during off-duty periods. Recent research we have underway for NIH and NASA on recovery sleep following a period of sleep restriction reveals that getting extra sleep during off-duty periods and days off work is one of the most important fatigue countermeasures—but it will only be effective if sufficient time is permitted for sleep off duty. If we could use fatigue management technology to teach people to use their downtime to sleep more we could reduce the risk of fatigue substantially, for we know that in the US population as a whole, work duration is the primary activity that is reciprocally related to sleep duration (Basner et al., 2007).

I will end my presentation by pointing out that we do not know which fatigue management technologies will be most useful and acceptable in commercial aviation. It is fairly certain that in order for valid technologies to be used, they must not violate the privacy rights of individuals. It is for this reason that I believe the technologies should first be developed as personal aids. These technologies should be used responsibly—they are not a substitute for reasonable working conditions. It is now possible to leverage what is being done in other Federal agencies to get a leg up on which fatigue management technologies might work best in commercial aviation. I believe that information from fatigue management technologies can help people involved in commercial aviation be less fatigued and more alert, and that this is an achievable goal worthy of our best efforts.

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IV. PANEL PRESENTATIONS

A. JOINT SESSION

OPERATIONAL DRIVERS OF FATIGUE: NATIONAL TRANSPORTATION SAFETY BOARD FINDINGS

June 17, 2008
10:15 – 11:30

Panel Overview

The *"Operational Drivers of Fatigue: NTSB Findings"* session was chaired by Dr. Vern Ellingstad of the National Transportation Safety Board (NTSB) and included three presentations by human factors experts, all from the NTSB. Dr. Malcom Brenner talked about different operational factors in both non-fatal and fatal airline accidents, Dr. William Bramble discussed causes of air controller fatigue and Dr. Jana Price closed by presenting the history and evolution of NTSB fatigue related recommendations. The session was intended to provide the audience with an understanding of operational factors commonly identified during NTSB accident investigations as contributing to fatigue related events during both flight and air traffic control operations. Specific fatigue related recommendations made over the years by the NTSB were also reviewed.

Fatigue has been, and continues to be, a contributing factor in several aviation accidents. Currently, the NTSB has seven aviation fatigue specific recommendations. Since 1993, the Safety Board has determined that fatigue contributed to seven air carrier accidents within the United States, resulting in 250 fatalities and 52 serious injuries. Recent events continually highlight the operational relevance of fatigue among flight crew; it is not uncommon that crew fall asleep while flying. NTSB investigations have found that flight crew on long duty days (a shift of more than 13 hours) exhibit a disproportionate amount of accidents when compared to those on short duty days (a shift of less than 13 hours). The longer the crews are awake the more errors they tend to commit, especially cognitive errors such as decision-making.

During NTSB investigations, the causes of fatigue are commonly divided into operational and personal factors. Operational factors contributing to fatigue induced by the workplace include short rest periods between shifts, which can be as short as eight hours under current regulations, rapid rotation of shift start times, which can disrupt circadian rhythms, working early morning and graveyard shifts, and duration of commute, among others. Equally important are personal drivers of fatigue, which are largely habits and behaviors controlled by the individual, such as ensuring proper duration of rest. However, personal drivers of fatigue also depend on many factors such as the presence of sleep disorders, circadian variability, additional employment, and use of alcohol and stimulants.

The NTSB's Most Wanted Safety Improvements currently includes fatigue risk management. As stressed during the panel, operational safeguards, or defenses that can prevent or mitigate flight crew errors (e.g., Fatigue Risk Management System) are critically important and should include both an educational component to increase awareness of fatigue-related issues and multiple fatigue management strategies. It was also recommended that Fatigue Risk Management Systems (FRMS) provide guidance based on empirical evidence, including information about the content and implementation of these systems. Future milestones can include determining how much fatigue risk is acceptable in terms of safety, and determining which strategies for managing fatigue will prove most effective within the field of aviation. FRMSs, once implemented, will require regular program evaluation to determine effectiveness in mitigating fatigue and reducing accident rates by improving performance.

"Operational Factors Contributing to Fatigue During Flight Operations"

MALCOLM BRENNER, PH.D.

National Transportation Safety Board

June 17, 2008: Joint Session

Abstract
Since 1993, the NTSB has determined that fatigue contributed to eight airline accidents in the United States involving 250 fatalities. Investigation provided evidence of fatigue-related factors in the accidents that included hours-of-service standards, education, attendance policies, screening and treatment of sleep disorders, rest environments, commuting policies, nutrition, and scheduling policies and practices.

Main Points

- Fatal airline accidents have occurred in which fatigue was a contributing factor.
- Non-regulatory issues were indicated in previous accidents investigations, including issues of pilot education, attendance policies, and treatment of sleep disorders.

A copy of Dr. Malcolm Brenner's biographical information and presentation slides are provided in Appendix B.

"Factors Contributing to Fatigue in Air Traffic Control Settings"

WILLIAM J. BRAMBLE, JR., PH.D.

National Transportation Safety Board

June 17, 2008: Joint Session

Abstract
In recent years, the Safety Board has investigated numerous runway safety incidents where deficiencies in air traffic controller performance have been identified. Controller fatigue is often documented in the investigation of such incidents, and fatigue is occasionally cited as a factor that contributed to such occurrences. In this presentation, the author will discuss operational and personal factors that appear to have contributed to controller fatigue in some runway safety incidents, regardless of whether such factors have been officially determined to be causal to such incidents. Operational drivers of fatigue include the restriction of sleep that results from short rest periods between shifts, and the disruption of normal sleeping patterns that result from the rapid rotation of shift start times. Personal drivers of fatigue include sub-optimal utilization of off-duty rest periods. Other factors that investigative findings indicate may contribute to controller fatigue or exacerbate its effects on system performance include the presence of untreated sleep disorders, increased workload resulting from the combination of active control positions, decreased vigilance resulting from continuous monitoring assignments, inconsistent use of memory aids, and the use of sub-optimal procedures for exchanging information during position relief. Investigative interviews have also revealed a lack of awareness among some air traffic control personnel about the predictable effects of fatigue on human performance and the availability of strategies to minimize fatigue when assigned to shift work.

Main Points

- The Safety board has documented controller fatigue in investigations of runway safety incidents where controller performance deficiencies have been identified.
- Drivers of fatigue include shift-scheduling practices and sub-optimal utilization of rest periods, but a variety of other factors also contribute to fatigue and allow its performance-degrading effects to influence system performance.
- There is a lack of awareness among some air traffic control personnel about the effects of fatigue on human performance and about strategies that can be used to minimize fatigue when assigned to shift work.

A copy of Dr. William J. Bramble's biographical information and presentation slides are provided in Appendix B.

"The Evolution of NTSB Fatigue Related Recommendations"

JANA M. PRICE, PH.D.

National Transportation Safety Board

June 17, 2008: Joint Session

Abstract
The National Transportation Safety Board has a long history of advocating changes that would reduce the likelihood of fatigue-induced aviation accidents. The NTSB has made well over 100 recommendations concerning operator fatigue since the 1970s, including more than 30 recommendations in the aviation environment. The majority of these recommendations have been directed towards air carrier flight crews; however, the NTSB has also made recommendations targeting general aviation pilots, aircraft mechanics, and air traffic controllers.

Many fatigue-related safety recommendations in aviation, and particularly those on the NTSB List of Most Wanted Transportation Safety Improvements, concern hours of service regulations, which provide a necessary set of basic scheduling limits for transportation workers. For more than a decade, the NTSB has urged the Federal Aviation Administration to modify the aviation hours of service regulations so they are scientifically based and take into consideration such factors as circadian rhythms and human sleep requirements.

In addition to its focus on hours of service changes, the NTSB has also recognized that other risk factors can contribute to fatigue such as sleep disorders, workload, and company attendance policies that discourage employees from calling in fatigued. The NTSB has made a variety of recommendations over the years to address these risk factors by calling for training and education, health screening, and the institution of organizational policies that will address human fatigue.

Main Points

- The National Transportation Safety Board has a long history of pushing for changes that would reduce the likelihood of fatigue-induced accidents.
- Many NTSB recommendations concern hours of service regulations, which provide a necessary set of not-to-exceed limits as the foundation for fatigue management efforts.
- As more becomes known about human fatigue, and the risk factors associated with fatigue impairment, NTSB recommendations have evolved to advocate additional countermeasures that can reduce the likelihood of fatigue-related accidents.

A copy of Dr. Jana Price's biographical information and presentation slides are provided in Appendix B.

B. JOINT SESSION

TOP-DOWN SAFETY FOCUS: FATIGUE RISK MANAGEMENT SYSTEMS (FRMS)

June 17, 2008
12:45 – 14:00

Panel Overview

The "*Top-Down Safety Focus: Fatigue Risk Management Systems (FRMS)"* session was chaired by Captain Paul McCarthy, an IFALPA representative to ICAO. The panel included presentations by aviation experts, two from US-based carriers and one from the aircraft manufacturing industry. Dr. New, of Delta Air Lines, reviewed the role of Safety Management Systems (SMS) in aviation environments and set the stage for the other two panel presentations that focused on Fatigue Risk Management Systems (FRMS). Dr. Graeber, Boeing Commercial Airplanes reviewed the current state of FRMS and also discussed suggestions for implementing FRMS within SMS for future alertness management initiatives. Captain Gunther provided an operational example of a FRMS by reviewing some components of Continental Airlines' approach to fatigue and alertness management. The panel was intended to provide the audience with an understanding of the components of a successful SMS, explain the role of a FRMS within a SMS and provide an example demonstrating potential operational benefits. Specific recommendations of how a FRMS could be implemented in a SMS were also addressed during the panel presentations.

Over the past few years, Safety Management Systems have become an accepted safety initiative in aviation environments throughout the world. One commonly accepted definition of a 'Safety Management System' is that provided in the ICAO Safety Management Manual (2006). Given the diversity of aviation operations, the specific processes to identify acceptable and unacceptable fatigue-related risks can be organizations specific. Independent of the uniqueness of operational needs, it is important that the specific processes be operationally relevant, standardized and applicable to the corporation as a whole.

Clear documentation of the components of the SMS is important to allow for successful implementation within an organization. As reviewed during the panel, some other important components include a safety policy that demonstrates a firm commitment to implement a safety management system, a non-punitive hazard reporting system for flight crew, safety assurance, and quality management techniques to identify hazards, analyze risk, and put appropriate actions into play.

A Safety Management System provides a valid context for implementing a Fatigue Risk Management System. A FRMS could be one of the important tools in the SMS "toolbox." However, as discussed during the panel, the challenge remains that FRMS approaches tend to have a foundation in science yet current flight time limitations have remained without update and do not assess fatigue-related safety risks. Despite these challenges, organizations can begin the development and implementation of a

FRMS as part of an overall Safety Management System or as a stand-alone approach for the mitigation of fatigue.

Airline carriers are currently taking some of the first steps of incorporating a FRMS into their overall SMS approach. Continental Airlines' approach for overseeing operational safety and ensuring mitigation initiatives are taken in a timely manner was presented as part of the panel to demonstrate the importance of a multi-level, broad organization approach. This helped to emphasize the panel's message of the importance of top management and the necessity for a valid scientific foundation in implementing successful FRMS approaches within the field of aviation.

C. PARALLEL SESSION

OPERATIONAL EVIDENCE OF FATIGUE: FLIGHT OPERATIONS

June 17, 2008
14:15 – 15:45

Panel Overview

The *"Operational Evidence of Fatigue: Flight Operations"* session was chaired by Dr. Mark R. Rosekind of Alertness Solutions and included three presentations in which data from studies of flight crew in operational and flight simulator environments were reviewed. Dr. John A. Caldwell of Archinoetics, LLC began the panel by discussing the primary causes and symptoms of pilot fatigue with a specific focus on studies that have evaluated the effects of fatigue on piloting capabilities. Dr. Leigh Signal, of Massey University, continued the discussion of data collected during actual operations by reporting on the quantity and quality of bunk sleep during commercial ultra-long range (ULR) flights. Dr. Matthew Thomas, University of South Australia, closed the panel with a presentation on effects of fatigue on operationally relevant performance measures and identified gaps in the current knowledge of fatigue in aviation operations. The panel was intended to give an overview of the effects of fatigue on various performance measures in order to give the audience a broader understanding of how fatigue-induced decrements translate into operational performance challenges. Implications from empirical research were presented to help establish a science-based perspective on fatigue among flight crew.

One of the primary contributors of fatigue in flight crew is directly related to sleep loss associated with a variety of scheduling factors. Night flights have a high potential for fatigue because flight crew are operating at the circadian low point. Crossing multiple time zones results in jet lag and disruption in both sleep quantity and quality. Other operational factors including time pressure, increased workload, multiple flight legs, extended work periods, consecutive duty periods without sufficient recovery time, and multiple take-offs and landings also contribute to further sleep loss and degradations in performance levels.

In-flight scheduling factors affect the amount of sleep flight crew obtain during flight. Although increasing in-flight rest breaks seems likely to contribute to increased total in-flight sleep durations, data have shown that this is not always the case. This was demonstrated in the ULR data presented during the panel demonstrating that flight crew obtained approximately 3 hours sleep during a ULR sector, yet they had over twice this time available for sleep. Short rest breaks can also introduce challenges for flight crew when the opportunities are underutilized in obtaining sleep. Thus, it is important to understand how fight crew use in-flight rest periods and the quantity and quality of their sleep when scheduling the arrangement of bunk sleep periods.

While sleep quantity and quality during ULR flights have been objectively documented, it remains that little is known about the effects of such operations on operational performance. There is a need to understand the impact of such operations on performance and safety levels. As stressed by the panel presenters, multiple measures are required to accurately determine the cognitive status of flight crew and document the extent of performance decrements and its operational relevance in aviation environments.

"Effects of Fatigue on Operational Performance"

JOHN A. CALDWELL, PH.D.

Archinoetics, LLC

June 17, 2008: Flight Operations Parallel Session

Abstract
This presentation will provide information on four topics relevant to understanding the effects of fatigue on operational performance. First, a short overview of the scheduling factors primarily responsible for fatigue-related problems in long-haul, short-haul, and regional operations will be presented. Second, the general symptoms of fatigue, with a focus on in-flight sleep lapses, will be reviewed. Data from pilot surveys and in-flight observations will highlight the extent of the problem and specific situations in which the risk of involuntary on-the-job sleep is greatest. Third, the effects of fatigue on basic piloting capabilities will be outlined, and illustrative examples from a recent flight-simulation study will be shown. The data will show the extent to which one night of sleep loss severely degrades complex cognitive performance, subjective mood states, and fundamental piloting skill. Furthermore, a breakout of simulator flight performance data will underscore the fact that group averages mask the full extent of individual fatigue-related decrements. Fourth and last, the impact of fatigue on operational safety will be discussed. Several mishaps will be cited along with recent fatigue reports from NASA's Aviation Safety Reporting System and data from one airline's flight safety awareness program (FSAP).

Main Points

- Scheduling factors are at the heart of fatigue-related problems in flight operations.
- Fatigue degrades a wide array of performance capabilities and ultimately leads to involuntary sleep episodes in flight.
- Controlled simulation studies show that one night of sleep loss degrades cognition, mood, and fundamental piloting skill.
- NASA's Aviation Safety Reporting System and airline FSAP reports routinely document the negative impact of fatigue on operational safety.

A copy of Dr. John A. Caldwell's biographical information and presentation slides are provided in Appendix B.

"Sleep and Psychomotor Performance during Commercial Ultra-Long-Range Flights"

LEIGH SIGNAL, PH.D.

Massey University, New Zealand

June 17, 2008: Flight Operations Parallel Session

Abstract

The amount and quality of sleep that flight crew are able to obtain on board the aircraft is considered to be a critical issue for designing safe ultra-long range operations. The present study was conducted as part of the Ultra-Long-Range (ULR) validation process undertaken by the Singapore ULR task force (CAAS, SIA, ALPA-S). The primary aim of this study was to accurately determine the quantity and quality of sleep flight crew were able to obtain during in-flight rest opportunities.

Data were collected on 8 ULR return flights between Singapore and Los Angeles from 41 flight crew (median age 43.66 years). Sleep was recorded during all in-flight sleep episodes using the Embla A10 ambulatory recorder (Medcare™). Performance was measured 3 or 4 times in flight using the Psychomotor Vigilance Task (PVT).

On the SIN-LAX sector (average flight time 15.45 hrs), flight crew obtained an average of 2.8 hours sleep, and on the LAX-SIN sector (average flight time 17.07 hrs) 3.4 hours of sleep. The sleep obtained in flight was predominantly Non-REM stages 1 and 2 and sleep efficiency was similar on both the SIN-LAX and LAX-SIN sectors (72% and 74% respectively). The division of scheduled rest opportunities, utilization of these, and the total amount of sleep obtained was dependent on the position of the flight crew member (Command or Relief crew). Although all flight crew involved in the study slept at least once on each sector, there was a great deal of variability in the amount of sleep obtained between individuals (a minimum of 47.5 minutes and a maximum of 5.5 hours). There was a trend for psychomotor performance to slow progressively across flights. Although there were differences between the average amount of sleep that Command and Relief crew obtained in flight, there were no statistically significant differences in their PVT performance. This may reflect limitations of the PVT in this setting.

These findings demonstrate that the arrangement of in-flight rest has direct implications for both the amount of time flight crew will spend trying to sleep and the actual amount of sleep obtained.

Main Points

- Flight crew obtained approximately 3 hours sleep during a ULR sector, yet had over twice this time available for sleep.
- The arrangement of in-flight rest has direct implications for both the amount of time flight crew will spend trying to sleep and the actual amount of sleep obtained.

A copy of Dr. Leigh Signal's biographical information and presentation slides are provided in Appendix B.

"Effects of Fatigue on Threat and Error Management Behavior of Long-Haul Flight Crew"

MATTHEW THOMAS, PH.D.

University of South Australia

June 17, 2008: Flight Operations Parallel Session

Abstract

Fatigue is associated with many forms of performance degradation, and laboratory studies have demonstrated impairment on performance measures such as vigilance, reaction time, and short-term memory. While the results of these studies are then typically generalized to real world behavior, the extent to which the outcomes of these experiments reflect the effects of fatigue on the performance of actual work tasks is not known. Specifically, relatively little is known about the effects of fatigue on the operational performance of a crew, within the complex domain of long-haul flight operations.

This study investigated the effects of fatigue on the operational performance of international long-haul flight crew. A total of 67 crew participated in the study after either completing a long-haul flight pattern (non-rested), or after having at least four consecutive days free of duty (rested). The study utilized trained expert observers to analyze and evaluate crews' threat and error management behaviors and decision-making performance during a simulated flight operation. The simulator scenario was designed to present crews with a "normal" flight operation, which included a series of operational threats designed to provide additional workload for the crews, yet not extend outside the parameters of normal flight operations.

The results of this study highlight the effect of fatigue, both in terms of the "fatigue-proofing" strategies used by crew to protect performance, and also the negative impacts of fatigue on operational performance. The results of the study highlight the impacts of fatigue on decision-making performance, and also the shifts in error profile and error management behaviors observed to be associated with fatigue.

Main Points

- Relatively little is known about the subtle effects of fatigue on the performance of flight crew during normal long haul flight operations
- This study examined the fatigue-related changes in threat and error management, and decision-making behavior of long haul flight crew

A copy of Dr. Matthew Thomas' biographical information and presentation slides are provided in Appendix B.

D. PARALLEL SESSION

OPERATIONAL EVIDENCE OF FATIGUE: SHIFTWORK OPERATIONS

June 17, 2008
14:15 – 15:45

Panel Overview
The *"Operational Evidence of Fatigue: Shiftwork Operations"* session was chaired by Mr. John Goglia, of Aviation Technology Solutions, and included presentations from scientists in the field of aviation and human factors research. Dr. David Schroeder, retired from the Federal Aviation Administration Civil Aerospace Medical Institute (FAA CAMI), reported the results of empirical research documenting fatigue concerns associated with air traffic control (ATC) operations. Similar fatigue challenges during aviation maintenance operations were reviewed by Dr. William B. Johnson, of the Federal Aviation Administration (FAA). Dr. Colin G. Drury, of the University of Buffalo: SUNY, concluded the panel by presenting fatigue data collected during aviation inspections settings. The purpose of the panel was to disseminate the results of data collected in a variety of aviation shift work environments documenting the inherent fatigue risks associated with operations.

Scheduling approaches in shift work operations are particularly challenging due to the lack of a regular sleep/wake cycle. Shift workers, compared with non-shift workers, are generally more fatigued, have disrupted sleep and poorer sleep quality, and experience more digestive problems and driving issues following shifts. Typically, sleep loss associated with the non-standard schedule can accumulate across the work week, and result in significantly negative effects on performance, mood and alertness. This is not unique to cabin and flight crew and needs to be considered in other aviation environments including Air Traffic Control (ATC), maintenance and aviation inspection operations. This was clearly demonstrated throughout the session.

Shift scheduling practices are highly varied in Air Traffic Control (ATC) operations and as reviewed during the panel, no single shift rotation plan completely eliminates scheduling demands placed on shift workers in ATC environments. While strategies are limited, napping in preparation of a challenging schedule or during a shift (on a scheduled rest break), can help to improve alertness and performance during the work shift.

Data presented during the panel suggests that maintenance shift workers do not get sufficient rest. This contributes to increased fatigue levels and as discussed during the panel, continues to be an apparent contributing factor in several accidents and incidents.

Aviation shift work operations often require individuals to work continuously on repetitive tasks, where there is a high requirement for sustained attention. Time on task performance decrements can occur and this has been clearly documented in aviation inspection operations, as presented by Dr. Drury. Specifically, aviation maintenance tasks requiring the ability to detect rare and perceptually difficult signals are particularly vulnerable. Scientific data, as well as anecdotal evidence, suggest that shift workers in all sectors of aviation could benefit greatly from the implementation of comprehensive fatigue management initiatives.

"Sleep/Wake Cycles and Performance of ATC Operators"

DAVID SCHROEDER, PH.D.

Federal Aviation Administration, Retired

June 17, 2008: Shiftwork Operations Parallel Session

Abstract
Concerns surrounding the effects of work schedules on employee fatigue, performance, and well-being in settings that require 24-7 service are not new. Internationally, scientists and organizational personnel have sought to identify ideal scheduling practices for many decades. This is a critical concern in air traffic control and the rest of the transportation industry given the safety critical nature of the job duties. CAMI scientists have investigated the effects of the rotating shift schedules of controllers in the US since 1973, a majority of the laboratory and field research occurred in the 1990s, with a focus on the identification of fatigue countermeasures. While controllers work a variety of shift schedules, considerable attention has been focused on the counterclockwise rapidly rotating 2-2-1 shift schedule. Results indicate the primary concerns associated with the 2-2-1 involve the short turn around between shifts and the amount of time available for sleep prior to the start of the night shift. A laboratory study comparing a counterclockwise with a clockwise rotating 2-2-1 schedule revealed that the amount of sleep obtained prior to the night shift on the two schedules did not differ, even though additional time off between shifts was available for those on the clockwise rotating schedule. Obtaining adequate rest during daylight sleep is a primary concern. Our research also suggests that individuals who are working straight early morning shifts may incur as much of a sleep debt during the week as those who work a rapidly rotating shift schedule. Results of a recent laboratory study revealed that two 20 minute naps obtained during the night shift were sufficient to improve alertness and performance on a cognitive task. Caution is necessary however, to avoid sleep inertia following napping. Outcomes from our research and other research reveal that there is no ideal shift schedule. Scheduling practices need to be adjusted to ensure adequate rest time for employees and schedulers and employees need to be educated regarding shiftwork and fatigue. Adjustments to shift schedules are often difficult given the need to have sufficient personnel available to meet traffic demands and provide sufficient flexibility for employees to adjust their schedules to meet their home and family needs. Scheduling tools can be used to assist personnel in adjusting the proposed schedules.

Main Points

- Provide an overview of FAA shiftwork-related research
- There is no ideal shift schedule to cover 24-7 operations
- There are positive and negatives associated with the counterclockwise rapidly rotating shift schedule employed in many ATC facilities in the US
- Shift rotation time should be no less than 10 hours
- Laboratory investigations have demonstrated that short naps (20

minutes) may be sufficient to improve alertness and attention during the night shift
- Schedulers and employees need to be educated concerning issues surrounding shiftwork and fatigue
- Modeling and scheduling tools can be used to assist in mitigating fatigue promoting schedules

A copy of Dr. David Schroeder's biographical information and presentation slides are provided in Appendix B

E. PARALLEL SESSION

CURRENT STATE OF MITIGATION: FLIGHT OPERATIONS

June 18, 2008
8:30 – 10:00

Panel Overview

The "*Current State of Mitigation: Flight Operations"* session was chaired by Mr. Robert Talcott Francis II, Flight Safety Foundation, and included presentations by representatives from an international carrier, a domestic carrier and the Federal Aviation Administration (FAA). Captain Simon Stewart, and Dr. Alexandra Holmes, both representing easyjet Airline, Ltd., provided an overview of easyJet's Fatigue Risk Management System (FRMS) and how it was incorporated into their Safety Management System (SMS). Dr. Jack Rubino, of United Airlines Flight Center, summarized the fatigue mitigation initiatives in effect at United Airlines and their steps to develop a comprehensive FRMS. The panel closed with a review of the history and current regulations regarding flight, duty and rest requirements provided by Mr. Gregory Kirkland, of the Air Transportation division of the FAA. The goal of the panel was to provide the audience with the latest developments in fatigue management in flight operations by presenting examples of fatigue risk management initiatives in both domestic and international operations. This panel also allowed an opportunity for the symposium attendees to hear a regulatory perspective of fatigue risk management approaches in operations.

As heard during the panel, both domestic and international air carriers are taking a proactive approach to enhance safety by implementing multiple initiatives that aim to manage fatigue during flight operations. These range from research programs involving sleep, fatigue and fatigue-related performance in pilots to comprehensive fatigue management programs. It has been demonstrated that effective components include comprehensive fatigue educational modules, software modeling tools to manage flight schedules, non-punitive processes for crew to report fatigue, scientific protocols for exploring key fatigue risks, processes for investigating the role fatigue played in incidents, and an accountable fatigue safety action group or committee that meets regularly. As heard by easyJet, a comprehensive FRMS approach that applies control and safety resources in a risk-based manner is seen as an essential component of a business model and long-term success of the company.

Fatigue management initiatives can help crew members to obtain adequate rest allowing their continued support of safe operations. However, the challenge remains with rulemaking in finding the right balance of safety, science, cost and operational efficiency. As stressed by the panel, it is important that regulations be reasonably balanced to assure that the adverse effects of fatigue do not jeopardize a flight and, at the same time, be cost effective and flexible enough for operational efficiency. The two examples presented during the session clearly demonstrated the feasibility of implementing fatigue mitigation strategies in current operations, under current regulations.

"The easyJet Fatigue Risk Management System (FRMS)"

CAPTAIN SIMON STEWART[1,2]
& ALEXANDRA HOLMES, PH.D.[3]

[1]easyJet Airline
[2]London City University
[3]Clockwork Research

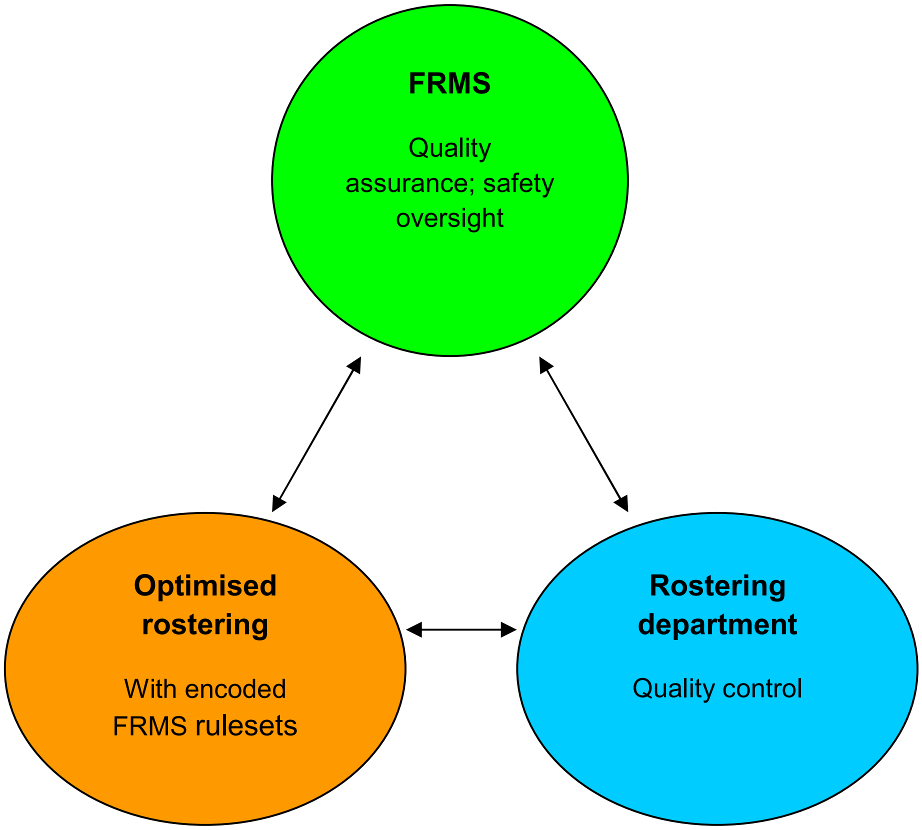
June 18, 2008: Flight Operations Parallel Session

Abstract
When employee fatigue levels adversely affect operational performance, fatigue presents a hazard to an airline. As is the case for any hazard, the risk that fatigue poses can be measured by assessing how it interacts with operational process over a period of time. The risk can then be managed within a safety management system (SMS). A system designed specifically to manage fatigue risk is known as a Fatigue Risk Management System (FRMS).

The easyJet FRMS started out as research program into the sleep, fatigue and fatigue-related performance that pilots were experiencing. The FRMS has since developed to incorporate tools and processes designed to detect, classify, investigate and manage fatigue risk to as low as is reasonably practicable. Example elements of the FRMS include a process for crew to report fatigue that is supported by a just culture, a scientific protocol for exploring key fatigue risks, a process for investigating to role fatigue played in all incidents and an accountable fatigue safety action group that meets monthly. A multi-layered database that collates all the information on fatigue collected from the operation is currently under construction. The information will be integrated to provide a comprehensive indicator of fatigue risk exposure. The FRMS is closely linked and supported by the company's safety management system.

In contrast to traditional safety approaches, the FRMS applies controls and safety resources in a risk-based manner. Thus, rather than acting as a barrier to commercial viability, the FRMS adds value by enabling the company to pursue flexibility and crew resource utilization within acceptable and defined risk boundaries. The FRMS is seen as being integral component of the easyJet business model and the long-term success of the company.

This presentation will describe the easyJet FRMS with a focus on how the system interfaces with the company's safety management system. Examples of how the FRMS has guided the company business model will be provided.



Main Points

- To provide an overview of the easyJet fatigue risk management system and how it links with the company's safety management system
- To describe the risk that fatigue presents to an airline's business model
- To describe how fatigue adversely impacts on an airline's operational processes
- Discuss the antecedents and consequences of fatigue
- Relate management of fatigue as a risk within a safety system

A copy of Captain Simon Stewart and Alexandra Holmes' biographical information and presentation slides are provided in Appendix B.

"Correlation between Fatigue Reports and Flight Performance Deviations"

JACK RUBINO, M.D.

United Airlines

June 18, 2008: Flight Operations Parallel Session

Abstract
This presentation will summarize the fatigue mitigation strategies in effect at United Airlines. We have attempted to collect data from our Flight Safety Awareness Program to evaluate the impact of fatigue on our operation. This data is collected and summarized for Senior Management on a monthly conference call. As a result of this conference call, decisions are made as to the elimination of onerous pairings for flight crew scheduling as well as an evaluation as to crew staffing. We have come to a decision that this approach has been reactive and we are attempting to become proactive. As a result, we are about to commence a comprehensive Fatigue Risk Management System in an effort to identify the risk of fatigue to our operation. This will include a comprehensive educational module as well as a software model to create our flight schedules.

Main Points

- Summary of our experience on fatigue based on FSAP Data
- Looking forward to a Comprehensive Fatigue Risk Management System

A copy of Dr. Jack Rubino's biographical information and presentation slides are provided in Appendix B.

"Crewmember Flight, Duty and Rest Requirements: FAA Regulations, Initiatives and Challenges"

GREGORY KIRKLAND

Federal Aviation Administration

June 18, 2008: Flight Operations Parallel Session

Abstract
The aviation industry requires 24/7 activity to meet operational demands. All flights require rested crewmembers to safely support around the clock operations. International long haul flights with passengers and cargo, domestic short haul, multi-leg flights and domestic transcontinental flights all present unique challenges to meeting this requirement. Current flight time limits and rest requirements for part 121 crewmembers are codified in 14 CFR part 121,subparts P, Q, R, and S, and in part 135, subpart F. The requirements apply to domestic, flag, and supplemental operations under part 121, and on-demand and commuter operations under part 135. This presentation will address rulemaking history, significant FAA initiatives undertaken to strengthen and clarify the intent of our regulations, as well as the challenges of regulating appropriate and safe flight, duty and rest requirements for all crewmembers.

A copy of Mr. Gregory Kirkland's biographical information and presentation slides are provided in Appendix B.

F. PARALLEL SESSION

CURRENT STATE OF MITIGATION: SHIFTWORK OPERATIONS

June 18, 2008
8:30 – 10:00

Panel Overview

The *"Current State of Mitigation: Shiftwork Operations"* session was chaired by Dr. Terry Allard, of the Office of Naval Research, and included presentations by three human factors experts. Dr. Ann Lindeis, of NAV CANADA, described the Fatigue Management Policy that has been incorporated into NAV CANADA's safety management system and Ms. Jacqueline Booth-Bordeau, of Transport Canada Civil Aviation, provided an overview and background to their Fatigue Risk Management System (FRMS) model. A regulatory perspective was provided by Mr. Kenneth Myers, of the Air Traffic Organization of the Federal Aviation Administration (FAA), giving an overview of the FAA's response to the National Transportation Safety Board (NTSB) recommendations regarding fatigue management in shift work operations. The main goal of the panel was to provide the audience with a greater understanding of managing fatigue in shift work operations using dynamic, science-based methodologies.

The panel was an opportunity for the symposium attendees to hear the regulator's perspective on the NTSB's recommendations addressing fatigue in aviation shift work operations.

While the components of a Fatigue Management Program depend on the specific operational demands, the two examples discussed during the session consisted of multi-component approaches. Both air traffic and aviation maintenance environments were used to demonstrate how fatigue management initiatives, although different in approach, can contribute to enhancing safety in aviation shift work. Some of the key components emphasized as part of this multi-component approach included fatigue and alertness educational programs for all personnel, scheduling practices that address fatigue related risks, policy development and procedures to assess fatigue levels associated with specific schedules and operations. A strong commitment from senior management with consequences for noncompliance was also stressed as potentially contributing to a successful program. However, the challenge remains of balancing scientific principles with both operational demands and personal lifestyle choices.

Important to the FAA are fatigue mitigation scheduling practices that are based on the most recent research in fatigue and alertness management. Additionally, the FAA strongly suggests that these science based principles and practices be applied to all personnel. The FAA is also in the process of implementing appropriate, empirically-driven counter-measures based on the NTSB's recommendations concerning fatigue and work scheduling policies and training programs for fatigue awareness and mitigation strategies. Furthermore, the FAA has expanded their scope to include all Air Traffic Operations (ATO) Safety Professionals.

"NAV CANADA's Fatigue Management Program"

ANN LINDEIS, PH.D.

NAV CANADA

June 18, 2008: Shiftwork Operations Parallel Session

Abstract
This presentation describes NAV CANADA's approach to managing fatigue in the 24/7 operation of air traffic services. The presentation's main focus is on the Fatigue Management Program, which consists of three main components: education, alertness strategies, and scheduling practices. The guiding principles of the program are also discussed. In addition to describing the Fatigue Management Program, the presentation will describe how the company routinely investigates for fatigue during operational incident investigations. The tools to collect and assess the fatigue-related data in incidents will be briefly described. Finally, the presentation will also describe the challenges of balancing scientific principles of fatigue with personal lifestyle preferences, the operational demands of traffic, and collective agreements.

Main Points

- To provide participants with a balanced approach to managing fatigue in a 24/7 operation.
- To provide participants with an overview of how to incorporate the collection and analysis of fatigue related data into safety investigations.
- To provide participants with an appreciation of the challenges of balancing what is known about managing fatigue from a scientific perspective, with other demands, such as lifestyle preferences, operational demands and collective agreements.

A copy of Dr. Ann Lindeis' biographical information and presentation slides are provided in Appendix B.

"Fatigue Risk Management Systems in the Canadian Aviation Maintenance Industry"

JACQUELINE BOOTH-BOURDEAU, M.A.

Transport Canada Civil Aviation

June 18, 2008: Shiftwork Operations Parallel Session

Abstract

For the past eight years, Transport Canada has worked to achieve a better understanding of fatigue issues in the Canadian aviation maintenance industry. Initial studies sought to understand whether there was an issue with fatigue in aviation maintenance and if so, whether duty times of aircraft maintenance engineers (AMEs) should be regulated with appropriate limitations. Through research efforts and consultations with the industry, it appeared that traditional approaches to AME fatigue, based on prescriptive limits to duty times, were unlikely to be an effective solution. An alternative, non-prescriptive approach was proposed. In this approach, approved maintenance organizations (AMOs) would be required to implement a Fatigue Risk Management System (FRMS) within their organizations.

The result of the consultation is a set of regulations that integrate a FRMS as a required component of a Safety Management System. In order to assist the industry in implementing FRMS, Transport Canada has undertaken to produce a set of audit methodologies, policy templates, and training materials. In advance of publication of the regulation (expected in 2009), AMOs can voluntarily use these tools to meet their needs and ensure proper management of fatigue-related risks. This presentation provides an overview of the background to the research, the various phases of the research and Transport Canada's FRMS toolbox approach and desired outcomes.

Main Points

- Provide background into why Transport Canada chose FRMS as a regulatory solution.
- Give an overview of the research efforts Transport Canada has undertaken in respect to fatigue in the Canadian aviation maintenance environment.
- Offer details of Transport Canada's FRMS toolbox and approach to implementation.

A copy of Ms. Jacqueline Booth-Bourdeau's biographical information and presentation slides are provided in Appendix B.

"Fatigue Management Initiatives within the FAA Air Traffic Organization"

KENNETH MYERS

Federal Aviation Administration

June 18, 2008: Shiftwork Operations Parallel Session

Abstract
COMAIR Flight 5191 (COM5191) crashed shortly after departure from Lexington Blue Grass Regional Airport on August 27, 2006. COM5191 had been cleared for take-off on Runway 22, however, the aircraft attempted to depart Runway 26, which was considerably shorter. Forty-nine passengers and crew died in this accident. The first officer, with serious injuries, was the sole survivor.

The Lexington Blue Grass Regional Airport is served by an FAA Airport Traffic Control Tower (ATCT). After clearing COM5191 for take-off the lone controller on duties was performing administrative duties and did not see that the aircraft had commenced take-off on the wrong runway.

As part of its accident investigation, the National Transportation Safety Board (NTSB) investigated the possible role of air traffic control in this incident. The NTSB determined that although the air traffic control specialist on duty was operating within FAA directives concerning the basic watch schedule (FAA Order 7210.3, paragraph 2-6-7), the employee had not attained sufficient restorative sleep to combat the effects of fatigue in rotating from the daylight shift to the midnight shift. FAA directives call for a minimum period of at least 8 hours between work shifts, a period of 9 hours had been provided.

The NTSB determined that a fatigue of the air traffic controller was a possible factor in this accident. The NTSB issued four recommendations concerning fatigue. The FAA has accepted all four recommendations and is in the process of implementing these recommendations.

Main Points

- NTSB recommendations cover the following areas
    - Work Scheduling Policies and Practices
    - Qualification and Proficiency Training Programs for fatigue awareness and mitigation strategies
    - Crew Resource Management to allow work teams to recognize fatigue factors and develop work strategies to mitigate
- NTSB recommendations compelled FAA Management and NATCA to work together on work scheduling policies and practices
- The FAA accepted all four recommendations and expanded their scope to include all ATO Safety Professionals
- What we have learned so far
    - There is no one (1) silver bullet that corrects fatigue issues

  - Employee life-style management is a key to any fatigue risk mitigation strategy
  - There are many possible causes for fatigue; some are not obvious
  - There is a great wealth of science
  - Tools are being developed to help measure the impact of fatigue on performance
- Initial Steps
  - Qualification and Proficiency Training Programs are being developed
  - Crew Resource Management Training has been developed and is being implemented
  - Scheduling alternatives are being looked at

A copy of Mr. Kenneth Myers' biographical information and presentation slides are provided in Appendix B.

G. JOINT SESSION

FATIGUE RISK MANAGEMENT SYSTEM (FRMS): MEASUREMENT AND EVALUATION OF EFFECTIVENESS

June 18, 2008
10:15 – 11:45

Panel Overview

The *"FRMS: Measurement and Evaluation of Effectiveness"* session was chaired by Dr. Tobjorn Akerstedt, from the Stress Research Institute of Stockholm University and Karolinska Institutet Department of Clinical Neuroscience. The session included three presentations by human factors and fatigue experts. Dr. Ann Williamson, University of New South Wales, stressed the importance of ongoing evaluation of fatigue risk management programs and provided some practical examples for conducting such evaluations. Dr. Steven R. Hursh, Institutes for Behavior Resources, described the usefulness of biomathematical models as part of a comprehensive FRMS and as a tool for ongoing evaluation of operations. The panel closed with a presentation by Captain Gregory Fallow, of Air New Zealand, describing the company's science-based fatigue monitoring and management program and ways in which they determine the effectiveness and success of their programs The purpose of the panel was to disseminate information on the importance of ongoing evaluation of Fatigue Risk Management Programs (FMP) for effectiveness and success in the field of aviation.

The process of evaluation for FMPs should ideally measure operator fatigue management, company level fatigue management, and system level fatigue management (relationships between individual operators, company, and other parties). Evaluation and measurements of both inputs (i.e., program design) and outputs (i.e., effect on fatigue levels) of the FMP is important for a comprehensive assessment. An evaluation of a FMP conducted in long distance road transportation was presented as an example to demonstrate the process of a formal evaluation.

A scientifically-derived, objective tool is one approach that can be used for measuring and evaluating the effectiveness of a FMP. For example, biomethematical models of fatigue and alertness can help to assess and forecast fatigue risk based on information that is readily available within the operational setting. However, it is imperative that the model be a valid predictor of performance and operational risk, and must be able to respond to new information about the environment and the states and traits of individuals. Any changes made to the FMP based on the results of the model feedback should be gradual and proportional to risk. Such models can also provide a useful foundation for schedule design and can be used to flag trips that may cause fatigue.

The evolution and structure of Air New Zealand's FRMS was provided as an example of a successful FRMS in the aviation industry.

Its success has been based on operational assessments and evaluations and the development of a non-punitive fatigue reporting system. As part of their program, they have formed a multidisciplinary Crew Alertness Study Group. This group is responsible for administering the program conducting operational studies, providing crew education, and providing advice to management on fatigue-related issues. In several cases, the study recommendations have led to changes to scheduling practices. Both the practical and operational process examples presented during the session provided valuable insight to carriers on potential ways to evaluate and assess their organization's FRMS.

"Evaluation of Fatigue Management Programs"

ANN WILLIAMSON, PH.D.

University of New South Wales, Australia

June 18, 2008: Joint Session

Abstract
Over the last decade or so, Fatigue Management Programs (FMP) have generated a great deal of interest as an approach to managing work and rest in the workplace. The concept of reducing reliance on prescriptive hours of service rules and introducing some flexibility to respond better to operational demands and variations in operator fatigue has considerable appeal. There are a number of potential problems with the FMP approach: arguably the most fundamental is the issue of the most effective FMP design. FMP's could potentially take a wide range of forms and this is one of the main attractions of the FMP. Evaluation of FMP's is therefore an important facet of the introduction of an FMP in any workplace.

This paper will review the issues in evaluating FMP's. It will distinguish evaluations of the potential for a proposed FMP to be effective that should be undertaken before it is introduced and evaluations of the effects of an FMP after it has been introduced. The paper will address the wide range of possible outcomes including those relating to the individual operator, the organization and the business. The paper will describe one of the few examples available of a formal evaluation of an FMP, conducted for long distance road transport in Australia and will discuss its implications for aviation.

Main Points

- To discuss the issues for evaluation of fatigue management programs
- To cover the range of different types of measurement that could be included in an evaluation of fatigue management programs
- To provide an example of an evaluation of a fatigue management program

A copy of Dr. Ann Williamson's biographical information and presentation slides are provided in Appendix B.

"Potential for Modeling Tools"

STEVEN R. HURSH, PH.D.

Institutes for Behavior Resources, Inc.

June 18, 2008: Joint Session

Abstract

An essential requirement for potential fatigue risk management systems is a technology for assessing and forecasting fatigue risk. To be practical in the near term, the technology must rely on information that is readily available within the operational setting. To be useful, the technology must be shown to be a valid predictor of performance and operational risk. To be adaptable, the technology must be able to respond to new information about the environment and the states and traits of individuals.

In the absence of a direct physiological marker of fatigue, the extensive body of evidence describing the physiology of sleep and circadian timing as it relates to human performance provides a rich foundation for biomathematical models of fatigue. Computer simulations or models of fatigue have the potential to describe the relationships between sleep, time of day, and human capabilities. Properly conceived, these models can predict with surprising accuracy the tendencies of the average person and the potential for performance degradation and attention lapses. Combined with a valid model of how work and rest schedules lead to limitations of sleep quantity and quality, such models can be used to predict changes in operator performance under dynamically changing schedules. Recent evidence has shown that such models can predict increases in accident risk and severity.

Current models provide a useful foundation for schedule design and assessment and for actuarial risk prediction. However, current models have limited ability to predict the performance of specific individuals and fall short as tools for guiding systems in real-time. Current research is focused on addressing this limitation by improving our ability to track the state of individuals across time and to more accurately represent enduring trait differences across individuals. First, research is underway to integrate monitoring technologies to provide continuous updates of several key state variables: actual sleep obtained and actual physiological circadian phase. Second, research is underway to periodically assess performance as a way to refine model parameters that reflect key trait differences in sensitivity to sleep restriction and in the properties of the endogenous circadian rhythm.

Main Points

- Effective fatigue risk management hinges on our ability to assess and forecast fatigue. In the absence of a physiological marker of fatigue, computer simulations or models can be used to describe the relationships between sleep, time of day, human capabilities, and operational risk.
- Current models of fatigue in combination with valid models of how work/rest schedules limit expected levels of sleep can provide surprisingly

accurate predictions of the tendencies of the average person and the risk of performance failure. Properly conceived, models of the average person can predict increases in accident risk and severity.

- Current models have limited ability to predict the performance of specific individuals. Current research is focused on technologies to better track the state of individuals across time and to more specifically reflect trait differences between individuals in sensitivity to sleep restriction and circadian variation.

A copy of Dr. Steven R. Hursh's biographical information and presentation slides are provided in Appendix B.

"Fatigue Management, Assessment and Evaluation: An Operational Perspective"

CAPTAIN GREGORY FALLOW

Air New Zealand,
IFALPA

June 18, 2008: Joint Session

Abstract
This presentation outlines the evolution and structure of a fatigue risk management system in an international airline. The programme commenced with an intention to use scientific methodology to drive decisions on rostering and scheduling. Early work involved gaining confidence of both management and union groups in a data-driven system, and evaluating available methods for collecting and analysing fatigue data. An important component of the programme is a non-jeopardy fatigue reporting system which can be confidential if requested. The programme is administered by a multidisciplinary Crew Alertness Study Group.

Since being established, the group has conducted scientific studies on a number of routes, initially for pilots and subsequently cabin crew as well. In several cases the study recommendations have led to changes to rostering or scheduling. Besides operational studies, the group is involved in education and training of crew, and in advice to management on fatigue-related matters. Over time, the management has developed confidence to accept the advice of the group based on previous experience and existing data, and on a number of occasions changes have been made to planned duties on the basis of this advice. Important to the success of the programme are the combined involvement of management, pilot (and cabin crew) representatives and medical/scientific resources. Crucial to the success is the commitment of management to act upon the data-driven recommendations. Another important component is regular external review by a panel of respected experts.

A large "top of descent" study was initiated to evaluate subjective alertness at the conclusion of a duty. This has led to a published article and another is in preparation. We have also surveyed pilots on 4 occasions over the past decade and demonstrated a progressive trend towards less fatigue impact; one of these surveys has been published. We have also assisted other airlines with fatigue studies. A PDA-based test kit incorporating subjective ratings and a validated performance test, were developed and made available publicly.

The structure and progression of the system will be presented, as well as representative data from a number of the studies. The future challenges for the group will be discussed, including the place of fatigue predictive models in designing crew work schedules, and the potential for universal data collection on board.

Main Points

- Identify the crucial components of a fatigue risk management system within a commercial airline

- List the major obstacles to establishing a system and how to overcome them
- Discuss ways to measure the success of a fatigue management programme within a safety management system

A copy of Captain Greg Fallow's biographical information and presentation slides are provided in Appendix B.

V. DISCUSSION GROUPS

A. OVERVIEW AND PROCESS

Overall Goals of Discussion Groups

Discussion Groups were assembled to encourage discussion among the symposium attendees, with a focus on fatigue-related challenges, barriers to change, and potential fatigue mitigation concepts.

The goals of the *Discussion Groups* were:

1. Develop an awareness of the fatigue-related challenges and drivers engendered by a range of aviation environments and the current (as well as historical) barriers to addressing these fatigue problems.

2. Share information and viewpoints on fatigue in the aviation workplace and discuss aviation fatigue mitigation concepts to address these problems.

3. Discuss practical applications of these concepts throughout the aviation industry, as well as in specific operations or activities.

Discussion Groups were asked to summarize and present their discussions on the morning of Day 3 to the symposium attendees and senior aviation community members. A PowerPoint template was provided to assist with the preparation of the report.

Structure of Discussion Groups

Five *Discussion Groups* were formed to specifically represent different aspects of aviation operations.

- International Long Haul Operations: Passenger and Cargo
- Domestic Operations: Transcontinental Focus
- Domestic Operations: Multi-Leg/Short Haul Focus
- Air Traffic Control and Tech Operations
- Maintenance, Ramp Operations and Dispatch

Each *Discussion Group* consisted of a range of 50 to 100 participants, and were led by leaders and facilitators representing scientific, industry and employee groups. Example topics and discussion points were provided to guide *Discussion Group* discussions. However, the material was not all-inclusive and the groups were encouraged to extend the discussion to any areas not listed if the group felt they were relevant to the topic of fatigue in aviation.

Each discussion group was assigned several leaders, a facilitator, and a scribe, as follows:

Discussion Group Topic	**Facilitator** ***Discussion Scribe***	**Panel Leaders**
International Long Haul Operations: Passenger and Cargo	Captain Mary McMillan (CSSI) *Mr. Kevin West* (FAA AFS-200)	Captain Jay Barnes (UPS) Captain Don Gunther (Continental) Captain Don Wykoff (DAL - ALPA)
Domestic Operations: Transcontinental Focus	Dr. Gregory Belenky, Washington State U. *Ms. Nancy Claussen* (FAA-AFS)	Captain Jim Bowman (FEDEX) Captain Doug Pinion (American - APA) Mr. Gary Thompson (Delta - ATA)
Domestic Operations: Short Haul/Multi-leg Focus	Dr. Kathy Abbott (FAA AIR-100) *Ms. Alberta Brown* (FAA AFS-200)	Captain Victor Cabot (American Eagle-ALPA) Mr. Lonny Glover (American - APFA) Captain Charlie Tutt, Sr VP (ASA)
Shift Work: Air Traffic Control & Tech Ops	Dr. Pam DellaRocco (FAA ATO) *Ms. Ruth Ellen Schelhaus (FAA-NISC)*	Ms. Kathy Carpenter (PASS) Mr. Tony Mello (FAA, Director, ATO Safety Service) Dr. David Schroeder (FAA CAMI Retired)
Shift Work: Maintenance, Ramp Ops & Dispatch	Mr. Jay Hiles FAA (AFS-300) *Ms. Jennifer Ciaccio* (AFS-300)	Mr.Roger Hughes (Jet Blue) Dr. Manoj Patankar, St Louis University. Mr. Dave Supplee, (US Airways, IAM)

Purpose of Discussion Groups

The groups were informed that the Aviation Fatigue Management Symposium was an event designed to present the most current scientific and industry-relevant fatigue information to a broad audience of aviation and fatigue/human factors science experts. Discussion Group Leaders and Facilitators were asked to encourage discussion on issues that broadly relate to the topical area. It was hoped that discussion of the formal presentation material would lead to improved understanding of fatigue in aviation and higher awareness of potential mitigation strategies and concepts that could be applied in the flight operations and shift work environments.

Group leaders and facilitators were aware that the information and viewpoints shared during Discussion Group discussions may entail proposals to continue the line of discussion or scrutiny in other venues and discussion/deliberative settings. If proposals arise in this regard, the Discussion Group leaders and facilitators were asked to lead the discussion towards identifying potential fatigue mitigation or management strategic concepts that could be pursued independent of this symposium by individuals or organizations.

Discussion Group Sessions

Discussion Group Sessions are scheduled to occur throughout the Fatigue Symposium.

<u>*Session 1*</u>: Day 1, 1.25 hrs of discussion

<u>*Session 2:*</u> Day 2, 3.5 hrs of discussion (*split into two sessions*)

<u>*Session 3*</u>: Day 3, 3.5 hrs for summary reports of Discussion Groups

Each *Discussion Group* was assigned to a specific room within the conference venue in which discussions occurred. The *Discussion Group* rooms were equipped with a computer, visual projector, whiteboard, flipcharts and notebooks to encourage interaction among discussion group members.

Discussion Group Objections
For each Discussion Group Area, there were three discussion objectives

- Objective 1: Compile fatigue-related challenges and drivers
- Objective 2: Compile the major current (as well as historical) barriers to fatigue mitigation.
- Objective 3: Compile potential fatigue mitigation concepts and activities that may apply to particular discussion group area.

Discussion Group Leaders
The Leaders were instructed enforce ground rules of courtesy, fairness, and balance in the discussion. They were encouraged to avoid contentious discussion on the application of any particular mitigation concept and to encourage open discussion on fatigue-related topics, rather than proprietary or economic concerns.

- Roles:
  - to guide the discussion
  - to summarize the group's discussion
  - to present a summary of the discussions to the Symposium on Day 3.
- Responsibilities:
  - to ensure complete and accurate responses to the objectives for discussion
  - to ensure that all those present who have constructive input to the discussion are heard and considered
  - to help guide discussion to both understand and apply fatigue mitigation concepts.

Discussion Group Facilitator
Each group had at least one designated facilitators. The role of the facilitator was:

- to initiate the discussion as outlined in the instructions
- to comment on the science relative to the fatigue drivers and barriers;
- to offer ideas for mitigation strategies to be considered by the group, and
- to prompt participation of other members in the Discussion Group who may have relevant scientific and operational experience.

The Facilitator attempted to:

- Make respectful suggestions to keep the discussion focused on one topic at a time and avoid tangents.
- Make note of points or ideas that may need to be addressed during later discussion if they are not part of the current topic.

The Discussion Group Facilitator & Leaders were instructed to involve everyone in the discussion and participants were told that they may submit a point anonymously to the group in written format.

Discussion Group Scribe
Each discussion group had a scribe with the following responsibilities:

- Record the main points of discussion, capturing the names of contributors when possible.
- Help compile the lists of challenges/drivers and barriers.
- Help compile the list of mitigation strategies and opportunities.
- Help prepare the report to the symposium.
- The notes of the discussion will be confidential and will not be provided to the government. Notes will be used to prepare the Symposium Proceedings by IBR and names will be deleted.

Discussion Panelists & Participants were expected to:

- Suspend their personal or organizational agendas;
- Contribute their knowledge to the discussion and to raise questions that will further group understanding of the issues;
- Focus comments to promote the goals of the Discussion Group and the symposium;
- Show mutual respect for other's ideas;
- Allow equal opportunity for participation by all panel members; and
- Avoid detailed and contentious discussion on the application of any particular mitigation concept.

Discussion Group Schedule

Day 1 Discussion

- Establish a list of major fatigue challenges and drivers, as well as barriers to fatigue mitigation, in the identified Discussion Group topic area.

Day 2, First Discussion Period

- Complete discussion of major fatigue drivers and barriers to improvement – compile list for report out.
- Initiate discussion of promising strategies for fatigue mitigation.

Day 2, Second Discussion Period

- Compile list of fatigue challenges/drivers and barriers.
- Compile list of strategic mitigation concepts and application opportunities.
- If possible, prioritize mitigation concepts and opportunities
  - starting with near-term, immediate opportunities, progressing to
  - far-term, potential concepts.
- Populate the report template for next day presentation to symposium attendees. Select report presenter.

Day 3, Reports of Discussion Groups

- **Flight Operations**
  - International
  - Domestic transcontinental
  - Domestic short haul
- **Shift Work**
  - Air Traffic Controllers and Tech Ops
  - Maintenance, Ramp Ops and dispatchers
- **Panel Overview**

- Fatigue drivers
- Barriers to change
- Promising strategies for mitigation,
  - flight ops
  - shift work

B. Introduction to Discussion Group Reports

There were five discussion groups led by several industry representatives from management and labor organizations.

- *Flight Operations*
  - International
  - Domestic transcontinental
  - Domestic short haul
- *Shift Work*
  - Air Traffic Controllers and Tech Ops
  - Maintenance, Ramp Ops and dispatchers

The five groups were assisted by one or more facilitators with special expertise in fatigue, and by a scribe who recorded the major discussion points to be covered in the report to the participants. Each group selected a person to report the findings of the discussion group and the content of those reports are included below, based on their oral presentation. The report was to cover the following topics and material, based on a template provided to each group:

Define Discussion Group Area

- List the major occupational groups and situations covered by this discussion group.
- List any special situations addressed by this discussion group (optional).
- List any situations or occupation groups excluded from the discussion (optional).
- List specific kinds of schedules that were considered by the group (optional).

Objective 1: Major fatigue challenges and drivers in the topic area.

- List points with sufficient detail to be clear to audience
- Use as many pages as necessary

Objective 2: Major current and historical barriers to fatigue mitigation in the topic area.

- List points with sufficient detail to be clear to audience.]
- Use as many pages as necessary

Objective 3: List major fatigue mitigation concepts and opportunities in the topic area.

- Compile list of strategic mitigation concepts and application opportunities.
- If possible, prioritize mitigation concepts and opportunities
  - starting with near-term, immediate opportunities, progressing to
  - far-term, potential concepts.

Concluding Remarks

- Provide any summary remarks that express the general sentiments of the discussion group.

The discussion group reports were followed by summary commentaries from four fatigue experts:

Steven R. Hursh, Gregory Belenky, Philippa Gander, and Martin Moore-Ede, each focusing on common themes across the five discussion groups, to include:

- Major Fatigue Drivers
- Barriers to Change
- Mitigation Strategies
- Regulatory Approaches

C. DISCUSSION GROUP REPORTS

"International Long Haul Operations: Passenger and Cargo"

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

International Long Haul Operations: Passenger and Cargo

The statements in this report reflect discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Definition of…

1. Lacking intellectual acuity
2. In a state of mental numbness
3. Without much intelligence
4. Slow to learn or understand; obtuse
5. Marked by a lack of intelligence or care; foolish or careless
6. Dazed, stunned, or stupefied
7. Pointless; worthless

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Definition of… STUPID or FATIGUED

1. Lacking intellectual acuity
2. In a state of mental numbness
3. Without much intelligence
4. Slow to learn or understand; obtuse
5. Marked by a lack of intelligence or care; foolish or careless
6. Dazed, stunned, or stupefied
7. Pointless; worthless

3

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Discussion Group Area

- Pilots and Flight Attendants
- Long-haul International and ULR

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

Overview

- Fitness for Duty
- Scheduling
  - Reserve, rest rules, coverage
- Layovers
  - Use of alcohol, activities
- Regulations
  - Differences, Whitlow
- Data and measurement
- Economics
- Operator culture and policies

5

Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Fitness to Report for Duty
  - Commuting
  - Managing time off
    - Outside employment
    - "Inside employment"
    - Military flying
  - Economic/Industry Stressors
  - Age
  - Adequate sleep
  - Corporate fatigue policy
  - Reserve/ Delay Considerations

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Scheduling
  - Marketing dictates the schedules - doesn't necessarily work with ops
  - Tradeoff between rest time and desire for "time off"
  - Schedule change from early reports to late reports- predictable
  - Trading trips may undermine scheduling to mitigate fatigue risk
  - Critical operations in the WOCL
  - Direction of flight- pattern/ rest construction

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Scheduling (continued)
  - Reserve scheduling practices/ regulations
  - Staffing levels
  - "Tag on" Flying
  - Part 91/121 Flying "tag on"
  - Mixture of Long-haul flying combined with in-theater operations.
  - Round the clock duty periods
  - Monthly trip pattern
  - Restorative sleep scheduling- based on more than total rest time, but also circadian

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Layovers
  - Quality of hotel
    - Quality of food available
  - Hotel not near airport on short overnights
  - Use of layover time
  - Use of alcohol, caffeine, eating habits, exercise opportunities
  - Ability to take advantage of sleep opportunities – sleep hygiene

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Data Collection
  - Should data collection be standardized or tailored to task (F/A v Pilot)? E.g., ASAP, FOQA, etc.
  - More difficult to analyze data because of non-standardization of categorization.
  - Lack of data on age effect on fatigue
  - Tracking of fatigue reports
    - Standardization of data collection
  - Use of data to measure, self-evaluate or predict fatigue.
  - Legality and liability issues

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Economics
  - Variances in or non-standard corporate fatigue policies (personal and organizational application)
  - Balance between marketing/ economic drivers of route development and ability to operate safely
  - Airline's need and desire to maximize productivity
  - Industry turmoil – flying more to make the same paycheck
  - Balancing operational needs with effective fatigue management

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Dated Regulations
  - Not based on science- aircraft evolution
    - Prohibits mitigation techniques (e.g., controlled flight deck rest)
  - No clear maximum duty day for international operations
  - Allow for extension of FTDT for irregular operations -- diversions
  - No Cabin Crew fatigue policy
  - Inadequate or non-existent Cabin Crew Regulations- rest/duty day
  - Address Medical issues
    - Identifying and treating sleep apnea and other sleep disorders
    - Pharmacological solutions?

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in International Long Haul

- Operator Culture and Policies
  - Lack of a Just Culture
  - Crewmembers who do not call in when fatigued
    - Sick policy versus fatigue policy
    - Perception of retribution re fatigue policy
  - Main purpose for those who abuse the system – some see fatigue the same as sick
  - Inappropriate use of fatigue policy

Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Objective 2: Major current and historical barriers to fatigue mitigation in International Long Haul Operations

- Fatigue has historically not "belonged" to anyone;
- Perceived lack of trust between stakeholders
- Advances in technologies have outpaced regulations
- Recognition of fatigue vs. tired

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Objective 3: List major fatigue mitigation concepts and opportunities

- Acknowledgement of shared responsibility of all stakeholders
- Near term:
  - Education for crewmembers and all levels of management
  - Policies that provide a physiologically suitable time for sleep
  - Commute- and fatigue- friendly scheduling
  - Controlled flight deck rest
  - Rest facilities
    - Hotels, in-flight, post duty rest facility
  - Provide strategy for sleep inertia recovery time
  - Use of prescribed medication
- Far term:
  - FRMS

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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"Domestic Operations: Transcontinental Focus"

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Domestic Operations-
Transcontinental Focus

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Objectives

For Each Discussion Group Area

- **Objective 1:** Compile fatigue-related challenges and drivers
- **Objective 2:** Compile the major current (as well as historical) barriers to fatigue mitigation.
- **Objective 3:** Compile potential fatigue mitigation concepts and activities that may apply to particular discussion group area.

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

2

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Discussion Group Area

- Major occupational groups represented in this discussion group include:
  - Representatives from the scientific community
  - Airline Management Representatives
  - Crewmember Labor Organizations
  - Crewmembers
- Specific schedules that were considered by the group were domestic operations with a transcontinental focus

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

3

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Challenges/Drivers

- Scheduled vs. irregular (actual) operations
- Current regulations blind to circadian rhythm
- Schedules
  - Daytime layover / night time flight
  - Consecutive back-to-back duty periods
- Layover quality
- Other issues in transcontinental flight

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

4

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Barriers

- Cost
- Lack of Education and Knowledge
- Negative public opinion
  - Napping
  - Pharmacology
- Regulations don't address circadian factors
- Prevailing parochial interests
- Trust

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

5

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Barriers

- Current regulatory limits may force undesirable schedules
- Science either not available or not validated for aviation
- Need data gathering / research beyond current regulatory limits
- Scheduling constraints
  - Slot times
  - Facility constraints
  - Connections
  - Competition

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

6

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Barriers

- Technology Barriers
- Undiagnosed sleep disorders
- Misinformation
- Complexity of regulations
- Need for confidentiality / anonymity
- Fatigue policy issues
  - No policy
  - Punitive
  - Not paid

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Aviation Fatigue Management Symposium: Partnerships for Solutions June 17-19, 2008

Presented by Federal Aviation Administration

Mitigations

- Scheduling Solutions
  - Fatigue Friendly schedules
  - Pairing, line-building and re-routing software that optimizes resources and incorporates a “fatigue” component
  - Apply the same “science” to both “scheduled” and “reserve” flying

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Presented by Federal Aviation Administration

Mitigations

- Controlled Rest (napping)
  - As a “coping”, not a “planning” tool
- Pharmacology
  - Sleep Aids
  - Stimulants
- Petition for Rulemaking
  - Alternative to current flight and duty limits based on FRMS concepts
  - Higher flight time limit vs. daytime layover

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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June 17-19, 2008

Presented by Federal Aviation Administration

Mitigations

- Fatigue Risk Management System
- Fatigue Policy
  - Policy standard developed by the FAA to ensure standardization
- Fatigue Reduction Education
- Health and Nutrition Education
- Fit for Duty- Shared Responsibility
  - Carrier to provide adequate rest opportunity
  - Crewmember to utilize rest opportunity

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June 17-19, 2008

Presented by Federal Aviation Administration

Mitigations

- Adequate layovers
  - True eight hour sleep opportunity
  - Hotel “standards” to promote rest
- Physiologic Measures
  - Establish validated measure of fatigue
- Data collection
  - Actigraphy to measure actual sleep
  - Model validation for aviation

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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June 17-19, 2008

Presented by Federal Aviation Administration

Concluding Remarks

- We can't eliminate fatigue, but if all the stakeholders can work together, we can take steps to mitigate its effects.

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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"Domestic Operations: Multi Leg/Short Haul Focus"

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Domestic Short Haul/Multi-leg Operations

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June 17-19, 2008

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Considerations for Short Haul/Multi-leg Operations

- Domestic, flag, supplemental rules are different
- Multi-leg operations can be more fatiguing
- Weather effect on short-haul, multi-leg ops
- Not as many reserves at smaller bases

2

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June 17-19, 2008

Presented by Federal Aviation Administration

Challenges, Drivers and Barriers: Categories

- Economics
- Scheduling
- Layovers
- Coming to work fit to fly
- Regulations
- Environment
- Operator culture and policies
- Data
- Other

3

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June 17-19, 2008

Presented by Federal Aviation Administration

Challenges, Drivers and Barriers

- Economics challenges and drivers
  - Basis of all airlines is to make money – they will schedule flights when the demand is there
  - Airlines maximize use of the crew members to maximize productivity
  - Lack of education about actual costs of fatigue, etc.
- Economics barrier: Perception of competitive disadvantage for carriers that allow fatigue calls

4

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June 17-19, 2008

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Challenges, Drivers and Barriers

- Scheduling Challenges and Drivers
  - Marketing dictates the schedules without working with ops/considering fatigue
  - Start early, end late - night flyers different
  - Schedule change from early reports to late reports
  - Changing airplanes
  - Reserve scheduling
  - Crew pairing - different individuals in different rest states
  - Unscheduled airline – crew doesn't know what they will be doing so cannot prepare
  - Part 91/121 mixing to extend duty day

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Challenges, Drivers and Barriers

- Scheduling Barriers
  - Tradeoff between rest time and desire for "time off"
  - Trading trips may undermine scheduling to mitigate fatigue

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Challenges, Drivers and Barriers

- Layovers Challenges and Drivers
  - Quality and safety of hotel –
    - bad (noise, temperature, other crewmembers, guests, housekeeping, other Interruptions, distance, etc)
    - And good
  - Hotel proximity to airport on short overnights
  - Time behind the door – nine hour layover but only six hours to sleep- sleep & rest different.
  - 12 hours in Detroit is not like 12 hours in Palm Beach

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Challenges, Drivers and Barriers

- Coming to work fit to fly: Challenges and Drivers
  - Commuting
  - Outside employment
  - Managing time off
  - Military flying

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Challenges, Drivers and Barriers

- Regulations are inadequate
  - Not based on science
  - Don't consider day or night
  - Interpretation varies, no preamble
  - No FA fatigue policy
  - "Sitting at the airport" time

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Presented by Federal Aviation Administration

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Challenges, Drivers and Barriers

- Operator culture and policies: Challenges and Drivers:
  - Attendance policy versus fatigue policy
  - Main purpose for those who abuse the system
  - Company says "last 10 hrs was your rest"
  - Many don't have policies and many don't work. Some treat fatigue as sick leave.
- Operator culture and policies: Barriers
  - Number of crewmembers do not call in when fatigued
  - Fear of retribution re fatigue policy

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Challenges, Drivers and Barriers

- Environment: challenges and drivers
  - Complex operating environment
  - Schedule pressure
  - Security demands
  - Equipment issues
  - Weather
  - Flight deck environment – noise, comfort, Crew Resource Management, etc
  - Physiological needs – food, etc

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Other Challenges and Drivers

- Cumulative fatigue
- Sleep disorders – Do we need education? Screening?

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Other Barriers

- Data and measurement
  - Lack of data on age effects
  - Non-standardization of report categorization
  - Tracking of fatigue reports
    - How many are investigated and analyzed
    - Retribution?
    - Fatigue related to duty
    - Lack of data on incidents, bad decisions, tracking from the fatigue reports
  - Limited ability to measure, self-evaluate or predict fatigue
  - Lots of science but not in operational context
  - Significant individual differences

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Other Barriers

- Lack of education

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Potential Principles for Fatigue Mitigation

- Scheduling and regulations should consider:
  - Science
  - Time of day/circadian rhythms
  - Length of day
  - Workload
  - Individual differences
  - Operational practicality
  - Social acceptability
- Individual responsibility should manage rest time (time off, layovers) to extent possible

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Potential Principles for Fatigue Mitigation (continued)

- Come to work fit to fly
- Operators need to manage their own risk
- Have a level playing field
- One size doesn't fit all
- Recognize that the irregular is regular

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June 17-19, 2008

Presented by Federal Aviation Administration

Potential Mitigation Concepts

- Education and communication
- Realistic scheduling that considers fatigue risk
- Implement SMS, to include:
  - Just Culture
  - Fatigue risk management
  - Non-punitive reporting
  - Appropriate measurement tools and metrics
- Regulations – update and harmonize

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June 17-19, 2008

Presented by Federal Aviation Administration

Potential Mitigation Concepts

- Transition the science to operational context
- Education/screening for sleep disorders
- Controlled rest in the flight deck
- Use part-time personnel
- Address issues with hotels & food
- Use and share lessons learned and best practices

18

"Air Traffic Control and Tech Operations"

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Shiftwork:
Air Traffic Control and Technical Operations

Aviation Fatigue Management Symposium: Partnerships for Solutions
June 17-19, 2008

Presented by Federal Aviation Administration

Shiftwork: Air Traffic Control and Technical Operations

Issues – ATC versus Tech Ops

- There are differences between scheduling practices. We looked at some Tech Ops schedules to understand some of the differences. There was extensive discussion around these and other issues. (Examples: Types of shifts; Number of hours allowed per day)
- There is a difference between the schedule and the shifts that are actually worked.

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Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in Shiftwork

- **Staffing and Position Management, including but not limited to:**
  - Insufficient Staffing (both ATC and Tech Ops)
  - Too Much Time on Position [ATC] (mostly on afternoon shift/thunderstorms; then come back/swing shift; cumulative effect)
  - Too Much Time on Task [Tech Ops] (coupled with reduction of proficiency) [UK has data]
  - Last Minute Schedule Changes
  - Shift Start/Stop Times
  - Too Much Overtime Required
  - Staff to traffic doesn't take into account circadian rhythms
  - Poor sector resource management

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Presented by Federal Aviation Administration

Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- **Scheduling Policies and Practices, including but not limited to:**
  - Call Backs
  - No breaks
  - Access to Leave
  - Individual Input to Schedule
  - Lack of Flexibility of Schedules
  - Shift swapping [managers and employees]
  - Overtime (10 hour days/6 day weeks)
  - Relief Periods

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Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- **Scheduling Policies and Practices, including but not limited to:** (con't)
  - Overtime Volunteer Procedures
  - Accounting for Individual Differences in Scheduling
  - Last Minute Schedule Changes
  - Shift Start/Stop Times
  - 24/7/365 Facilities
  - No negotiations of schedules
  - Unpredictability of schedule [see what railroads have done]

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Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- **Personal/Individual Fatigue Management, including but not limited to:**
  - Age
  - Domestic Situation (New born, etc.)

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Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- **Current Cultures, including but not limited to:**
  - Rigid HR Policies
  - Lack of Ratified Contract (relates to staffing)
  - LR Conflicts/Stress
  - Conflicting Agency Goals (Safety v. Efficiency)

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Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- Ability to Nap/Lack of Ability to Nap
- Quiet Rooms
- OJTI (on the job training instruction)

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Objective 1: Major fatigue challenges and drivers in Shiftwork (con't)

- Fatigue at end of shift and driving home
- Fatigue from Working Bad Weather
- Larger Geographic Areas to Work (more time behind the wheel)

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Objective 2: Major current and historical barriers to fatigue mitigation in Shiftwork

- The mission has to get done
- Insufficient staffing (at some facilities)
- FAA Policy: Not allowed to have "distractions" in operating quarters (i.e., book, listen to radio)
- FAA Policy: Not allowed to nap
- No place to rest (in some facilities)

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Objective 2: Major current and historical barriers to fatigue mitigation in Shiftwork (con't)

- Barriers to straight shifts—not maintaining operational proficiency
- Awareness of fatigue in self and others
- Trust (Just Culture)
- Economics

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Objective 3: List major fatigue mitigation concepts and opportunities

- **Strategic Napping/Rest (including closing one's eyes)**
  - **Short term: Change/remove wording in applicable orders and regulations**
  - **Interpretation on agency side about rest during breaks (i.e., break is not part of assigned duty time)**
  - **Build in breaks to schedules**
  - **Mid-term/Long term: Formal program for strategic napping and/or providing napping facilities written policy**
  - **Address the legality and**
  - **Address issue of sleep inertia**

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Objective 3: List major fatigue mitigation concepts and opportunities (con't)

- **Address Length of Time Off Between Shifts**
  - **Short Term: Evaluate options to identify minimum time between shifts of work week; Use a computer tool that includes FAST or similar; must demonstrate inclusion of science to determine evaluation approach**
  - **Mid-Term/Long Term: Increase the length of time off in between the shifts**

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Objective 3: List major fatigue mitigation concepts and opportunities (con't)

- **Initiate FRMS**
  - **(Policy; steering group; Education & Train; Monitoring Outcomes; Education; Alertness mgt.; Scheduling)**
  - **Need a technology initiative to develop assessments of schedules (automated tools; beyond SAFE to incorporate traffic levels)**
  - **Need full participation of all stakeholders (mgt.; unions; fatigue experts as technical experts; FAA medical; NTSB; etc.) at very beginning so that everybody is at the table**
  - **Conduct pilot study at higher risk facility for AT and TO**

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Objective 3: List major fatigue mitigation concepts and opportunities (con't)

- **Awareness**
  - **Public awareness about fatigue (ease acceptability); also get a public advocates**
  - **Access to health care for sleep disorders**
  - **Survey Current Environment for Baseline**
  - **Survey of Retired/-Resigned ATCS**
  - **Do a study concerning workload and recovery periods**
  - **Individual differences**

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Objective 3: List major fatigue mitigation concepts and opportunities (con't)

- **Scheduling**
  - **Build breaks into Schedule (Tech Ops)**
  - **Having People/Staffing on Call**
  - **Not be disciplined for calling in fatigue**d
- **Use of Fatigue Modeling**
- **Add fatigue into ASAP/ATSAP**

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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Contentious Issues

- Labor - Management Relationships
- Staffing Levels

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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June 17-19, 2008

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Concluding Remarks

- There was high level of interaction between the discussion group participants.
- Participants gained an understanding of the complexities involved in developing and implementing fatigue mitigation strategies

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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June 17-19, 2008

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Concluding Remarks (con’t)

- There are commonalities but many differences between ATC and Tech Ops fatigue mitigation strategies
- Recognition that there are differences between individual facilities

The statements in this report summarize discussions among symposium participants and do not reflect the official position of the Federal Aviation Administration.

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D. PANEL COMMENTARY ON DISCUSSION GROUP REPORTS

"Comment on Fatigue Drivers"

STEVEN R. HURSH, PH.D.

Institutes for Behavior Resources, Inc. and
Johns Hopkins University School of Medicine

June 19, 2008: Discussion Groups Session

DR. STEVEN R. HURSH: My focus this morning is to talk about the fatigue drivers. Taking the perspective of a scientist, many of the particular fatigue factors, such as the environmental, personal, and organizational factors that were described today can be lumped into conceptual categories that translate into scientific principles related to fatigue. I will organize the discussion group findings using this kind of scientific perspective.

I propose that there are five categories that encompass the majority of the particular fatigue drivers that were mentioned.

The five categories are, from my perspective at least:

- inadequate restorative sleep, for whatever reason;
- long hours of wakefulness, again, for whatever reason;
- circadian timing of critical tasks – aviation is a 24/7 operation, and sometimes critical tasks occur at bad times of the day from the point of view of a person's physiology;
- workload and the demands of the job itself; and
- personal factors.

I will discuss each of those in detail to illustrate some points. In the area of inadequate restorative sleep, that really breaks down into two subcategories: one is insufficient time for sleep, and the other one is that the opportunities to sleep are at less than optimal circadian times.

Inadequate time to sleep may be broken down into inadequate planned time to sleep - the schedule simply did not permit it; or it could be that the time was available but it wasn't utilized as it should have been.

And often times inadequate sleep time has to do with the shift work scheme, for example, from our last two presenters looking at aviation shift work schedules, the shift work scheme itself simply does not have enough time between shifts to permit adequate restorative sleep. Under other conditions the environment in which the sleep is going to be taken, be it on board the aircraft or during a layover, is a poor sleep environment, so the sleep that is taken is not restorative. In addition, the schedule may not consider the time it takes to transport to rest, be that transport provided by the airline or transport arranged by the individual, erodes the time available for sleep. Finally, there are competing activities - organizationally arranged activities or personal choices of activities – and these competing activities erode the opportunities to sleep.

There are also schedule extensions: the schedule looked good on paper, but given weather, given equipment problems, given other kinds of considerations, the schedule itself is not what was planned for in the first place.

There may be a lack of napping opportunities. Inadequate sleep can be sometimes addressed by opportunities to take naps, but the regulations often don't permit it.

Corporate fatigue policies may not allow a person to opt out of a work assignment to get restorative sleep, or there is the perception, at least, that the policy doesn't permit that.

Individual trips themselves may not erode opportunities for sleep, but when one constructs a monthly trip line or bid package, they may have done a clever job of preventing themselves from getting enough restorative sleep between trips. And some of this relates to economics and lifestyle decisions that drive these decisions.

The second category is long hours of wakefulness. And long hours of wakefulness is not just because of ULR or long hours of duty, but when you combine long hours of duty with a long period of wakefulness prior to duty that may be created by a long commute, then we have long hours of wakefulness, and that is a shared responsibility of both the operator and the individual to arrange commuting such that when the person has commuted to their place of departure, they have allowed themselves enough time for pre-trip rest. However, often times provisions for pre-trip rest isn't self selected, and education might help to restore that.

Reserves and delays can cause long hours of wakefulness. When a person is on reserve, the trip may be repeatedly delayed so that the time for them to report is also constantly delayed. If called off reserve, then all of a sudden they have a long time of wakefulness prior to actually having to report, and that creates problems.

The problem of rolling delays relates to predictability. If you don't have a predictable schedule, it's often very difficult to get restorative sleep, and that then creates long hours of wakefulness by the time the shift is over.

Finally, outside activities can create long hours of wakefulness because the person has opted to do a military task or some other work assignment that is combined with the actual aviation work assignment.

The circadian timing of tasks is another critical fatigue factor. Many commercial transportation operations in this country economically require us to work the back side of the clock. That is a fact of life, and we are going to have to mitigate that risk, not by eliminating those jobs, but by dealing with the reality of working at those times of the day.

Shift work requires that we work at odd times of the day. So we must develop strategies to mitigate the potential erosion of our performance and build in barriers to error that would take into account the degradations of performance.

We should consider the timing of critical tasks. We don't do a very good job of thinking about when critical tasks are going to occur with respect to our physiological time. Sometimes, if we had planned ahead and had the option of moving the task to a different time, then we would have changed the schedule and reduced the fatigue risk.

Delays and diversions can move block times. The take off or land would have been perfectly fine from a circadian perspective, but owing to a delay or diversion, all of a sudden, critical tasks are now scheduled at a time that wasn't anticipated to be a bad time, but now is. And some of that problem is created by marketing.

Workload is another key factor. We have heard a lot today about how many takeoffs and landings in a work duty period can create additional fatigue, and we need to take that into account. But again in the area of the shift workers, congestion of our airports and reduced staffing, and the stress of work demands creates additional workload.

Personal factors include age, sleep disorders, and self-medication. Sometimes because of a lack of education, people self-medicate in ways that are actually counterproductive to getting restorative sleep.

There are also trait differences in sleep need that are often not considered, either by the individual or by the organization. For example, there are differences between individuals in their ability to sleep on board an aircraft. If we are counting on those on-board sleep opportunities to make the schedule feasible, we need to consider that some people just simply can't do that, and we must consider how to accommodate that problem without creating economic disadvantage for those individuals.

As a fatigue modeler, I have a personal responsibility to make it clear that many of these factors that I just mentioned are not easily considered by modeling. Fatigue modeling, especially in the hands of the operator, often assumes a nominal sequence of events. And many of the things I just mentioned would not be considered by modeling. So the modeling ends up being a best case scenario.

Transport to rest usually is not considered by modeling, especially if that transport is delayed by traffic or some other unforeseen event.

Competing activities are not visible to the operator, and can't be modeled. Commute times that are self-selected by the individual from their domicile to their place of reporting often are not considered in the modeling.

Predictability is very difficult for modeling to consider. All the model sees is that there is a rest opportunity, and the model doesn't consider that the rest opportunity could not be utilized because of the unpredictability of the report time.

And delays and diversions are often ad hoc changes that the modeling doesn't consider because the model was fed the nominal schedule, not the actual schedule.

So these are some of the limitations of modeling - not to mention many of the personal factors that modeling currently does not consider. We have to be very rational and realistic about what modeling can do for us. It is oftentimes the best case scenario.

One way to mitigate that limitation is to think, not only of the modeling results as a nominal prediction, but consider also the variance around that prediction. If we know that in a particular season of the year schedules are going to be disrupted very frequently because of weather, consider that factor in the modeling, and say, well, this is what the nominal schedule is, but we know that 30 percent of the time it is not going to be this way, it is going to be this way, then the modeling should start to reflect the variance, not only the mean, in the realistic forecast.

And finally we can often use, since this is a shared responsibility, and many of the things that I describe to you that erode our opportunities for restorative sleep or create long periods of wakefulness are choices of the individual, then one way to address that, at least from an educational perspective, is to put modeling in the hands of the operators themselves: the pilot, the shift worker, the flight attendant. If crewmembers had an opportunity to access a model of their own schedule, then they could exercise some discipline in considering the consequences of their own choices and the impact of their choices on their expected performance at the end of that next duty assignment.

So I see an opportunity here for shared responsibility to create schedules that are workable, and to give employees the tools they need to evaluate their own actions and how lifestyle decisions impact on their fatigue and state of rest.

A copy of Dr. Steven Hursh's biographical information is provided in Appendix B.

”Comment on Barriers to Change”

GREGORY BELENKY, M.D.

Washington State University

June 19, 2008: Discussion Groups Session

First let me extend kudos to the FAA for organizing this wonderful conference, and all of you for participating, and for participating in the discussion sections. Our discussion section was simply excellent, and we had a variety of different opinions and perspectives expressed.

I'm going to extract from all the talks a set of higher order barriers to good management of fatigue and sleep, barriers to the implementation of fatigue risk management.

Taking a step back, one of the big barriers is the investment in prescriptive hours of service rules.

Another barrier is the apparent conflict between cost, productivity and efficiency on one hand, and safety on the other.

And a third barrier, growing out of this mix of things, is the sometimes adversarial relationship between regulator, industry and labor, and advocacy groups instantiated in agreements and negotiations, and culminating in a general suspicion of other people's motives.

Looking at prescriptive rules, it seems, despite the development of sleep science - we know cockpit napping improves performance; we know that the circadian rhythm modulates sleep propensity and performance - ,we seem to be unable to integrate sleep science into prescriptive regulation. Cockpit napping is not available to U.S. carries; current prescriptive rules ignore circadian modulation.

With respect to circadian rhythm, a prescriptive rule that is very safe if you are flying, maintaining, or working during the day and sleeping at night, is totally inadequate if you are trying to sleep during the day at adverse circadian phase, and then working through the circadian trough at night. It is day and night, the difference.

The productivity and efficiency and safety issues must all be integrated in some way. If you look at successful fatigue risk management programs, it appears that there are improvements in productivity and efficiency that go hand in hand, and maybe even lead, to improvements in safety.

Successful development and implementation of a fatigue risk management systems simultaneously overcomes all three of these barriers in an interesting and potentially very useful way.

Thus development and implementation of FRMS requires some lightening of the rigid one-size-fits-all prescriptive regulatory scheme that, at times, is overly restrictive, and at other times, potentially unsafe.

The Union Pacific Railroad has initiated a successful implementation of FRMS. The UP took the existing prescriptive rule and developed

FRMS within it. The Federal Railroad Administration enforces hours of service rules required by legislation (as opposed to regulation). Union Pacific found that FRMS led to improvements in safety, and, also, found improvements in productivity. Union Pacific found greater throughput of trains on their railroad using fatigue risk management.

Union Pacific did many other things at the same time to improve efficiency of operations, so they will tell you that they can't really ascribe the improvement in throughput to fatigue risk management; nevertheless, it was associated.

If you look at the wonderful presentation we heard yesterday from easyJet, using an FRMS system in aviation, they have reduced their insurance cost 30 percent, a substantial savings; and, they reduced their regulatory costs, because they pay to be regulated and they are being visited less often because the regulator has confidence.

In implementing FRMS, Union Pacific was, with the agreement of labor and the Federal Railroad Administration, to take fatigue out of the arena of labor management negotiations, where it is for lots of industries, and put it into the safety management system, making it less adversarial. And you see in the case of easyJet, they were working very closely with their regulator, and were enabled to get some relief for regulations.

The same was true in the Air New Zealand case that we heard about. Thus, we have three successful implementations of FRMS that improve safety, employee wellbeing, and also reduce costs and improve the bottom line.

In other words, if one takes a comprehensive FRMS approach, you may be able to really lighten prescriptive rules; resolve the apparent contradiction between productivity and safety; and in the process of developing the FRMS reduce the tension and adversarial nature of relationships through the establishment of what people have talked about at some length at this conference, and that is, a just culture.

There are some other subsidiary issues. Napping in the cockpit, we've known for a long time, is effective in restoring performance. It's not just cockpit napping; it is napping in general. If you have a situation where you are sleeping during the day, and only getting five hours of sleep, and working through the night, it should be routine in every workplace - in aviation for pilots, maintenance, tech ops, flight attendants, ATC - there should be provision for a short nap during the night. That should be built into the workplace. That should not just be for aviation but for all workplaces where there are 24/7 operations. You simply cannot get decent amounts of sleep by sleeping during the day.

Pharmacology should be considered. This is a taboo issue. “Pilots sleeping in the cockpit” or “Pilots taking drugs”, everybody thinks this is going to be on Jay Leno, and everybody is going to have a fit about it. Yet the solution is, perhaps, a matter of education - as a number of people at this conference have touched upon.

One final thing, we talked about the disconnect between the schedule as planned and the schedule as flown. That presents a huge problem. And here FRMS also can be of help. If you combine FRMS, including mathematical sleep/performance prediction modeling, with actual measurements of sleep though actigraphy or self-report then you actually can handle exceptions in real time, and re-optimize your operation to maximize all the different constraints, including economics, routes available, crew availability, plane availability, and fatigue issues and sleep.

So as I see the situation, looking over the issue of prescriptive rules, productivity, safety and efficiency, and the adversarial climate, FRMS emerges as a tool to resolve all of those things yielding safer, more efficient, more profitable operations.

A copy of Dr. Gregory Belenky's biographical information is provided in Appendix C.

"Comment on Mitigation Strategies"

PHILIPPA GANDER, PH.D.

Massey University, New Zealand

June 19, 2008: Discussion Groups Session

Good morning, and thank you for still being awake to those of you who are. One of the things about sitting up here is, you can see who had a good night last night.

I have been asked to look at the themes that have come out around mitigation strategies, mitigation strategies at the organizational and the individual level. And I guess I've been really impressed by the wealth of detailed ideas that have come forth in the presentations, and also in the working group that I was in.

It's certainly not possible in the five minutes, stretched a little bit, that I have been allowed, to reflect on all of those. So I'm just going to talk about the main recurrent themes I think that have come through in these mitigation strategies.

I think the first thing that is quite clear is that they have to be framed within the context of a just culture, that everybody is fully in agreement that this can only work where there is an acceptance of shared responsibility, and where there is a non-punitive culture around managing fatigue.

So a lot of the ideas that have been put forward are very valuable, but they can only work when there is an environment of trust by all parties, amongst all parties.

And I think there has been quite a lot of recognition implicit, not very explicit, that quite a few of the organizations represented do not have what people here would consider to be a sufficiently just culture, or a sufficient level of trust at this point in time.

And one of the things that some of us who have worked in the fatigue risk management implementation field have found is that, in fact, this can be a platform for improving or developing a just culture. Because it's one of those areas where the scientific issues are common to all human beings. There is a central neutral ground in this area, and that can be used to try to bring a rapprochement, to move this whole area out of industrial relations and into safety. There is a scientific middle ground, and I think we shouldn't lose track of the fact that everybody has a stake in this.

I think we need to also be aware, and that was very nicely illustrated in the different presentations today, that the mitigation strategies will have to be tailored to the particular issues in the organization, and the particular issues in the jobs that different people in the organization are doing, and that they are going to have to be tailored by and for individuals because of their different needs.

And I think we have also got to add the realism which Mary in particular talked about, that we have to find a balance between economical operational needs and good fatigue management practices, and we can't propose the impossible, so we do have to keep that balance in mind. And another dimension that was mentioned, which I think we also need to keep in mind, is that the mitigation strategies we want to talk about need to be operationally practical, but they also need to be socially acceptable, and that is again implying that there is going to have to be negotiation, and there is going to have to be multi-party discussion about the use and development of strategies.

So what are the common strategies that people have talked about here today? Well, the first one which I think should be first is education: education about the causes of fatigue, about the consequences, about assessing the risk of fatigue and your particular organizational part in it, from top level management right through the whole organization.

In fact, just as an anecdote we did a fatigue risk management implementation exercise with BP some years back, and it really took off when we started educating the senior managers about the risks of driving sleepy. That was when suddenly everybody realized that it was an issue, that it is an "everybody" issue. But there is a real need to get buy-in at top level.

We talked quite loosely about education, and there were some aspects I think that were brought up today that need to be kept in mind. One is the consistency of information that people are being given. And one suggestion was that this should be good advisory circular material.

Another possibility of course is to have some kind of accredited training, some kind of standards for training. Another issue that was raised today is that we are talking about behavior and cultural shifts, and you don't get that with one-off training. You need to be thinking about recurrent training and creative ways of doing that.

One suggestion that was given was to debrief incidents and events that have happened within the organization as a way of doing recurrent training.

I think we could raise the question of whether this should be competency based training and possibly different levels of training or different types of training for people with different roles in the organization; those are all things to be considered.

There was talk about the need for a company fatigue management policy, and clearly this is a vital part of setting structures in place for fatigue risk management to work.

There has to be top level commitment; that was a theme that people came back to. And there have to be mechanisms for feedback of information for monitoring and feedback of information, about the fatigue status of the organization as it is going along. That involves, of course, a collection of data, and raises the issues about how the data are handled, how the issues of privacy and confidentiality are handled.

There were calls for policies that focused on restorative sleep scheduling, and I think that that is entirely consistent with the science that we have been talking about.

There were some specific policies that people raised repeatedly. One is about the consequences of calling in too fatigued to work. Those sorts of things I think need to be explicit in the fatigue risk management policy.

And the need for a steering group, presumably a tripartite steering group that would be overseeing the actual implementation of the policy.

And one suggestion which I thought was quite novel was to include in that a professional code of conduct. And I think I can see a lot of value of that particularly in an area like this where we are talking about a shared responsibility.

1. Just as a note, people have done other exercises on what should be in a fatigue risk management policy, and the document from the Flight Safety Foundation ULR workshops has a list of ideas, many of which were mentioned here today, and some others that were not (Flight Safety Digest 26, 2005).

The next common mitigation strategy that everyone has concerns about is scheduling. We are looking for fatigue friendly scheduling, we are looking for scheduling that focuses on providing restorative rest; and one of the specific suggestions was the idea of bolting on some of the fatigue models to your rostering software, so that you are actually assessing the likely fatigue associated with the particular schedules or bid lines that they are developing.

And I know that Air New Zealand is working on doing this.

I think that there were several comments about the fact that the scheduling is actually designed by marketing, and maybe one of the recommendations is to have better communication between marketing and ops, and possibly to have somebody from marketing involved on the fatigue management committee, so that those issues are communicated to all parts of the organization.

I think one of the big challenges which came up today, and which I don't think any of us had solutions for, so it's not really a mitigation strategy that we have, but it's one that we would like, is how to deal with the issue of unpredictable events of different kinds of work, being on call, or weather delays for example. But the issue of unpredictability, I think, is a major issue for all the different types of organizations that were discussed earlier.

One of the ways of visualizing this is that you have both strategic and tactical fatigue management. But I'm a little bit concerned that with the level of disruption to schedules and delays, the planning side of things sometimes becomes fairly irrelevant, and it's all left down to tactical fatigue management. And I think we need to think very hard about better ways of managing in each of the different environments, the challenges that come about from either unpredictable or unplanned things, and things like being on call and how long you are on call before you have to be stood down even if you haven't worked; and those kinds of issues.

There were a range of other types of mitigation strategies that were discussed, and I think we can't ever leave staffing levels out of the equation in fatigue risk management. The only specific strategy that was offered was the use, potentially, of part-time employees. But I think that that is an integral part, obviously, of fatigue risk management, and can't be overlooked.

There was some talk about new technologies that might be available, potentially in the cockpit environment, and in other environments, to help recognize fatigue, and to help people manage themselves when they are fatigued. My own view of this is that it is a valuable potential strategy, but it is the ambulance at the bottom of the cliff. I don't want to know that the pilot has just fallen asleep; I'd rather it hadn't gotten to that point. But there is a place for them in certain situations I think.

There was a lot of talk about the availability of napping as a strategy. There is plenty of evidence that it's an effective strategy. There seems to be sentiment that controlled cockpit rest be allowed. However, again, we must recognize that this is a coping strategy, not a planning strategy. It's not the idea that if people can sleep at work, then they should be allowed to work longer. It's designed as a strategy for coping with a situation where you are fatigued. It's not a way of extending what you can get out of people.

Napping and ATC was mentioned. There is quite a lot of data on napping in ATC as well, and the availability of napping in ATC. So I think that there is a consensus here that napping is a valuable strategy that we should find ways of making accessible to people.

In addition, in situations where people nap, it is important to have suitable napping facilities or environments where people can have a sleep.

That brings us to another recurrent theme related to hotels, specifically, is the need within the fatigue management policy, a policy that specifies the standards required of layover hotels which facilitate people getting decent sleep.

There is quite a lot of talk, and I think quite a lot of difference of opinion, about the use of sleep aids and stimulants as mitigation strategies. My own view is that I would put it in the same category as napping, that this should be thought of as a coping strategy, not a planning strategy. We have seen examples in the trucking industry in Australia where when you get your pay package, you also get your uppers and your downers for the next week. And we have actually seen fatigue crashes where the driver attributed it to having taken a stimulant at the wrong point in the schedule.

So my own view is that that is not a way of running routine operations, but there probably is a place for the use of stimulants, and for sleep aids under specific and controlled situations.

I think there were a lot of calls for data and science in terms of providing mitigation strategies, and certainly some of these are there. There has been a call to improve the transfer of scientific information into operationally usable information and into tools, and I think that is an ongoing challenge.

There is a general call to develop biomathematical models in the aviation environment if they are going to be used as mitigation strategies, and I would applaud that.

There is a call for standardizing and sharing data where that is possible between different organizations. And again I think that is a worthwhile thing to think about. But we have to sort out the issues of confidentiality, and be very clear about what we are using the data for.

There was a suggestion to run a pilot study to look at the interaction between workload and fatigue in traffic control. My own view is that this is one of the areas where our current modeling is deficient, that we do not adequately take account of the interaction between workload and the other factors, and the type of work, and the kinds of performance consequences and what the impact of that is likely to be.

The only study I know of that has done it systematically is actually some work that Mick Spencer did with QinetiQ in the validation of the SCRATCOH report, the validation of the UK ATC regulations. So if anybody is interested in looking at that, they did a very elegant job of parceling out the effects of workload, time on task, time of day, and sleep on fatigue in air traffic control.

But I guess as a scientist, and as a scientist who Charley Billings many years ago diverted from being a bench scientist to being somebody who tried to grapple with problems in the real world, I guess I have to be humble at this point and say, please don't expect that science will have all the answers. Because there will never be enough science to answer all the detailed questions that you will need to have answered in an operation. And we have to go about this fatigue risk management exercise, in my view, as a collaboration.

Your operational knowledge, your business knowledge, is actually just as relevant, and must be taken into the picture, because science will never have all the answers.

And so with that I will pass over now to Martin who is going to talk about some of the regulatory mitigation strategies that have been raised that will enable implementation of the organizational and individual strategies that I have talked about.

A copy of Dr. Philippa Gander's biographical information is provided in Appendix C.

"Comment on Regulatory Approaches"

MARTIN MOORE-EDE, M.D.

CIRCADIAN

June 19, 2008: Discussion Groups Session

Coming last, after all the leaders in the aviation industry and the leaders in the science of fatigue have spoken, is a little bit of a challenge!

We all really do have to stop and congratulate the Federal Aviation Administration (FAA) for the extraordinary proactive leadership that they have shown through organizing this conference, and on this whole issue of fatigue risk management.

This has been an extraordinary opportunity to share and exchange knowledge amongst such a broad range of stakeholders, and to bring an entire industry up to speed. This is a remarkable achievement that we all can recognize as being an important step forward.

In 25 years we have come a very long way. Twenty-five years ago a young slim congressman, who later became Vice- President Al Gore, invited to testify before him in a Congressional hearing a young slim Harvard professor - that would have been me- about the science of sleep and circadian rhythms and how it applied to industry.

I had just completed a study with Chuck Czeisler, one of my colleagues, of an industrial shift work facility that had called us up and said, "We have problems with sleep here, and our workers are falling asleep on the job. We have accidents. We have low productivity. "

In response to this challenge we had taken that nascent science and actually built what probably was the first fatigue risk management system, -- scheduling, education, training and so forth within an industrial shift work facility. We found that when you started to apply this science, that really so far had been largely bench science, safety improved and accidents went down. Health ratings improved. Productivity went up 22 percent, which really caught their attention. Specifically, the number of tons of product leaving that site went up 22 percent without any more people being hired or any more capital investment.

After we wrote up the results and published it in Science, Al Gore decided to invite us to come and testify on the Hill about this research, and what the potential might be.

At that time he also invited a panel of representatives from four federal agencies, including the FAA and the NRC. At that panel three out of those four federal agencies said, on cross examination by Al Gore, fatigue is not an issue! So you can see how far we have come today.

We have come an enormous distance. But I can tell you it has been a challenge. It has been a culture shift. And it has been not just in the agency; it has been in the industry; it has been in the unions. Everyone's awareness and interest has advanced considerably, and the opportunity before us now is really an extraordinary one.

In the last 25 years we have seen the science mature. I am not saying there are not a lot of remaining scientific questions, but the core scientific principles have actually become well established. When I recently convened a panel of 11 scientists who were polled separately on a technical issue about how to schedule sleep and duty hours, all 11 agreed precisely on the core scientific principles independently of each other. And I must say in a scientific community that loves to debate each other on every single point this was remarkable. For example, even Greg Belenky, who is sitting beside me, was one of the people who actually agreed with everybody else!

This just shows you that the core science that fatigue risk management is based on is firmly established. The core of this science is no longer what attorneys call "emerging science". Of course, beyond this core, there are a lot of great discoveries being made in circadian genetics, and other aspects of circadian and sleep physiology.

Over the last 25 years, there has been a comprehensive set of tools developed across multiple industries, and we really need to become aware of these tools. There are tools for not only education and training; there are tools for fatigue risk modeling. There are tools for accident investigation, for what is the probability of fatigue being a causal factor in an accident. There are proportional staffing tools that address the problem we have heard about balancing staffing versus workload.
All of these tools exist and are used, day in and day out, in multiple different industries that employ 24/7 workforces.

In addition, the process of creating in an organization a "just culture" has been very well developed. One of the very important lessons about just cultures is that it helps if you have got a concrete issue to work that just culture around. It cannot be a theoretical issue. Fatigue risk management is the perfect issue, because there is so much win-win, there is so much gain for everybody out of this process including quality of life, health, personal safety, corporate productivity and efficiency, and corporate budget ROI. All those things come out as a real win-win from this fatigue risk management process. The just culture comes about by working on a project like this together. Once you've got that just culture, guess what? All sorts of other things can then be addressed through that collaborative process.

The challenge, of course, is how to operationalize this science and shiftwork experience in the aviation industry. This has been a large part of this conference. I can tell you that the aviation industry is the most complex industry by far - and I have worked across many, many industries. All the moving parts and moving equipment and moving people, and all the time zones and geographical locations and times of day, make it the most complex of challenges.

In a sense, for us scientists, this is the pinnacle of fatigue risk management. You have whetted our appetite. This is an opportunity to take everything we know and move it forward.

The just culture, of course, involves some key principles, as we have been talking about. One is truth telling. One is protection of people who tell the truth. And the third is leadership to actually do something about the truth and continuously improve. These three principles are actually the key to the whole just culture process.

My mandate is to talk a little bit about the regulatory issue. One vital truth is that we have a regulatory paradox, and it is not just in this industry – it is in every other industry that has prescriptive work-rest regulations. The critical paradox, that we have been talking about at this conference, is that you can be legal but unsafe, or you can be safe but illegal.

As long as we have this regulatory paradox it just numbs the mind, and, in fact, it is a prohibitive barrier to dealing with the fatigue issue. Because if everyone ignores this paradox, how can we address everything else and claim we are telling the truth at the same time?

The challenge, then, is how do we deal with this issue? This regulatory paradox actually has a very real cost to it. It has a safety cost to it. It has a health cost to it. It has a productivity cost to it.

And so just as fatigue risk management systems have to find their proper interface and plug into safety management systems, fatigue risk management systems also have to find their proper interface and be plugged into the regulatory structure. And that is going to take some regulatory innovation, just as it is going to take some innovation on the safety management side.

We were delighted to hear during the course of the conference that the FAA is already working hard on this issue. We were delighted to learn they are ahead of the game. They are thinking about this issue, and how do you can do it.

The scenario is going to happen very soon, stimulated by this conference, where one or more airlines are going to come to the FAA and say, "We have got together with our union and we need an exemption or waiver from certain aspects of the flight-time duty-time regulations that run counter to fatigue risk management. We have worked out a real fatigue risk management approach - we are ready to really move this thing forward, and we just want to go full steam ahead while everyone understands the issue and has got the energy".

The airline will say to the FAA "We have got a well developed fatigue risk management system. We have documented it, and we have got it all in place, and we are implementing it as a continuous improvement process. We are bringing you the scientific evidence for safety equivalence, but we need your help to do something with the prescriptive rules that are getting in the way of this safety solution."

That rule could be something like, for example, the eight-hour limit on the two-person cockpit. If we stay on duty for nine hours you could have people fly during the daytime instead of having to flip them, and have them come back for productivity reasons overnight.

So the request to the FAA might be something like that. But whatever the request is, that airline is going to come to the agency and is going to say, "How do we do this? How do we go forward? Do we go the exemption route? Do we go through the Part 11 exemption process? Do we need an alternative rule like AQP, the Advanced Qualification Program, or alternatively under Part 121 subparts N & O – so you see, I'm learning some of the lingo here! Or do we address the flight-time, duty-time regulations, and revise the whole regulation?

First of all revising the whole regulatory framework is a huge headache, and if you want to see how difficult it is, look at the trucking industry and what the FMCSA have been bashing their head against for year after year.

So clearly one of the questions is how do we fast track important safety improvements? What happens if we don't have a facilitated, thought out mechanism that is transparent, that's peer reviewed, that has been through the appropriate due diligence? If it is not in place when that airline arrives seeking approval for a creative solution to fatigue risk, there is a substantial cost of waiting.

The cost of waiting is loss of energy. When the request arrives from an airline everyone is energized. If they cannot move promptly ahead team members get assigned to other duties, so the team that was together, that put this whole creative solution together, starts dissipating.

Furthermore airlines have to make a decision on whether to invest in a fatigue risk management system. Any change like this is going to require a significant investment in systems and processes and costs to make this work. The energy required for an airline to make that commitment is going to be dissipated- and management is going to hang back unless the regulatory exemption process moves forward in a timely way.

I have seen these problems with regulatory innovation in a number of industries, including railroads and trucking. Most recently we have helped a major trucking fleet file an application for an exemption from certain hours of service rules, which is pending before the Federal Motor Carrier Safety Administration (FMCSA). We submitted it over a year ago, and are still waiting for the answer. In the meantime the company, Dart Transit, has won the Innovator of the Year Award from the trucking industry for this comprehensive fatigue risk management solution which they cannot implement until the FMCSA approves it. Safety equivalence has been demonstrated; a dozen letters from leading fatigue and sleep scientists are supporting it; support has come from the American Trucking Association, driver organizations and the industry. But it is a challenge to move even such a big opportunity for safety improvement forward, and it is a challenge to a regulatory agency to deal with such a request.

When the Dart Transit exemption request was published in the Federal Register, it received almost 100% completely positive comments. Only one public advocacy group opposed it, but they have never been known to like anything proposed by the industry. That goes with the territory.

The question today is how do we move regulatory innovation forward in the aviation industry? That is the challenge. What can we do to gives the confidence to the airlines and the unions to encourage them to invest in the intellectual capital, the monetary capital, the human capital, to make this happen?

So the biggest challenge I have heard from this conference is where is the home for this fatigue risk management process within the regulatory structure? I am convinced that the industry would have the energy, and would be willing to move this whole fatigue risk management process rapidly forward if the regulatory issues are seen to be promptly addressed.

A copy of Dr. Martin Moore-Ede's biographical information is provided in Appendix C.

VI. CONCLUSIONS

"Together, We Can Address Fatigue in Aviation"

MR. NICHOLAS SABATINI

Associate Administrator for Aviation Safety
Federal Aviation Administration

June 19, 2008: Conclusions Session

MR. NICHOLAS SABATINI: Good morning. What a week this has been! As Dr. Mallis told us on Tuesday morning, we have 325 aviation safety professionals from eight countries here this week (see Appendix D). We have the world's leading experts on sleep, fatigue, performance measurement, mitigation and aviation safety. We have people who have known each other, who have worked with each other, and who have wrestled with these issues for years.

And, what a symposium it has been! Yet, hasn't it been a study in contrasts — to be at a conference on fatigue, and to feel so much energy in the room.

Conferences like this do not just happen. Any conference takes a lot of planning and coordination and work. Good conferences take even more planning and coordination and participation. Great conferences take work, yes, but they also require planning by experts and participation by professionals. To our conference planners, speakers, and participants: This has been a great conference. For me, I can tell you that this has been an outstanding professional and personal experience.

Thank you all and I will single out the dynamic duo of FAA's Rick Huss and Dr. Melissa Mallis of the Institutes for Behavioral Resources for their A-plus work on this symposium and for all their work fostering the "collegial energy" here this week.

For this symposium, we, at the FAA, set out to accomplish three things:

- Provide the most current information on fatigue physiology, management, and mitigation alternatives;
- Share information and perspectives among decision makers and scientists about fatigue management; and
- Discuss fatigue mitigation concepts and best practices.

We accomplished all three. Tuesday, we immediately got off to a great start with our keynote speakers.

Acting Administrator Bobby Sturgell put the issue right on the table when he said, "Fatigue can kill." That is why we are here. He said that "even with an outstanding safety record, we're not where we need to be when it comes to understanding and managing fatigue."

Then, we had a great history presentation from NTSB Vice Chairman Robert Sumwalt. Looking at those early air mail letters was a powerful reminder of why we are here this week. Why we do what we do. And, how fatigue is a timeless, yet timely, issue. As Mr. Sumwalt reminded us, "Fatigue is real and it does affect safety."

Next, we turned to the science and we got an excellent state–of–the–science snapshot from Dr. David Dinges. The easy way to sum up his fact-filled presentation can be done in six words: Sleep is good. Everyone needs more.
Yet, those six words do not begin to do justice to this presentation from one of the world's leading authorities on sleep and human performance. Dr. Dinges rightly pointed out that fatigue is not an aviation issue, nor is it limited to transportation. Fatigue risk management is a universal issue and, as he said, with our modern society, it will remain so.

Dr. Dinges reminded us, "We are biological creatures … and "our ability and desire to go further than our biology can lead to disaster" … if we don't take steps to properly manage and mitigate it.

One thing this week's session has made very clear: We have science and technology on our side. We can use technology to predict and detect vulnerabilities. We can use data and technology to be proactive and take preventive measures, and we can use them to help with interventions and mitigation strategies.

Three things that Dr. Dinges said really resonated:

- One, he urged us to leverage what has already been done for other federal agencies — such as the Air Force, NASA, and NHTSA.
- Two, the U.S. must come to grips with novel and creative ways to manage fatigue.
- And, three, our children will make change happen.

I'll come back to those points. They are important.

Next, we heard from the NTSB and we heard very clearly in a data-rich presentation why the Board has recommended actions on fatigue.

On the panel on Fatigue Risk Management Systems and SMS, Boeing's Curt Graeber gave his own history lesson about the work that has been done on fatigue management. Yes, Curt, research and data are available, and the time is now to determine the best way to apply existing science and knowledge to operations. Yes, indeed, it is time to "stop thinking about tomorrow."

And, as Captain New reminded us: Safety management begins from the top down.

Just as illuminating as the panels were the sidebar conversations, with their intensity and passion. With our current work on data sharing and analysis, I appreciated Mary McMillan's comment that, "Fatigue is the advertisement for the effectiveness of ASAP."

Yesterday, day 2, was rich in mitigation strategies and best practices. Across the globe, many are putting the science to work for their organizations. We heard from NAV CANADA about its science-based comprehensive approach, which includes education, alertness strategies, and scheduling practices.

We heard from EasyJet and United Airlines about their understanding of fatigue risk management and the controls they put in place. Mitigation is the key word here. Which brings me to one of the most important points raised this week: Measurement.

Aviation has come so far. Across the board, we have a much greater appreciation that you cannot manage what you do not measure. With measurement comes evaluation and evaluation enables continuous improvement. And, in aviation's dynamic environment continuous improvement is essential.

FAA's Greg Kirkland provided a rulemaking overview. While rulemaking in this area may be in the future, rulemaking is tough. And, it takes a long time.

We need to start now, working together, to address and mitigate risk. Yes, we need to balance science with safety and with operational realities. Not everyone can travel, or work, on 9-to-5 schedules. And, we are a global economy with 24 time zones. I think everyone understands after this week that domestic short legs, as well as shift work, present challenges as —or more — difficult than long-haul flying.

As you heard yesterday, we will make the proceedings available in six to eight weeks. This morning's report-outs captured the work of the discussion groups on identifying challenges, barriers, and potential mitigation concepts.

As for challenges, I have to agree with the multi-leg / short-haul group: "12 hours in Detroit is not the same as 12 hours in Palm Beach."

The challenges are many. As you heard, rulemaking is tough. Gary Thompson of Delta Air Lines summed it up for the TransCon discussion group: "Under the current rules, you can be legal, but not safe, and safe, but not legal."

The International Long-Haul Group and the Multi-leg / Short-haul Group came to the same conclusion: About the paramount importance of education across all the stakeholders. Knowledge and understanding are key.

The Maintenance / Ramp Operations / and Dispatch group agreed that counter-measures to fatigue must consider both individual responsibilities as well as organizational responsibilities, and "organization" includes employer, union, and professional organization.

Ken Myers of the ATC / Tech Ops group joked that they "would not *rest* until they solved this fatigue issue." Seriously, this group was energized by the challenge to address the significant human performance differences between controllers and technicians … and to develop fatigue mitigation strategies.

We just heard from a panel of experts, and to a one, they reinforced the wisdom of our conference planners in naming this symposium: partnership for solutions.

Together, we can address fatigue. Together, we manage fatigue issues.

Alone, we cannot.

In that regard, I would like to add my sincere thanks to our Discussion Group facilitators, panel leaders, and scribes. They invested their time and their impressive leadership to prepare for, and lead, productive discussions. These discussions have expanded and clarified our understanding of issues, which built on the outstanding scientific presentations that we have heard this week. Their hard work has delivered to us the product of this landmark event. To each of you – THANK YOU.

After a week like this, it is really important, no, it is imperative, that no one go back to our workplace next Monday to "business as usual." As if there is ever "business as usual" in aviation!

This week, we wanted to have a conversation. We wanted to share the science and best practices. We also want to maintain momentum. As Acting Administrator Sturgell urged us, we wanted you to think outside the box this week. And, we got a great start with the discussion groups to come up with novel and creative ways to manage fatigue.

Look beyond aviation; we do not have all the answers. And, as you build and expand your Fatigue Risk Management Programs, develop younger talent. As Dr. Dinges said, "Our children will make change happen."

In closing, on Tuesday morning Vice Chairman Sumwalt was eloquent in his evocation of Lindbergh's historic transatlantic crossing. I will close by repeating one of the Lindbergh quotations that we heard on Tuesday. Lindbergh wrote: "Nothing that life can attain is quite so desirable as sleep."

I agree! And, after this intense week … of hard science … of hard work … and of hard discussions, we are all rightfully fatigued. I urge you all to go home, say hello to your families, and get some sleep — deep restorative sleep.

Then, on Monday, after you have paid your sleep debt in full, it is back to work. Use the facts and science, the networks and the resources that you gained this week.

Take what you learned to make aviation safer for all those people who depend on us.

Thank you, again, for your participation, your passion, and for everything that you do for aviation safety.

Biography

Nicholas A. Sabatini became Associate Administrator for Aviation Safety, effective Oct. 15, 2001. Mr. Sabatini is responsible for the certification, production approval, and continued airworthiness of aircraft; certification of pilots, mechanics, and others in safety-related positions. He is also responsible for certification of all operational and maintenance enterprises in domestic civil aviation; development of regulations; civil flight operations; and the certification and safety oversight of some 7,300 U.S. commercial airlines and air operators. Mr. Sabatini oversees some 6,800 employees in FAA Washington Headquarters, nine regional offices, and more than 125 field offices throughout the world. The FAA's annual aviation safety budget is over $1 billion.

At the time of his appointment, Mr. Sabatini was director of FAA's Flight Standards Service. From 1990 until May 2001, he was manager of the Flight Standards Division for FAA's Eastern Region. From 1979 to 1990, he served in a variety of aviation operations and management positions in the agency's Eastern Region, as a principal operations inspector, aviation safety inspector, manager of the Flight Standards Division Operations Branch, and assistant manager of the Flight Standards Division. Prior to joining the FAA in 1979, Mr. Sabatini was a pilot for the U.S. Customs Service in New York. From 1958 to 1976, he was a police officer and helicopter pilot for the New York City Police Department. He served in the U.S. Army from 1956 to 1958.

Mr. Sabatini holds an airline transport pilot certificate and the following ratings: Airplane multi-engine land, rotorcraft-helicopter, DC-9, CE-500, BH206, EMB110, commercial privileges, airplane single-engine land, as well as flight and ground instructor certificates. He attended the John Jay College of Criminal Justice; the Kellogg School, Northwestern University; and the Fletcher School of Law and Diplomacy, Tufts University.

Mr. Sabatini was recognized in 2002 with the Aviation Week & Space Technology magazine's Laurels Award for his vision and actions that expedited the publication of the landmark document, "Criteria for Approval of Category I and Category II Weather Minima for Approach." In 2003, the Air Transport Association's Engineering, Manufacturing and Materiel Committee awarded him its "Nuts and Bolts" award for outstanding contributions to the airline industry. In 2006, the Aircraft Electronics Association recognized Mr. Sabatini with its Industry Partnership Award. In 2007, Aviation Week & Space Technology nominated Mr. Sabatini for a Laureate Award for his leadership in FAA's Aviation Safety organization achieving ISO 9001:2000 registration. This made Aviation Safety the largest government entity to operate under a single Quality Management System. In 2007, Mr. Sabatini was elected a Fellow of the Royal Aeronautical Society.

Mr. Sabatini is a member of the Auburn University Aviation Management Advisory Board. The Board provides guidance in support of the University's aviation management program's instruction, research, and outreach.

Parallel Session

Current State of Mitigation: Shiftwork Operations

Fatigue Risk Management Systems in the Canadian Aviation Maintenance Industry

Ms. Jacqueline Booth-Bordeau
Transport Canada Civil Aviation

9:00 - 9:25

June 18, 2008

Jacqueline Booth-Bordeau
Biography

Jacqueline is the Chief, Technical Program Evaluation and Coordination with Transport Canada's Standards Branch. Jacqueline's current responsibilities include the coordination of the Civil Aviation domestic and international regulatory program, technical program evaluation, safety promotion and regulatory initiatives that span all aspects of the Civil Aviation program.

Jacqueline is currently involved in the development of regulations and guidance material relating to safety management systems (SMS) and has worked on all aspects of SMS within Civil Aviation. Her previous position involved developing human factors training standards within the aviation maintenance sector. Her current projects include the revision of Civil Aviation advisory material supporting the implementation of SMS regulations in airports, maintenance and flight operation organizations. She is also working on the development of a Civil Aviation plan for alternative forms of regulatory surveillance and other infrastructure projects supporting the implementation of SMS throughout Transport Canada Civil Aviation.

In addition to SMS, Jacqueline has been involved with a Transport Canada research project looking at fatigue in aviation maintenance and flight operations. The project is part of a four-phased effort designed to increase awareness of fatigue in the maintenance environment and provide practical and risk based solutions for dealing with fatigue. The culmination of this work is a FRMS toolbox and assessment protocol for implementing and assessing fatigue risk management systems.

Jacqueline holds Bachelors and Masters degrees as well as a diploma in Aviation Safety from the University of Southern California.

Transport Canada's FRMS Approach

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Presentation Outline

- Transport Canada and Fatigue Risk Management
  - Background to FRMS
  - Research into fatigue in the maintenance environment
  - Transport Canada's FRMS Model
  - What's involved

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Background

SATOPS Report Recommendation:

- Transport Canada should "initiate a Canadian Aviation Regulation Advisory Council (CARAC) review to determine if aircraft maintenance engineers (AMEs) duty times should be regulated, and if so, determine appropriate limitations."

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Background (cont'd)

Survey on hours of work of Aircraft Maintenance Engineers (AMEs) in Canada

- Fatigue and excessive periods of work may be present in the work force
- Other surveys of AMEs showed similar results:
  - S. Folkard, 2003: Work Hours of Maintenance Personnel; UK CAA
  - Sian & Watson, 1999: Study of Fatigue Factors Affecting Human Performance in Aviation Maintenance, USA: FAA

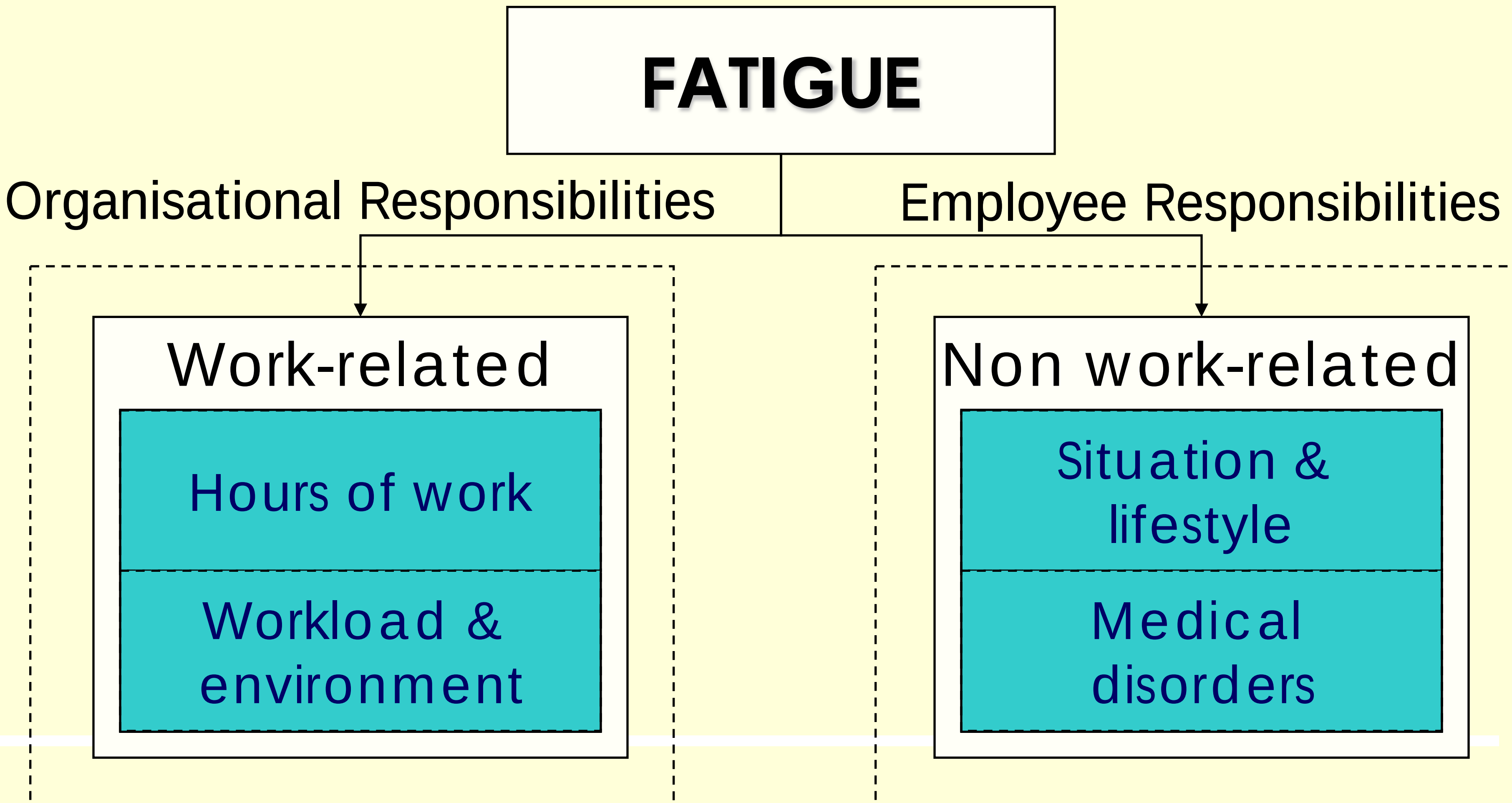
Rulemaking: CARAC Technical Committee

- Options proposed:
  – Status Quo
  – Duty Time Regulation
  – Fatigue Risk Management Approach
- FRMS emerged as the preferred option
  - Caveats:
    – Develop support tools
    – Integrate in to the SMS requirements

What is a Fatigue Risk Management Program?

- A Fatigue Risk Management System is a *systematic method whereby an organization optimizes the risks associated with fatigue related error*

Joint Responsibility



TC Approach

- Transport Canada proposed to adopt FRMS comprising three levels of activities:
  - Development of policy statements for the management of fatigue
  - Training and education programs for all employees
  - Fatigue audit systems to assess fatigue levels within an organization

Contents of TC's FRMS Toolbox

- ***FRMS for the Canadian Aviation Industry: Introductory Booklet (TP14572)***
  - Introductory materials designed to raise awareness about fatigue
- ***FRMS for the Canadian Aviation Industry: Fatigue Management Strategies for Employees (TP 14573)***
  - Provides the knowledge and skills required to apply appropriate fatigue management strategies at the individual level
- ***FRMS for the Canadian Aviation Industry: Employee Training Assessment (TP 14574)***
  - An optional module intended to assess employee competence in topics covered in the Applied Strategies Workbook

Contents of TC's FRMS Toolbox

- ***FRMS for the Canadian Aviation Industry: Developing and Implementing a Fatigue Risk Management System (TP 14575)***
  - Teaches how to manage the risks associated with fatigue at the organizational level within a SMS framework
- ***FRMS for the Canadian Aviation Industry: Policy and Procedures Development Guidelines (TP 14576)***
  - Proposes a policy structure while providing guidelines and examples to help organizations through the process of designing FRMS policies and procedures
- ***FRMS for the Canadian Aviation Industry: Fatigue Audit Tools (TP 14577)***
  - Proposes two types of tools to help employers determine whether scheduling provides adequate opportunities to obtain sufficient sleep
- ***FRMS for the Canadian Aviation Industry: Trainer's Handbook (TP 14578)***
  - Provides background information for delivery of the employee training workshop, including descriptions of training techniques, learning outcomes and questions frequently asked by participants

FRMS Structure & Strategy

Hazard Control Model

	Hazard Assessment	Error Trajectory	Control Mechanism
Latent Errors	Sleep Opportunity	1	Rules of rostering Fatigue Modeling
	Sleep Obtained	2	Prior Sleep/Wake Data
	Behavioral Symptoms	3	Symptom checklists Self-report behavioral scales Physiological monitoring
Active Errors	Fatigue-related errors	4	Fatigue-proofing strategies Error analysis system
	Fatigue-related incidents	5	Incident analysis system

FRMS Policy

- Senior Management Commitment
- Purpose and goals of the FRMS
- Responsibilities for all employees managing fatigue risk
- Training Requirements
- Reporting Procedures for Fatigue-Related Hazards
- Fatigue Reporting Procedures (including non-punitive and punitive actions taken as a result of non-compliance)
- Procedure for the Evaluation and Continuous Improvement of the FRMS

FRMS Policy cont.d

Each section of the policy document is divided into three sections:

- *Guidance notes*: information about the purpose, theory and framework of the given policy component
- *Points to Consider*: a summary of the main points to be considered in the given policy component. These have been framed as questions, which can be used as a framework for discussing the core components of an FRMS in consultation workshops
- *Sample Text:* examples of what might be considered in a policy component section

FRMS Policy Example

Responsibilities of Company Personnel

Guidance: You must ensure that responsibilities for fatigue risk management are specified in the organizational structure. This is likely to include:

- Safety Manager
- Person Responsible for the FRMS
- The SMS/FRMS Committee
- Employees

Points to Consider:

- What are the specific expectations and responsibilities of each subgroup of employees for managing fatigue within the context of the FRMS?
- How do those responsibilities fit within the organizational structure?

FRMS Policy Example

Sample Text: Accountable Executive

The Accountable Executive is responsible for oversight of minimizing the risks associated with work-related fatigue. Accordingly, the Accountable Executive will:

- Encourage a workplace culture to manage fatigue-related risk effectively
- Advise Transport Canada of any changes to the FRMS
- Provide oversight and direction to the person responsible for the FRMS and/or committee during FRMS design, implementation and review
- Provide appropriate resources to effectively implement and maintain the FRMS
- Ensure compliance of the organization with the FRMS policy.

Training and Education Program

- Introductory Fatigue Training (TP 14573)
- Employee Training Assessment (TP 14574)
- Employee Training: Competency-based, with Assessment Unit for Competency Certification

http://www.shiftwork.com.au/

- Management Training or “How to Develop and Implement a FRMS” (TP 14575)
- Trainer’s handbook (N/A)

Education and Awareness

- Sleep (good sleep hygiene)
- Napping (the restorative power)
- Shift work and digestion
- Drinking water
- Caffeine, alcohol and sleeping pills
- Family issues (pressures on shift-working families)
- Social life issues
- Commuting

Education and Awareness (cont.d)

- The shift system (rostering)
- Shift Length (advantages and disadvantages of long shifts)
- Fatigue and performance
- Health impacts of shift work
- Physical exercise
- Information on what you individual responsibilities and those of your employer are in regards to fatigue.*

Internal Evaluation Methodologies

- Shift scheduling reviews
- Fatigue level assessments
- Risk management techniques
- Work and rest standards

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

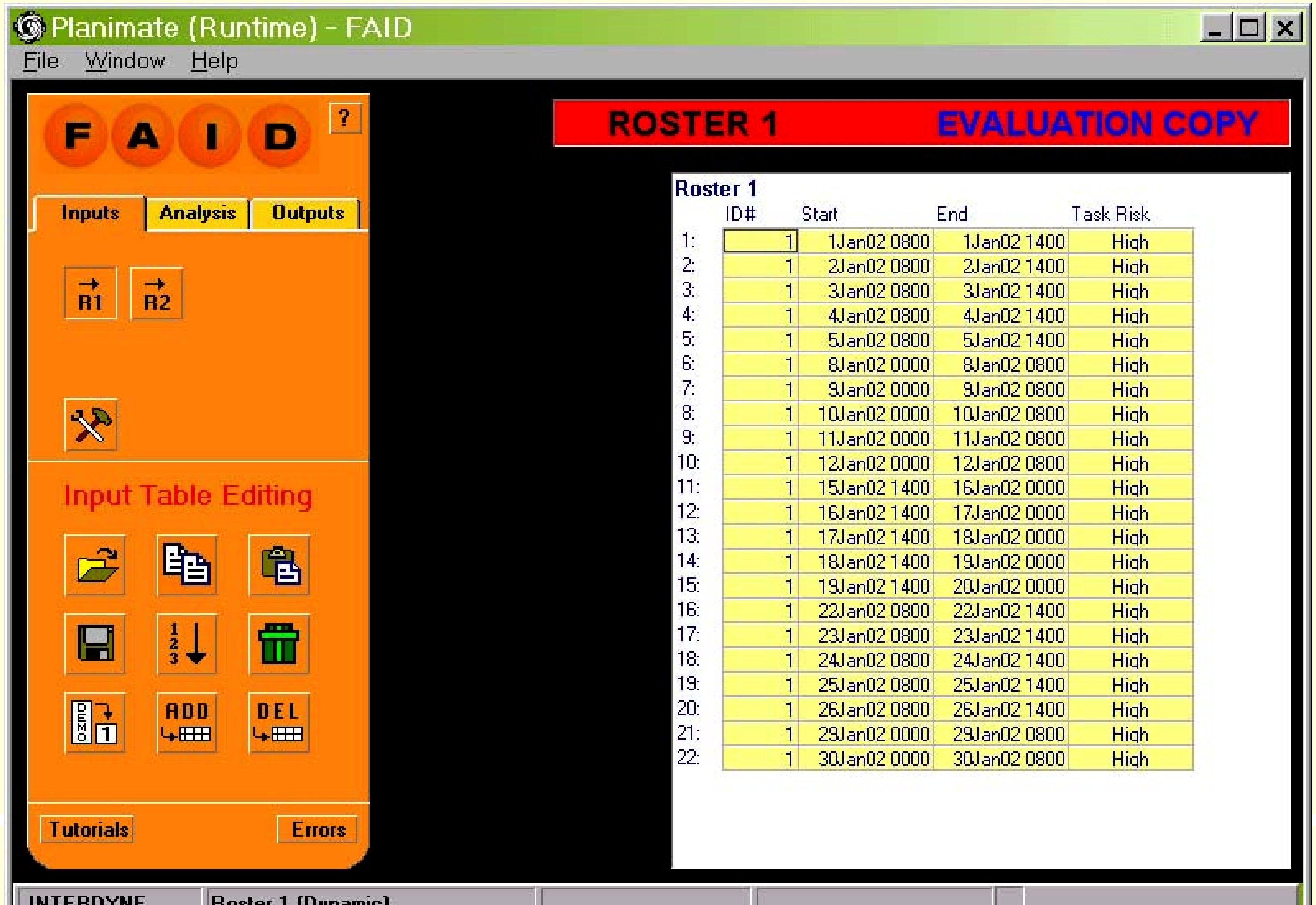
Fatigue Audit Tools

- Assessment of work schedules for sleep opportunity
    - Biomathematical Modelling (FAID)
    - Fatigue Likelihood Matrix Score (paper & pencil method)
    - Hours of Service Rules

Quantifying prior sleep and wake

- Low tech - prior sleep wake model
  - Count sleep prior to commencing work
  - Count wake time until end of shift
  - Simple, objective, easy suited to employees and management
  - /Pilot, spreadsheet and/or paper-and-pencil versions available
- Software-based fatigue estimation algorithm using evidence based data collected from workers
  - length and time-of-day of shifts and breaks
  - prior work history
  - biological limits to rest and recovery

Data Input



Planimate (Runtime) - FAID
File Window Help
FAID
?
Inputs Analysis Outputs
R1 R2
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Errors
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Roster 1
ID# Start End Task Risk
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2: 1 2Jan02 0800 2Jan02 1400 High
3: 1 3Jan02 0800 3Jan02 1400 High
4: 1 4Jan02 0800 4Jan02 1400 High
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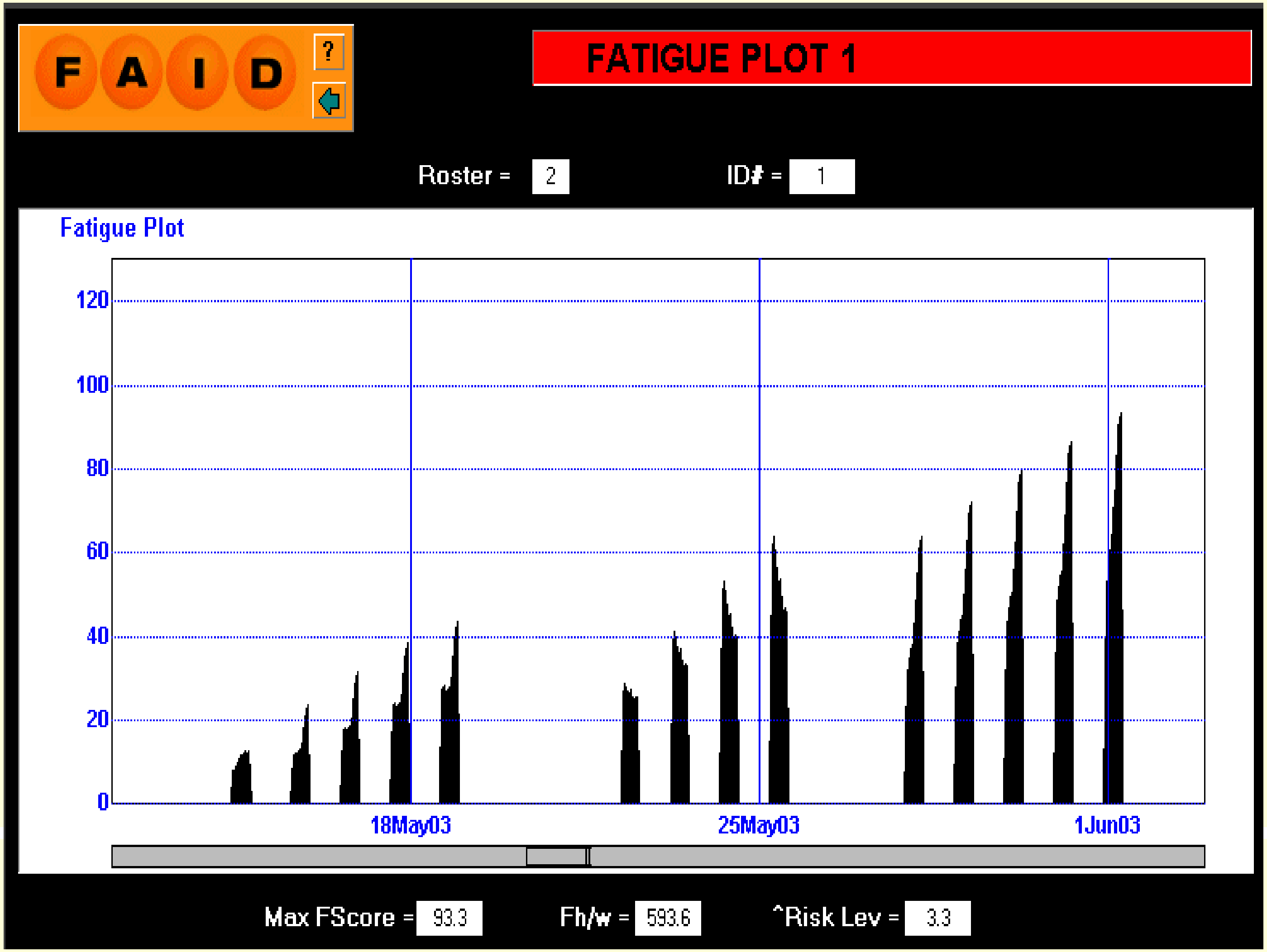
INTERDYNE
Roster 1 (Dynamic)

Data Output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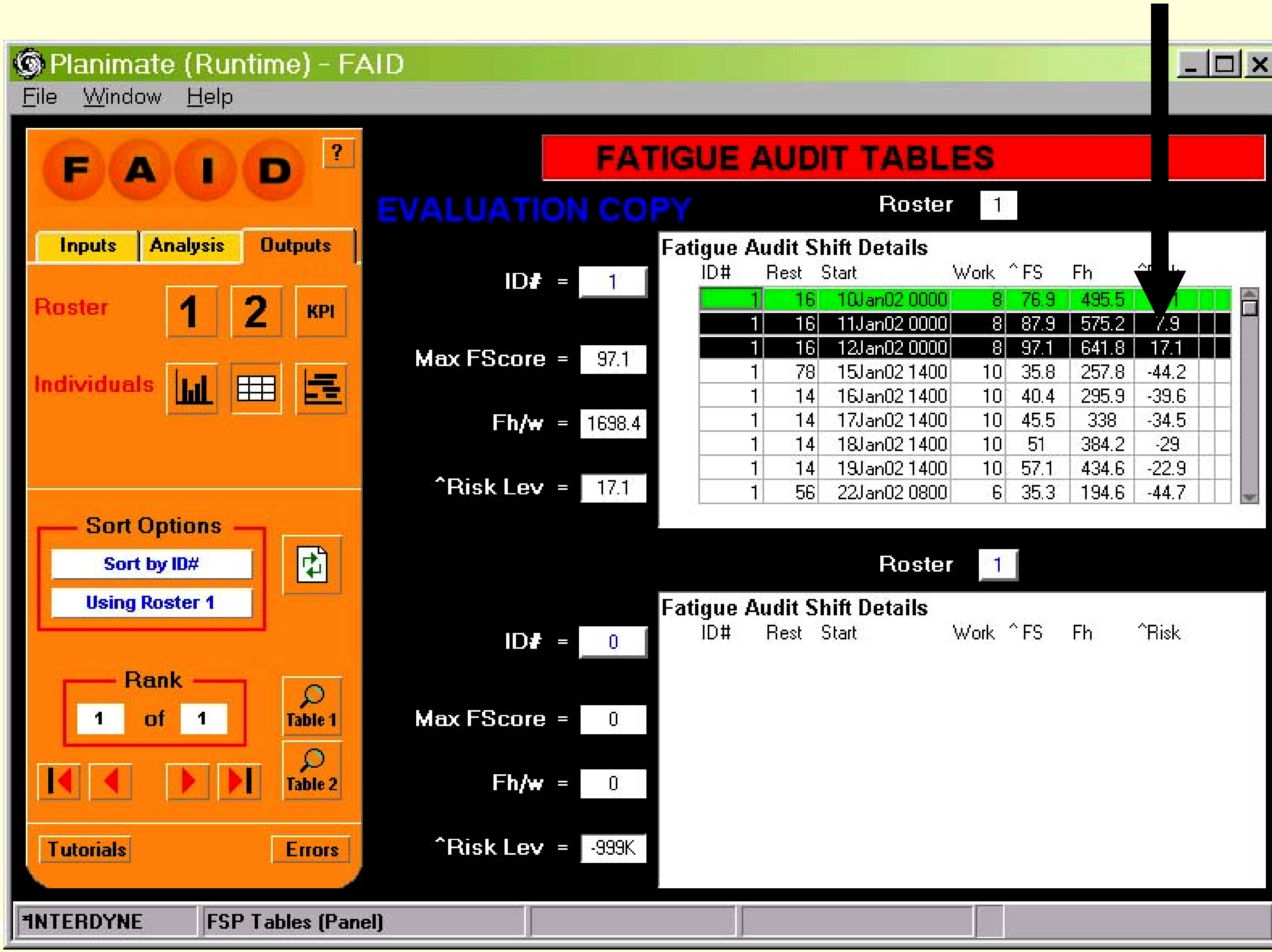
FATIGUE PLOT 1
Roster = 2
ID# = 1
Fatigue Plot
120
100
80
60
40
20
0
18May03
25May03
1Jun03
Max FScore = 93.3
Fh/w = 593.6
^Risk Lev = 3.3

Fatigue violations are flagged



Free Evaluation Copies

www.interdynamics.com.au/faid

Paper and Pencil Models

- Assess Prior Sleep and Wake (actual level of sleep achieved)
- Identify Presence of Fatigue-Related Symptoms
- Incident Investigation Protocols

Ensuring Adequate Sleep Opportunity

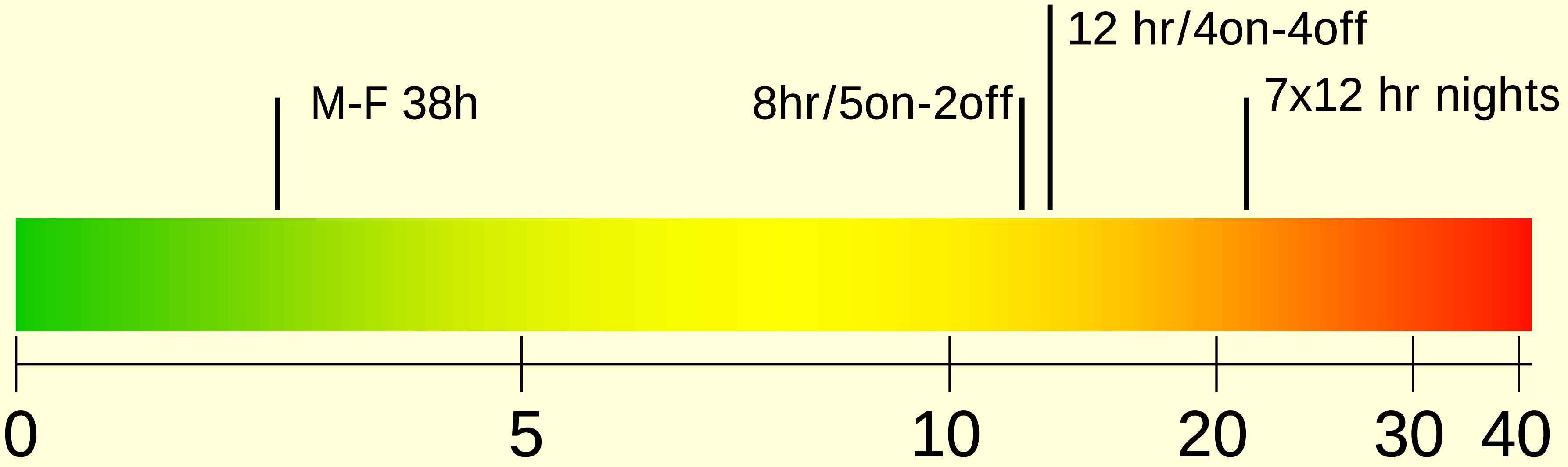
- 5 dimensions that indicate the likelihood of work-related fatigue associated with a given schedule:

  1. Hours worked per 7 days
  2. Shift duration
  3. Short break duration [work-sleep-work]
  4. Hours of night work per 7 days [9pm-9am]
  5. Long break duration per 7 days

Work-Related Fatigue Likelihood Assessment

Schedule Dimension	0	1	2	4	8
Max Hours per 7days	≤ 36h	36-43h	44-47h	48-54h	55+
Maximum Shift Duration	≤ 8h	8-10h	10-12h	12-14h	≥14h
Minimum 'Short Break' Duration	≥16h	16-13h	12-10	10-8h	≤ 8h
Max Hours of Night Work per 7 Days	0h	1-8h	8-16h	16-24h	≥24h
'Long Break' Frequency	≥ 1/7d	≤ 1/7d	≤ 1/14d	≤ 1/21d	≤ 1/28d

Estimating Fatigue Likelihood



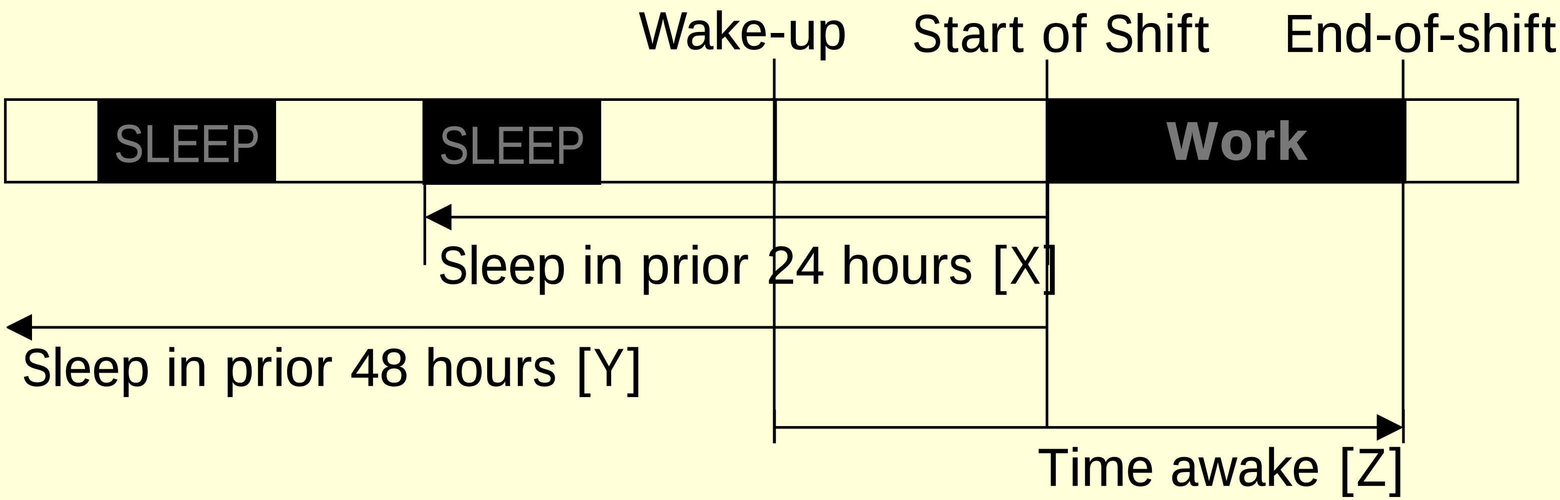
Fatigue Likelihood Score [FLS]

The point score associated with an assessment of each of the 5 dimensions of the roster can be calculated and rated on the scale above. It may be possible to regulate that rosters with a FLS greater than 5 require significant controls beyond level 1

Possible Methodologies

- Sleep Diaries
- Activity Monitors
- Prior Sleep/Wake Model

Prior Sleep & Wake Rules



X = Sleep in Prior 24 Hrs	Y = Sleep in Prior 48 Hrs	Z = Time Since Last Sleep

As prior sleep decreases and prior wake increases the likelihood of fatigue [symptoms, errors and incidents] also increases. In general, **X** should be greater than threshold **[5],** Y should be greater than threshold [**12**] and **Z** should be less than **Y**

Mutual Obligation using Prior Sleep/Wake Rule

- **[the start rule]** Must obtain X [5] hrs sleep in the 24hrs prior, and Y [12] hrs sleep in the 48hr prior to commencing work.

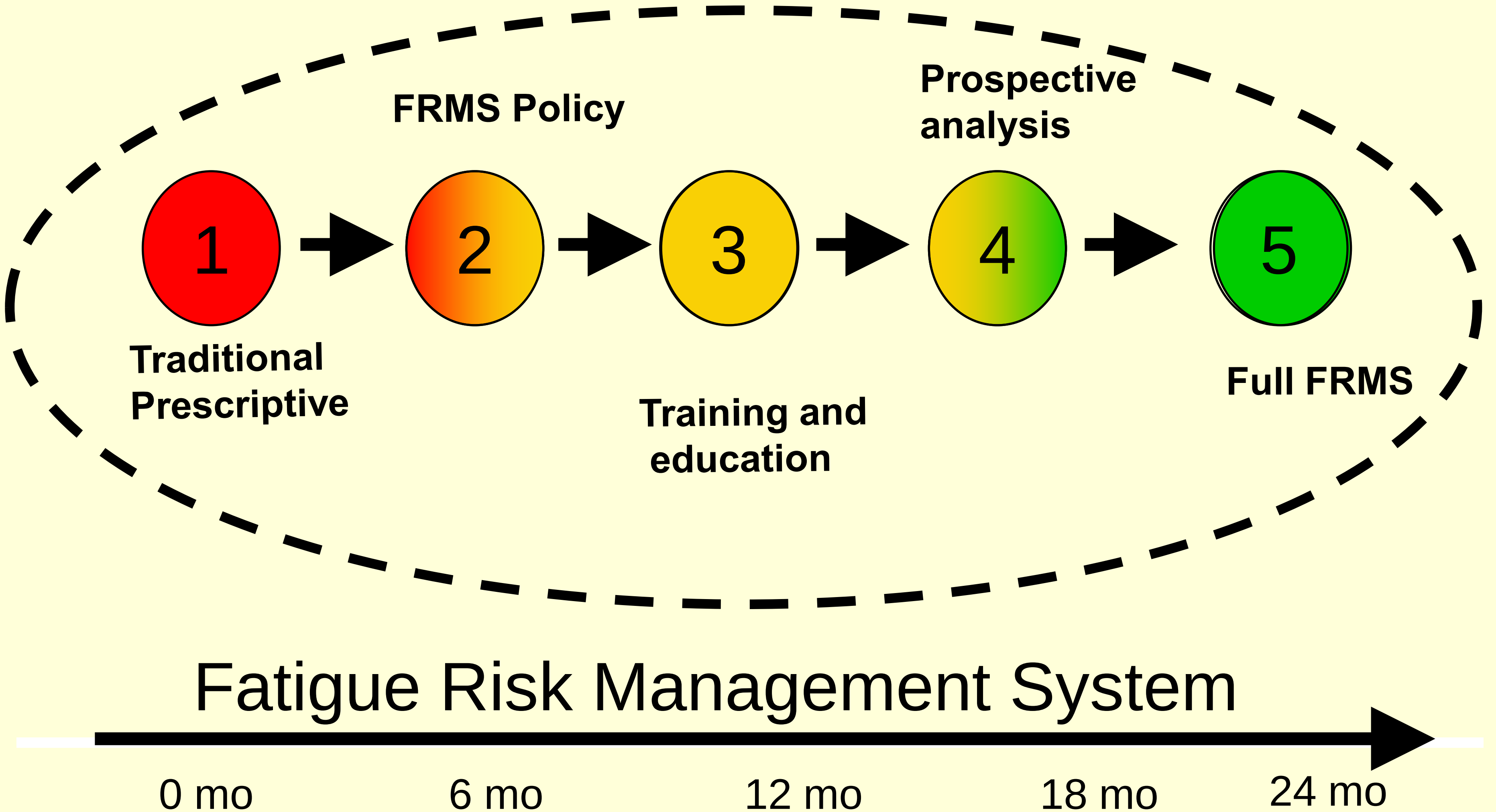
- **[the finish rule]** The period from wake-up to the end of shift should not exceed the amount of sleep obtained in the 48 hrs prior to commencing the shift

- **[the action rule]** If either rule is broken, fatigue is a potential problem and the individual should notify their line manager and the organisation should engage in an auditable risk reduction action

Calculate Fatigue Likelihood Score

- An example scoring system [n.b. the points are arbitrary]
  - Add **4 points** for every hour of sleep below the **24 hour** prior sleep threshold [X]
  - Add **2 points** for every hour of sleep below the **48 hour** prior sleep threshold [Y]
  - Add **1 point** for every hour of work beyond the **prior wake** threshold [Z]
  - **Sum and refer to decision tree to determine appropriate response.**

FRMS Development



Assessing FRMS

- Transport Canada's FRMS assessment guide
- Assesses compliance and effectiveness
- Comprises:
  - ✓ Expectations – framework of what you expect to see
  - ✓ Questions – open ended, all levels in the organization
  - ✓ Scoring Criteria – 1-5 score, 3 = compliance
- Inspectors will use FAID to make an initial determination of whether a schedule is acceptable or not

Need more information?

http://www.tc.gc.ca/civilaviation/SMS/FRMS/menu.htm

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Joint Session

Operational Drivers of Fatigue: National Transportation Safety Board Findings

Operational Factors Contributing to Fatigue during Flight Operations

Malcolm Brenner, Ph.D.
National Transportation Safety Board

10:20 - 10:40

June 17, 2008

Malcolm Brenner, Ph.D.
Biography

Malcolm Brenner is a National Resource Specialist – Human Performance at the National Transportation Safety Board (NTSB) Office of Aviation Safety.

He holds a B.A. degree from Boston University, M.A. degree from Stanford University, and Ph.D. from the University of Michigan in Psychology.

Before joining the Safety Board, Dr. Brenner conducted research on human performance for the National Aeronautics and Space Administration (NASA) and the U. S. Air Force and served as an expert witness for the U.S. Senate Judiciary Committee and for litigation resulting from major aviation accidents representing both plaintiff and defense positions. Since joining the Safety Board, he has helped investigate human performance issues in dozens of major transportation accidents including those involving USAirways Flight 427 at Pittsburgh. Dr. Brenner is a private pilot.

NTSB National Transportation Safety Board

Operational Issues from Fatigue

Malcolm Brenner, Ph.D.

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Fatal Airline Accidents

- 8/97 Guam: 228 fatalities
- 6/99 Little Rock, AR: 11 fatal
- 10/04 Kirksville, MO: 11 fatalities

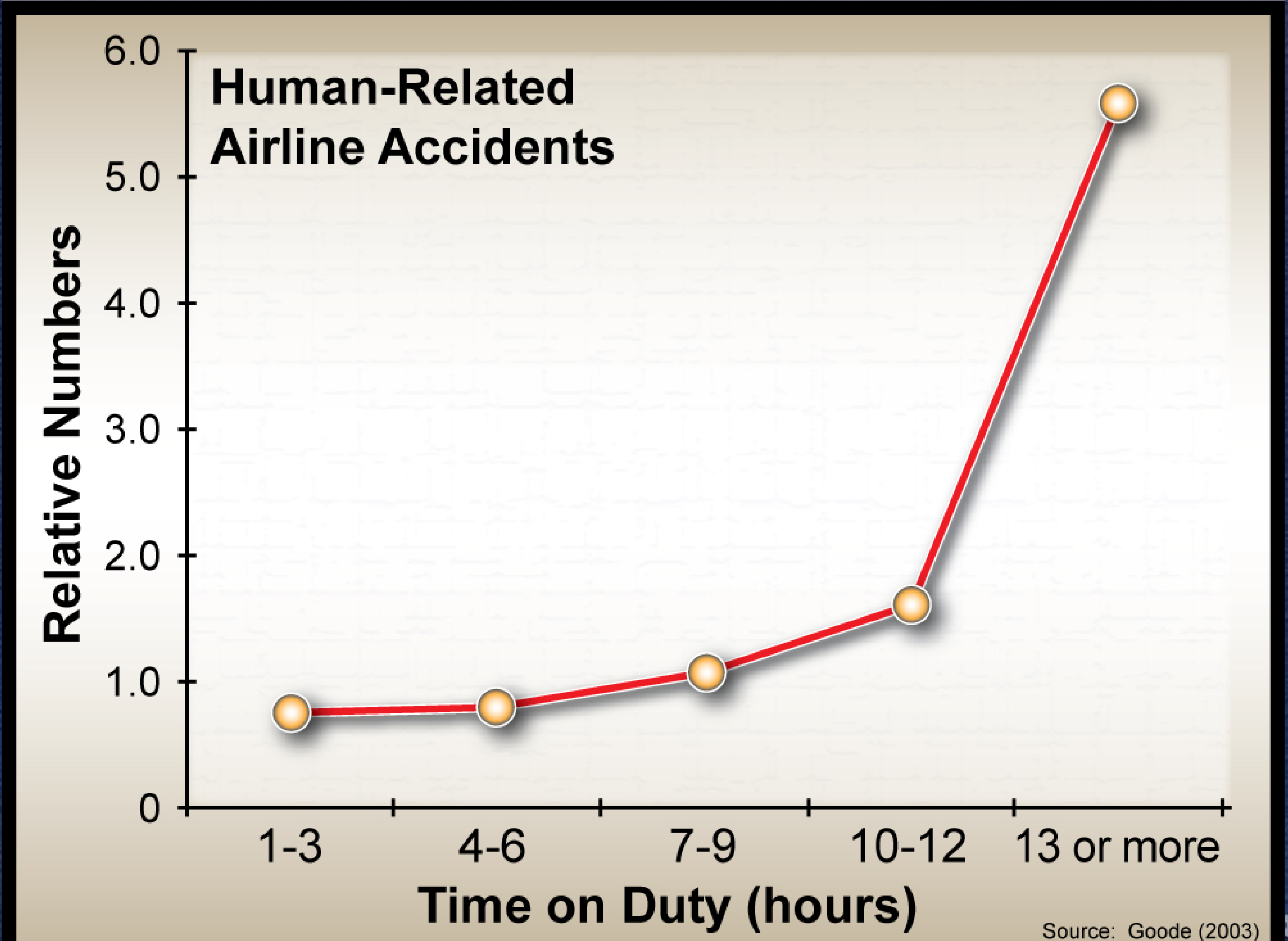
Non-Fatal Airline Accidents

- 8/93 Guantanamo Bay, Cuba
- 7/02 Tallahassee, FL
- 2/07 Cleveland, OH
- 4/07 Traverse, City MI

Long Duty Day

NTSB

Long Duty Day



Back of Clock

Workload

NTSB

Attendance Policy

Education

Medical Screening and Treatment

Commuting Policies

Nutrition

National Transportation Safety Board

- Long duty day
- Back of clock
- Workload
- Education
- Attendance policy
- Medical screening and treatment
- Commuting policy
- Nutrition

NATIONAL TRANSPORTATION SAFETY BOARD

NTSB

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Fatigue Deficiencies

• Guantanamo	Ignored stick shaker
• Guam	descended below altitude profile
• Tallahassee	Ignored solid red PAPI for 40 seconds
• Little Rock	Failed to deploy spoilers
• Kirksville	Descended below MDA
• Cleveland	Lost visibility of field

Parallel Session

Operational Evidence of Fatigue: Flight Operations

Sleep and Psychomotor Performance during Commercial Ultra-Long Range Flights

John A. Caldwell, Ph.D.
Archinoetics, LLC

14:20 - 14:45

June 17, 2008

John A. Caldwell, Ph.D.
Biography

Dr. John Caldwell has over 21 years of experience conducting applications-oriented research and development aimed at improving safety and performance in operational contexts. He has conducted numerous studies in specialized laboratories and specially-instrumented flight simulators and aircraft, and he has collected and analyzed a wide variety of cognitive, mood, physiological, and flight-performance data from pilots. He has developed and delivered a number of tailored aviation counter-fatigue workshops and well over 100 presentations to physicians, pilots, scientists, and the general public. He has published one book, six book chapters, over 32 first-author peer-reviewed scientific papers, and more than 60 first-author articles in user-focused journals, conference proceedings, and government reports. He is a fatigue-management consultant for a major airline, NASA, the Army, the Air Force, and the Marines. Before joining Archinoetics, Dr. Caldwell was employed by the U.S. Air Force and the U.S. Army, conducting research, training, and consultations designed to enhance and sustain the effectiveness of the operational aviation community. He has completed two assignments with NASA's Human Factors Division at Ames Research Center in California where he focused on counter-fatigue research and applications aimed at aviation and space personnel.

Effects of Fatigue on Operational Performance

John A. Caldwell, Ph.D.
Senior Scientist
Aviation Fatigue Countermeasures Research
Archinoetics, LLC
John@archinoetics.com

This presentation will cover four topics

- Quick overview of the primary causes of pilot fatigue
- A summary of the general symptoms of pilot fatigue
- A review of what controlled studies have revealed about the impact of fatigue on basic piloting capabilities
- A look at how fatigue-induced decrements translate into operational performance problems

What are the primary sources of pilot fatigue

Both long-haul and short-haul pilots commonly associate fatigue with scheduling issues

- Night flights (operating at circadian low point)
- Multiple time-zone crossings (jet lag)
- Early wakeups (truncated sleep)
- Time pressure (increased workload)
- Multiple flight legs (extended work periods)
- Consecutive duty periods without sufficient recovery time (chronic sleep loss)

Rosekind, Gregory and Miller, 2000

Regional pilots also say scheduling factors are top contributors to operational fatigue

- Multiple take-offs and landings every day (chronically high workload)
- Continuous-duty overnights (shift lag)
- Reserve status (acute sleep deprivation)
- Night flights (operating at circadian low point)
- Early report times (truncated sleep)
- Breaks that are too short to eat or nap
- Extended breaks that translate into long work hours with minimal flight time

Co et al., 1999

What are some of the symptoms of pilot fatigue

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

ARCHINOETICS

Fatigue degrades performance and mental abilities

- Accuracy and timing degrade
- Lower standards of performance become acceptable
- Attentional resources are difficult to divide
- A tendency toward perseveration develops
- The ability to integrate information is lost
- Everything becomes more difficult to perform
- Social interactions decline
- The ability to logically reason is impaired
- Attention wanes
- Attitude and mood deteriorates
- Involuntary lapses into sleep begin to occur

Falling asleep on the flight deck is a common result of fatigue

- Objectively-measured crew micro-sleeps have been documented during many revenue flights
- Approximately 50% of military pilots admit to having fallen asleep in the cockpit
- Eighty percent of regional pilots say they have nodded off during a flight
- Seventy-one percent of corporate/executive pilots have made a similar admission
- But remember: *Long before nodding off occurs, performance is already impaired!*

Petrie and Dawson (1997), Co et al. (1999), Caldwell & Gilreath (2001)

After several hours of continuous wakefulness, alertness decrements in the cockpit are clear

Caldwell, Caldwell, Smith, and Brown (2004)

ARCHINOETICS

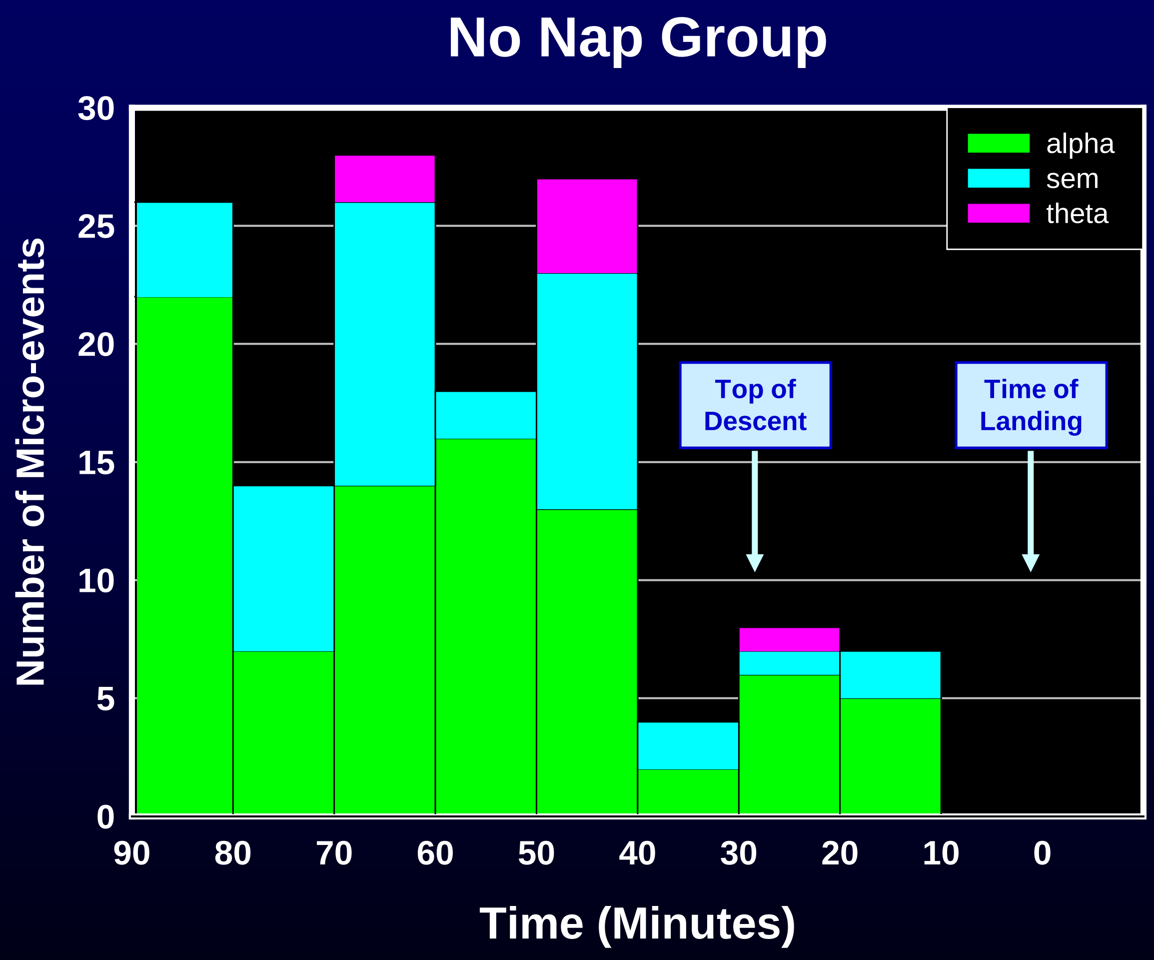
Fatigue produces clear and dangerous neurophysiological effects

- **Long-haul pilots are particularly susceptible to vigilance lapses during cruise segments, but sleepy pilots will lapse *anywhere***
- **Lapses are more pronounced during return trips than during outbound trips**
- **The longer the flight, the greater the probability of spontaneous micro-sleeps**
- **Micro-sleeps are *9 times more likely during night* flights than day flights**
- **One night-flight simulation study revealed outright sleep episodes in *over half* the subjects**

Cabon et al. (1993), Wright & McGown (2001), Samel, Vegman, & Vejvoda (1997), Neri et al. (2002)

ARCHINOETICS

Operational research has shown that microsleeps occur even on final



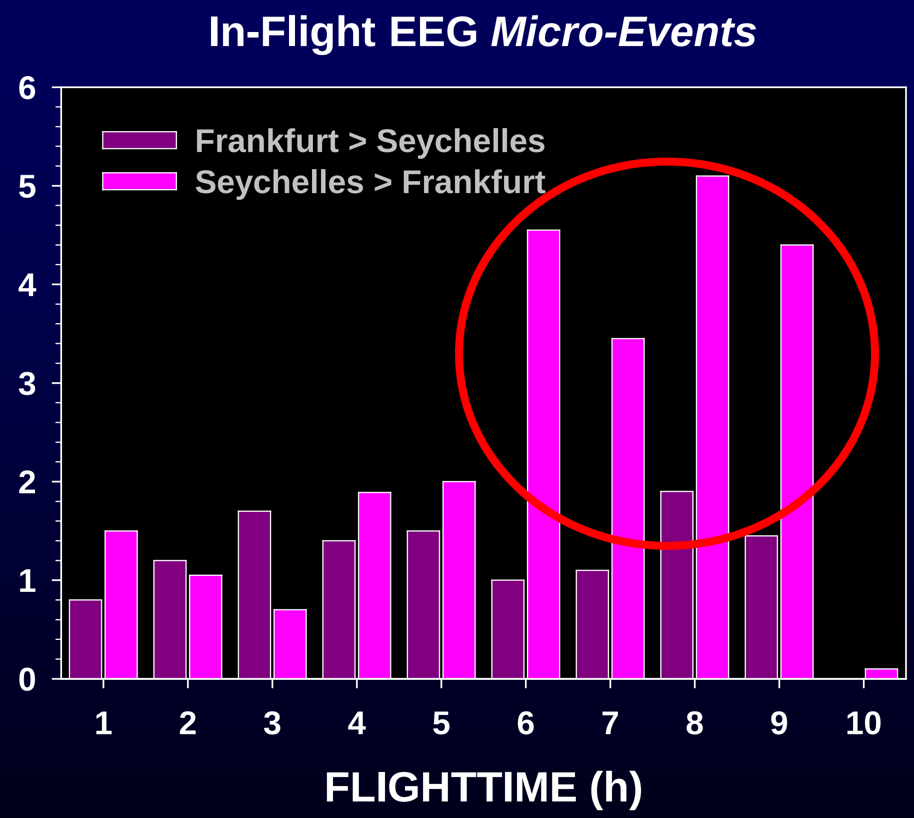
Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Rosekind et al. (1994)

ARCHINOETICS

Fatigue often rears its head more on the return trip than on the outbound leg

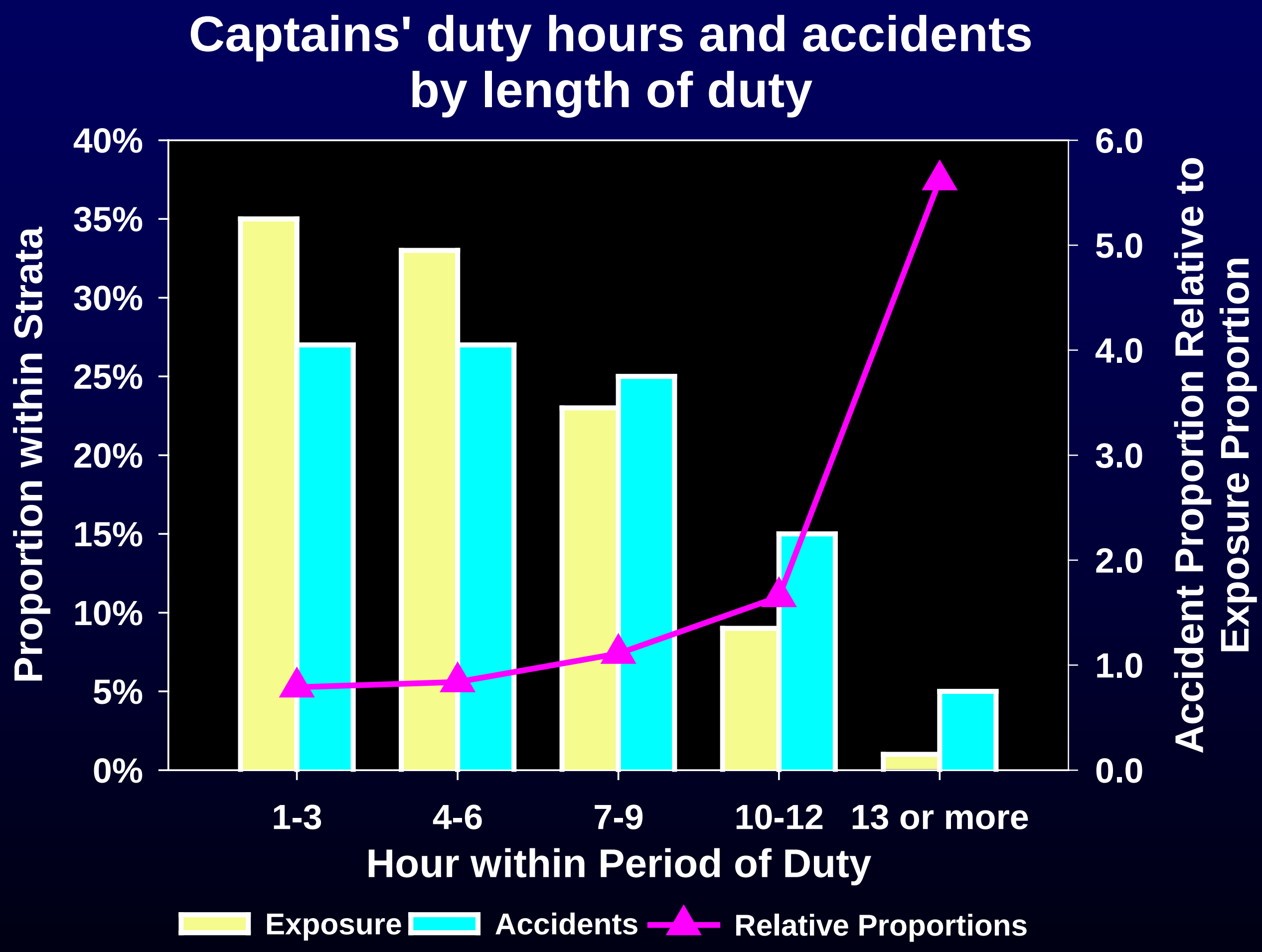
- By the time of landing in Seychelles, the crew had been awake 22 hours
- The layover (with 5 hours of daytime sleep) was 12 hours
- EEG micro-events clearly indicated escalating fatigue on the return trip



Samel, Wegmann, and Vejvoda (1997)

ARCHINOETICS

Long duty hours (and long wake periods) increase "dozing off" and accident risk

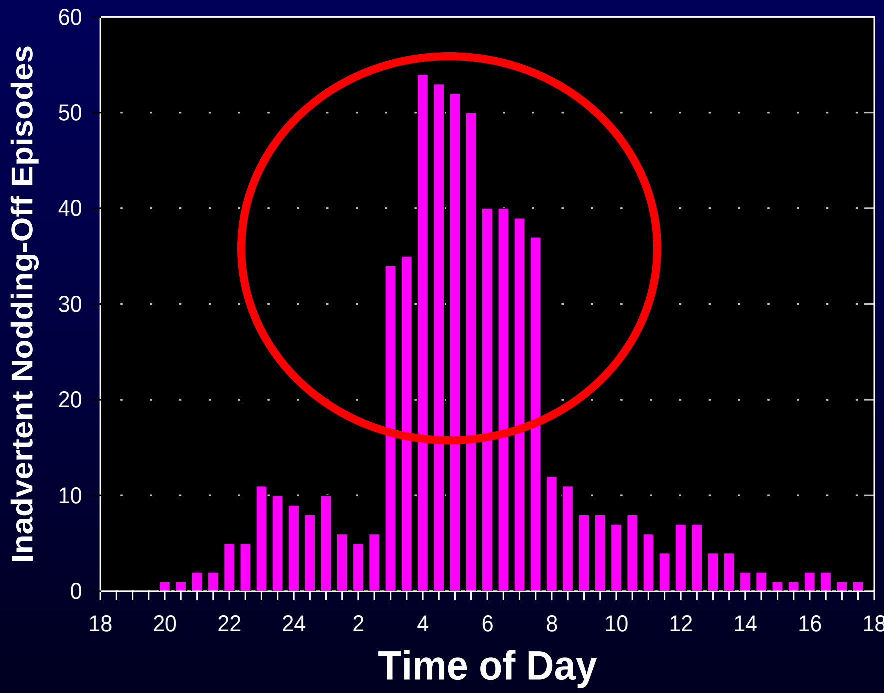


Goode, 2003

Alertness is especially compromised in the late-night and morning hours

- A study of night flights undertaken in the 1980's revealed numerous instances of nodding off in the cockpit
- In the early morning hours, the frequency of such lapses increased tenfold
- Note than many of these occur well after sunrise!

In-Cockpit Nodding Off Episodes



Moore-Ede. (1993)

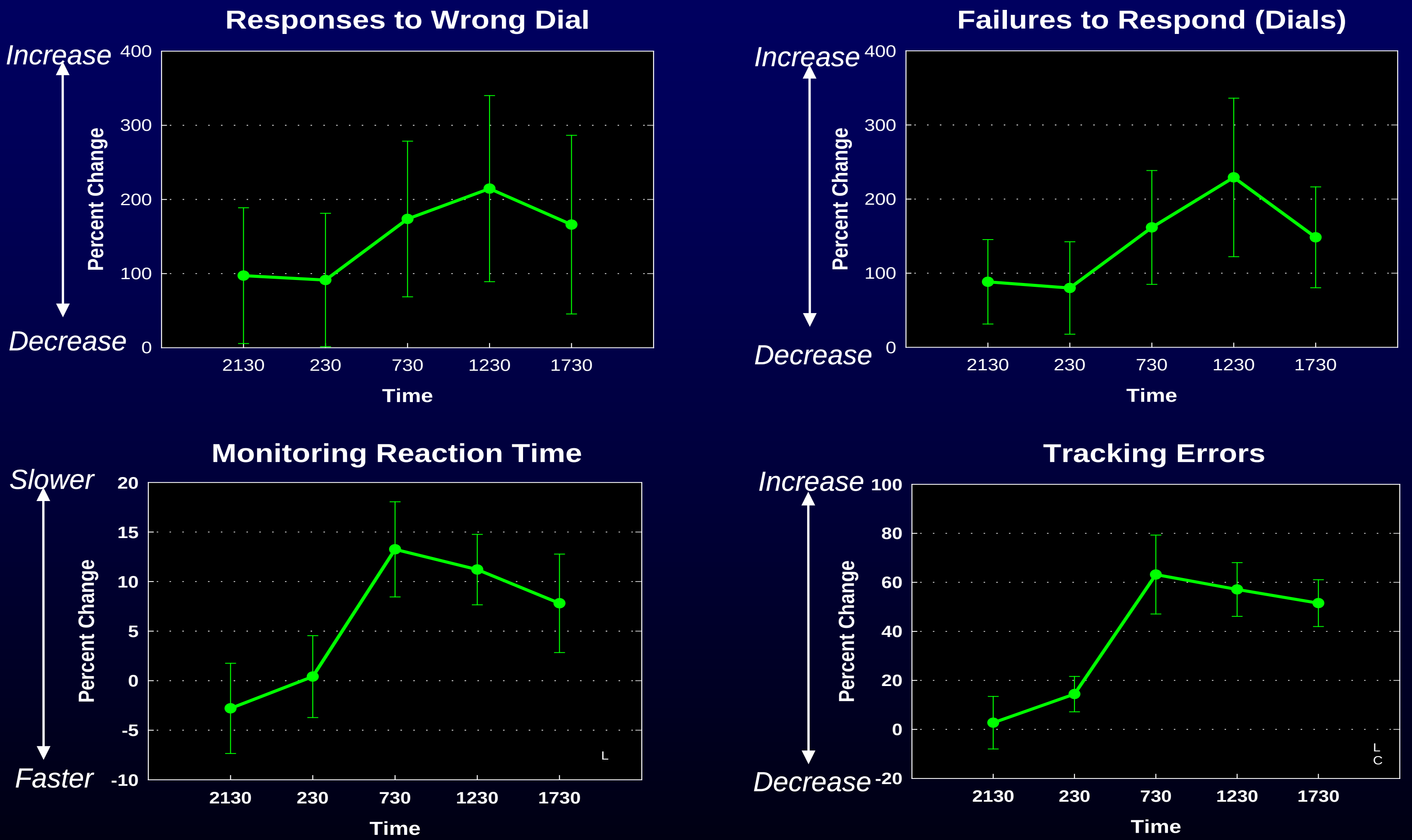
What are the effects of fatigue on pilot capabilities

?

Fatigue degrades basic piloting skills, decision making, and teamwork

- **Standardized laboratory tests show decrements in pilots' attention, reaction time, and accuracy**
- **Fatigue-induced mood changes compromise crew resource management**
- **Flight simulation and in-flight studies show deteriorations in fundamental flight skills**
- ***And the group effects fail to highlight the full extent of impairments experienced by some pilots***

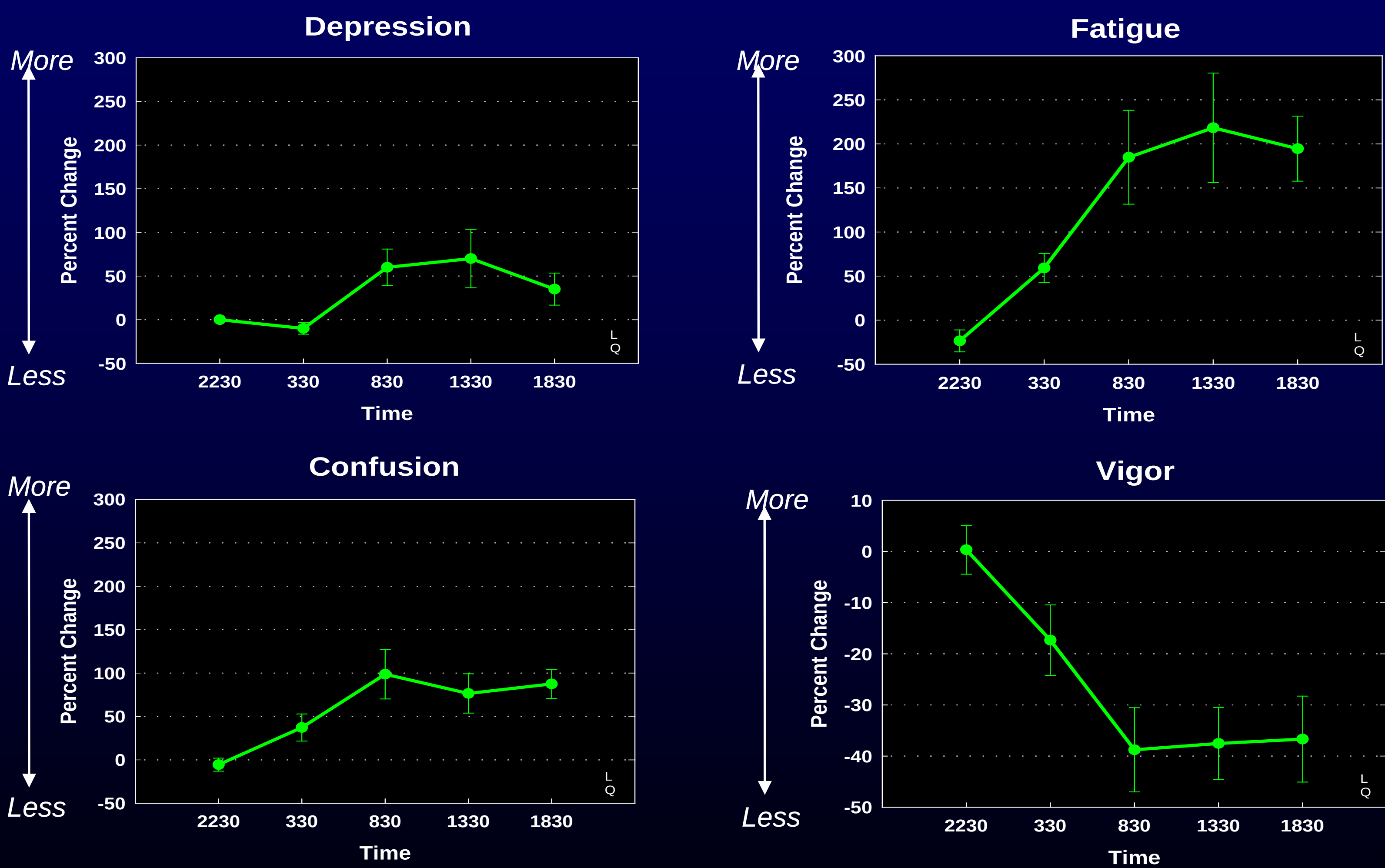
Complex multi-task cognitive performance degrades with one night of sleep loss



Caldwell, Caldwell, Brown, and Smith (2004)

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

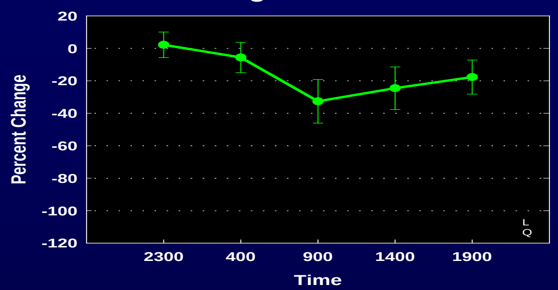
Self-reported mood deteriorates as a function of sleep deprivation



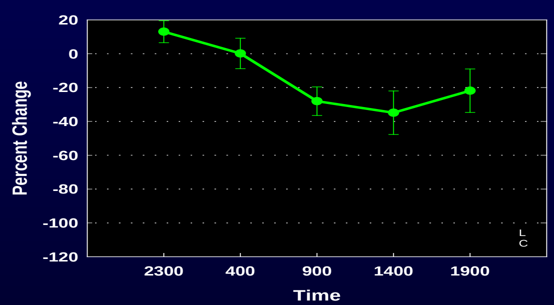
Caldwell, Caldwell, Brown, and Smith (2004)

Fundamental flight skills suffer after long hours of continuous wakefulness

Right 360 Turn

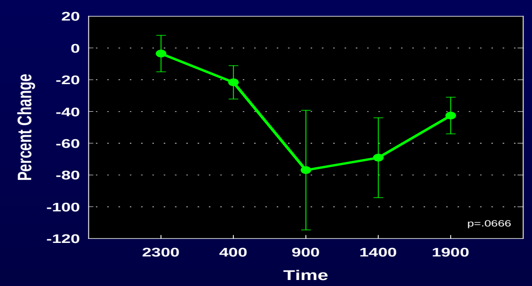


Left 360 Turn

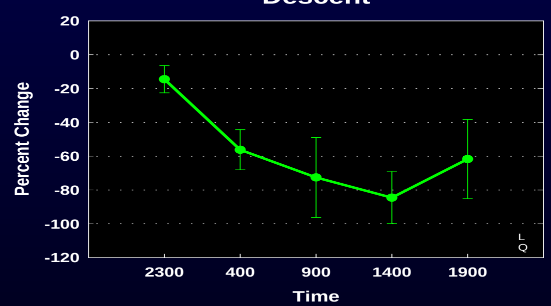


Straight and Level

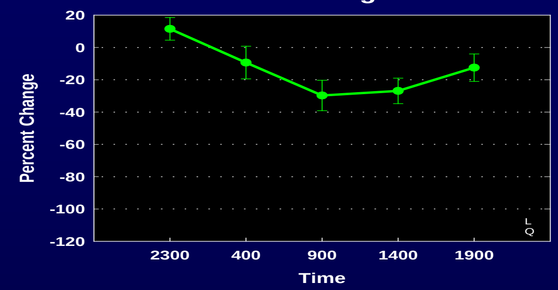
Climb



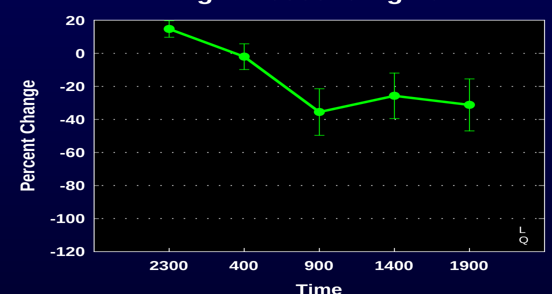
Descent



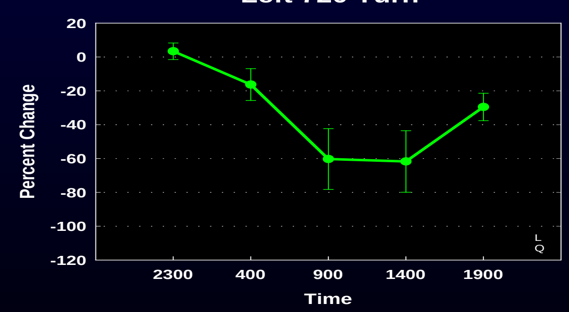
Left Climbing Turn



Right Descending Turn



Left 720 Turn

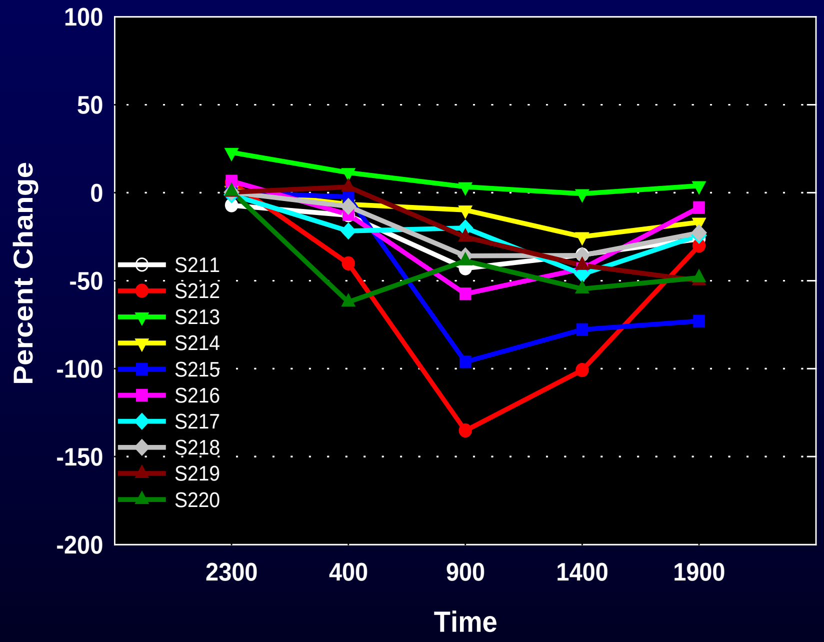


Caldwell, Caldwell, Brown, and Smith (2004)

Some pilots are affected more by fatigue than others

Average Response: Ss 211-220
(last training session used as baseline)

Individual Differences: Ss 211-220
(last training session used as baseline)



Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Caldwell, Mu, Smith, Mishory, George, Caldwell, Peters, and Brown (2005)

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What is the impact of fatigue on operational safety

?

The global effects of fatigue undermine operational performance

- **Although "planes aren't falling out of the sky", fatigue increases the <u>risk</u> of a mishap and several noteworthy mishaps have been attributed to fatigue**
- **As they say, *if you think safety programs are expensive, just wait until you get the bill for an accident***

Some infamous aviation examples

Amer. Intl. Flight 808

Korean Air Flight 801

American Flight 1420

FedEx Flight 1478

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The NTSB found fatigue to be a factor in each one

- **American International 808 (1993):** *probable cause of this accident was the impaired judgment, decision-making, and flying abilities of the captain and flightcrew due to the effects of fatigue…*
- **Korea Air 801 (1997):** *probable cause of this accident was the captain's failure to adequately brief and execute the nonprecision approach and the first officer's and flight engineer's failure to effectively monitor and cross-check the approach. Contributing to these failures were the captain's fatigue*
- **American Airlines 1420 (1999):** *probable causes of this accident were the flight crew's failure to discontinue the approach…and failure to ensure that the spoilers had extended after touchdown. Contributing to the accident was the flight crew's impaired performance resulting from fatigue …*
- **FedEx 1478 (2002):** *probable cause of the accident was the captain's and first officer's failure to establish and maintain a proper glidepath during the night visual approach to landing. Contributing to the accident was a combination of the captain's and first officer's fatigue…*

NASA's Aviation Safety Reporting System contains numerous fatigue reports

- A B747-400 PLT RPTS OBSERVING AN UNSTABLE APCH FROM THE JUMPSEAT RESULTING IN A FAST, LONG LNDG. RPTR FAILED TO REQUEST A GAR.

- B767 FLT CREW SELECTS FLAPS 30 PRIOR TO THE LANDING GEAR REACHING FULL EXTENSION WHICH CAUSES A WARNING HORN TO SOUND. THE FLAP LEVER IS THEN MOVED TO 25 THEN BACK TO 30 WHEN THE HORN STOPS, RESULTING IN TRAILING FLAPS STUCK AT 25.

- A B757 CAPT REPORTS HAVING VERTIGO DURING A RAPID POST TKOF TURNING CLB WITH A LOW ALT LEVEL OFF. POOR CRM CITED ON AN EARLY MORNING FATIGUED FLT.

NASA Aviation Safety Reporting Sys FAR 121 Flight Crew Fatigue Reports 31 Jan 2008.

Internal airline safety reports highlight fatigue's impact on operations

- **In one company, fatigue was found to contribute to 9 percent of FSAP reported events:**
  - 88% of procedural errors
  - 42% of unstable approaches
  - 41% of lining up on incorrect runway
  - 21% of landing without clearance
  - 13% of altitude deviations
  - 13% of speed deviations
  - Etc…

And just last week, pilot fatigue made the news in every major media outlet (again)

NTSB NEWS

NATIONAL TRANSPORTATION SAFETY BOARD · WASHINGTON D.C. 20594

FOR IMMEDIATE RELEASE June 10, 2008 SB-08-25

NTSB RECOMMENDS FAA ADDRESS FATIGUE MANAGEMENT SYSTEMS IN AVIATION

Washington, DC -- The National Transportation Safety Board today made two recommendations to the Federal Aviation Administration (FAA) to address human fatigue within airline operations. The Board recommended that the FAA develop guidance, based on empirical and scientific evidence, for operators to establish fatigue management systems, including information about the content and implementation of these systems.

The Board also made a recommendation to develop and use methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents.

"The Safety Board is extremely concerned about the risk and the unnecessary danger that is caused by fatigue in aviation," said NTSB Chairman Mark V. Rosenker. "We have seen too many accidents and incidents where human fatigue is a cause or contributing factor."

The Board's recommendations letter cites three accidents and an incident highlighting the danger of human fatigue within airline operations:

- On October 19, 2004, Kirksville, Missouri, Corporate Airlines flight 5966 struck several trees on its final approach and crashed short of the airport. Both pilots and 11 passengers were killed. Two passengers received serious injuries.
- On February 18, 2007, Delta Connection flight 6488, operated by Shuttle America, Inc., overran the end of the runway as it was landing at Cleveland-Hopkins International Airport. All 72 passengers and a crew of four deplaned without serious injury.
- On April 12, 2007, Pinnacle Airlines flight 4712 ran off the runway after landing at Cherry Capital Airport, Traverse City, Michigan. None of the 49 passengers or crew of three were injured.
- On February 13, 2008, Go! flight 1002, operated by Mesa Airlines, flew past its destination airport, General Lyman Field, Hilo, Hawaii. Air traffic control repeatedly attempted to contact the crew for over 18 minutes, as it flew over Maui, crossed the big island of Hawaii and headed southeast over the Pacific Ocean. The airplane traveled 26 nautical miles beyond its intended destination airport before the flight crew responded. There were no injuries.

"It is imperative that the FAA take action to reduce human fatigue in airline operations," Rosenker said. "Addressing this safety related measure is long overdue. We must and can correct this serious concern."

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Summary and conclusions

- **Fatigue is a major risk factor in aviation operations**
- **Scheduling factors are primarily responsible for fatigue-related problems**
- **Sleep deprivation and circadian disruptions compromise basic pilot functioning and fundamental flight skills**
- **In-flight and simulation studies have shown the extent of cognitive, mood, and skill decrements**
- **NASA's ASRS and company FSAP reports have documented the impact of fatigue on operational performance**
- **Fatigue is a REAL issue requiring scientifically-based solutions!**

ARCHINOETICS

John A. Caldwell
Archinoetics, LLC
john@archinoetics.com

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Joint Session

Fatigue Risk Management Systems: Measurement and Evaluation of Effectiveness

Fatigue Management, Assessment and Evaluation: An Operational Perspective

Captain Greg Fallow

Air New Zealand,
IFALPA

11:05 - 11:30

June 18, 2008

Captain Greg Fallow
Biography

Greg Fallow is currently an Air New Zealand B777 check and training captain having previously flown B767, B747-200, B747-400, B737 and F27 aircraft for the airline. His aviation career spans just over 40 years encompassing both military and commercial operations. He has flown long-haul operations with Air New Zealand for over 20 years and has had active involvement in fatigue management as a pilot representative for the past 13 years. He represents the New Zealand Air Line Pilots' Association as a member of Air New Zealand's Crew Alertness Study Group.

He is a member of the IFALPA Human Performance Committee, and represented IFALPA as a member of the Flight Safety Foundation ULR Steering Committee which conducted workshops to obtain industry consensus on the best way forward for emerging ultra long range (ULR) operations. He currently represents IFALPA as member of the ICAO Operations Panel Fatigue Risk Management subgroup which is tasked with drafting Standards, Recommendations and Guidance Material for the Operations Panel to consider as part of a task of the Air Navigation Commission for amending ICAO Annex 6 provisions on flight and duty time limitations.

In addition to his involvement in fatigue management Greg is also a FOQA analyst for Air New Zealand's B777 operations which, similar to fatigue management, forms part of the airline's safety management system.

Fatigue Management, Assessment, and Evaluation: An Operational Perspective

Captain Greg Fallow

Air New Zealand Crew Alertness Study Group

AIR NEW ZEALAND

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Overview

- The genesis of the company's fatigue monitoring and management
- Measures used to assess crew alertness in the workplace
- Crew reporting
- Some examples of studies and data collection
- Evaluation of effectiveness
- Current initiatives

FIRST STEPS

Gaining regulatory approval
Identifying methodology
Achieving union support / Importance of a “Just Culture”
External supervision

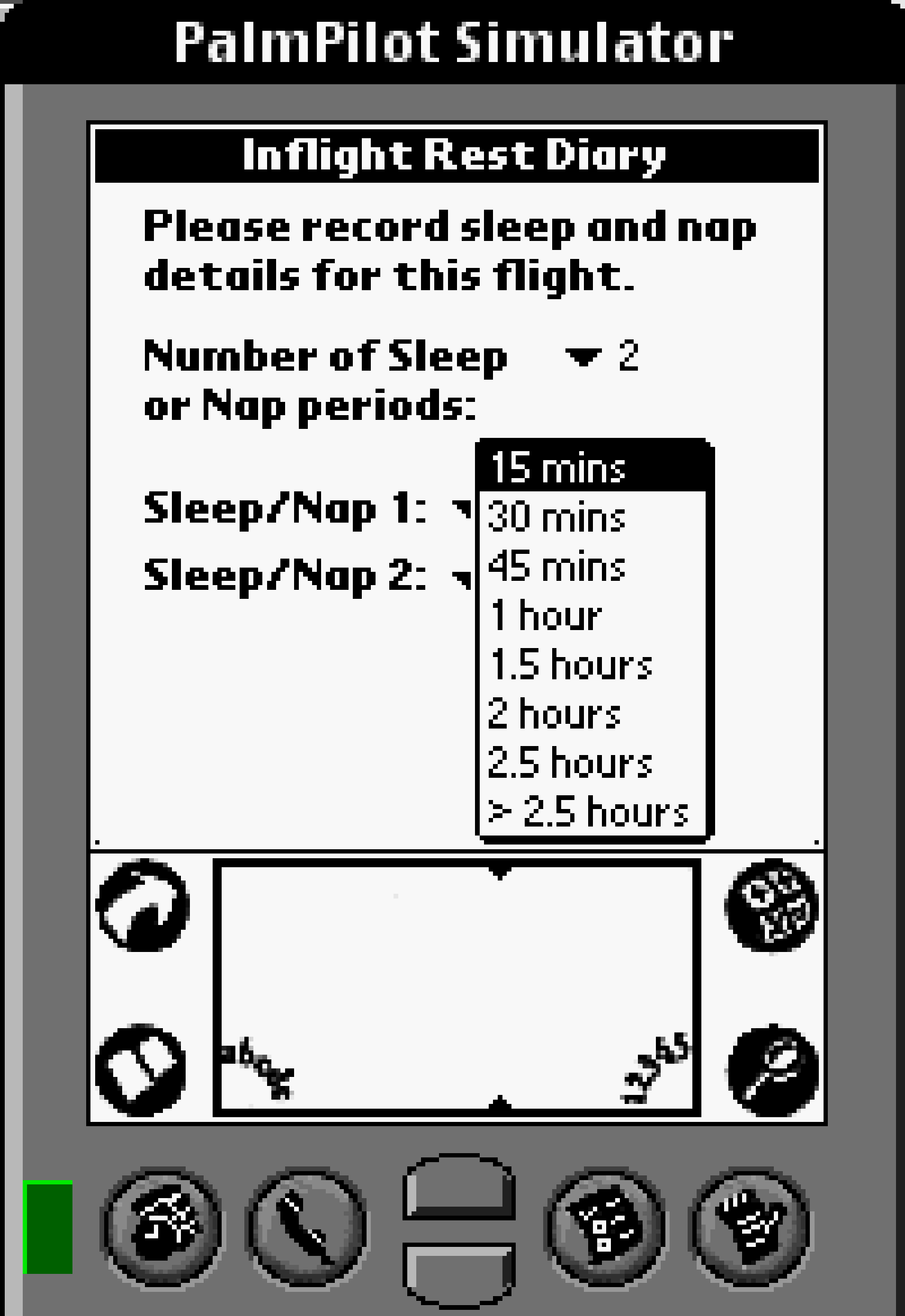
Early Studies

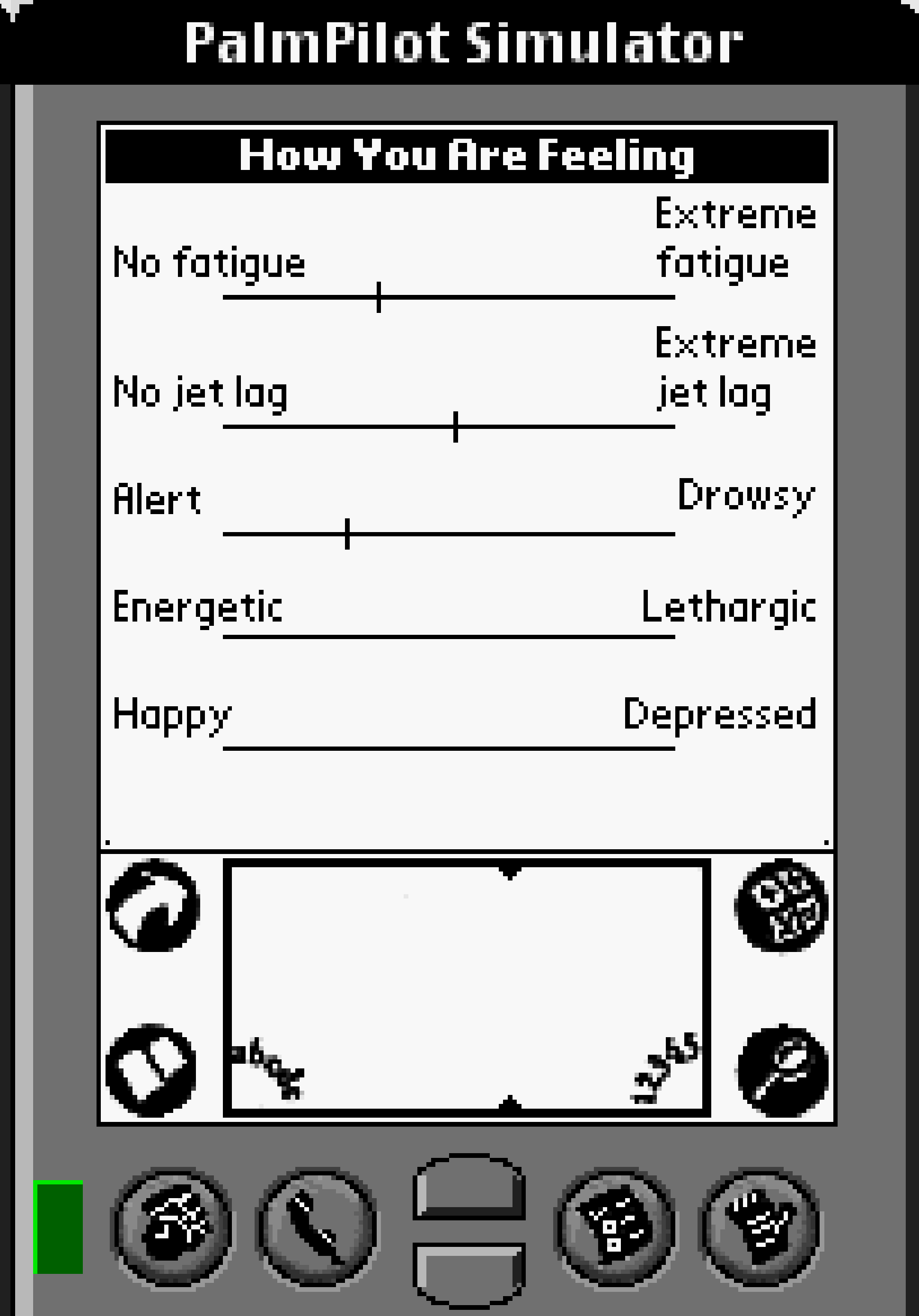
- PVT and Paper
- Actilumes
- No experimenter
- Double FRA (melatonin study)

- TPE-BNE-AKL
- NRT-NAN-AKL
- AKL-SIN-CHC
- Freedom Air

Later Studies

- Palm Pilot – Establishment + 3-stage Validation





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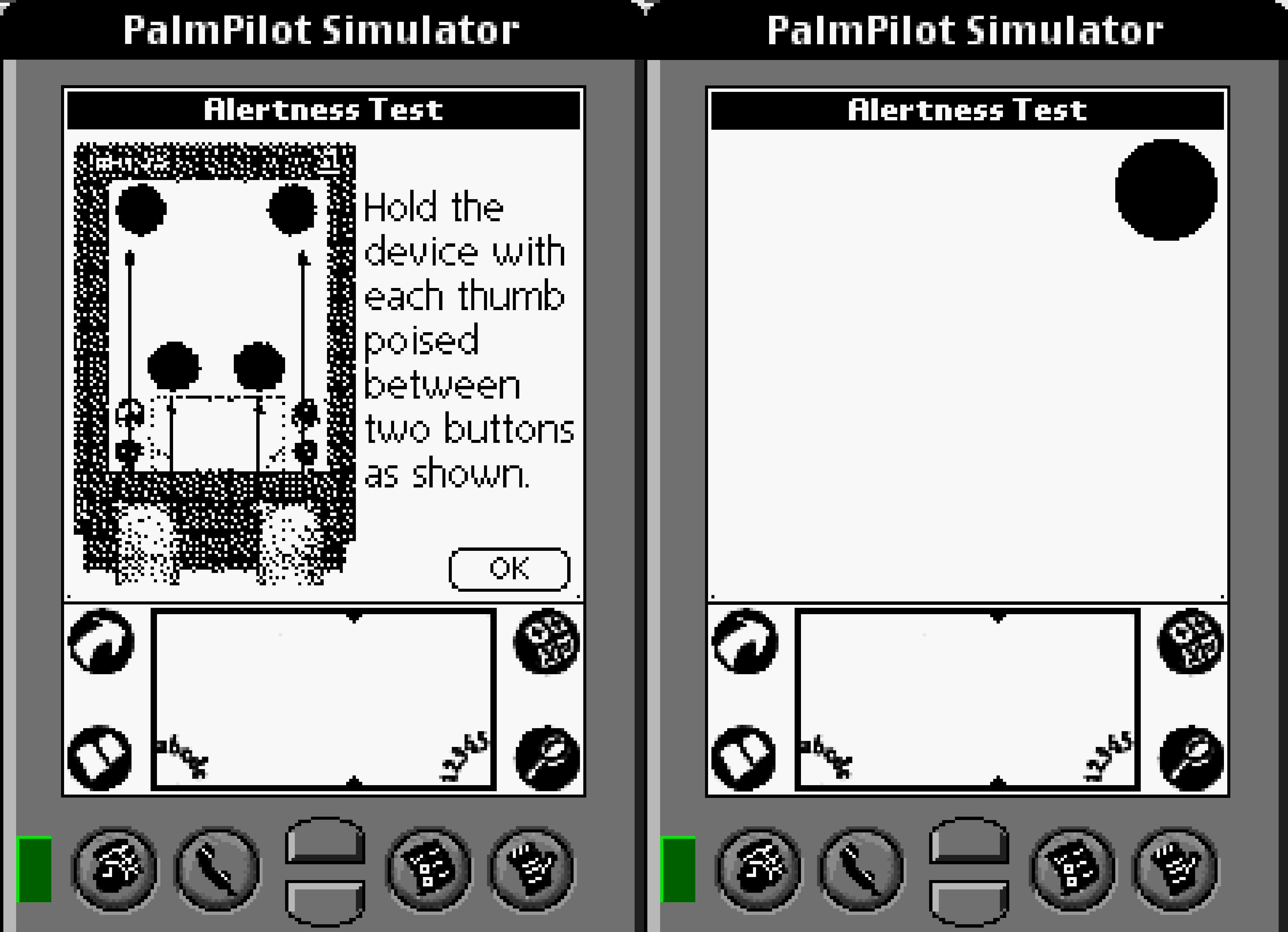
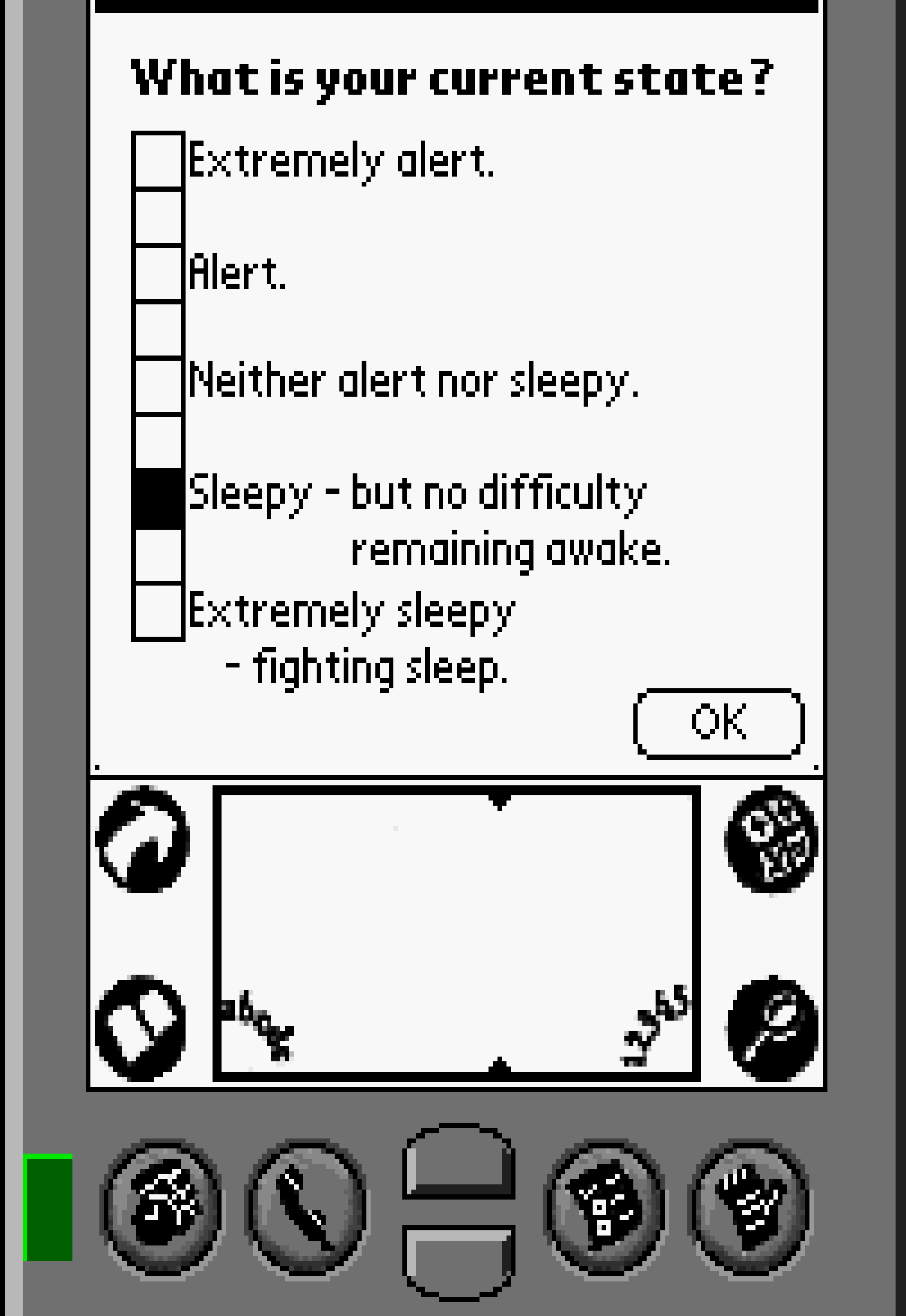
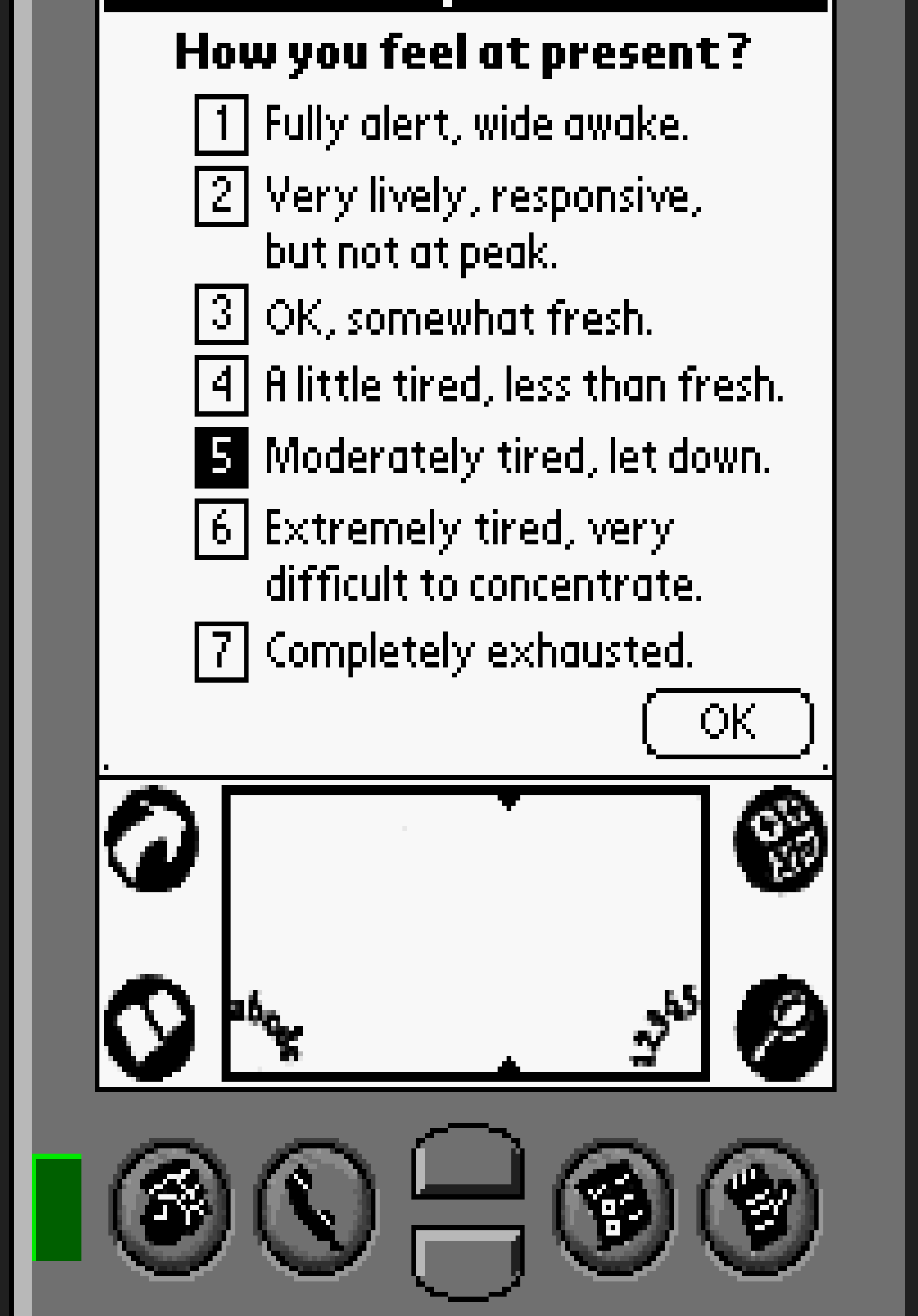

PalmPilot Simulator
Alertness Test
Hold the device with each thumb poised between two buttons as shown.
OK
PalmPilot Simulator
Alertness Test


What is your current state?
Extremely alert.
Alert.
Neither alert nor sleepy.
Sleepy - but no difficulty remaining awake.
Extremely sleepy - fighting sleep.
OK


How you feel at present?
1 Fully alert, wide awake.
2 Very lively, responsive, but not at peak.
3 OK, somewhat fresh.
4 A little tired, less than fresh.
5 Moderately tired, let down.
6 Extremely tired, very difficult to concentrate.
7 Completely exhausted.
OK

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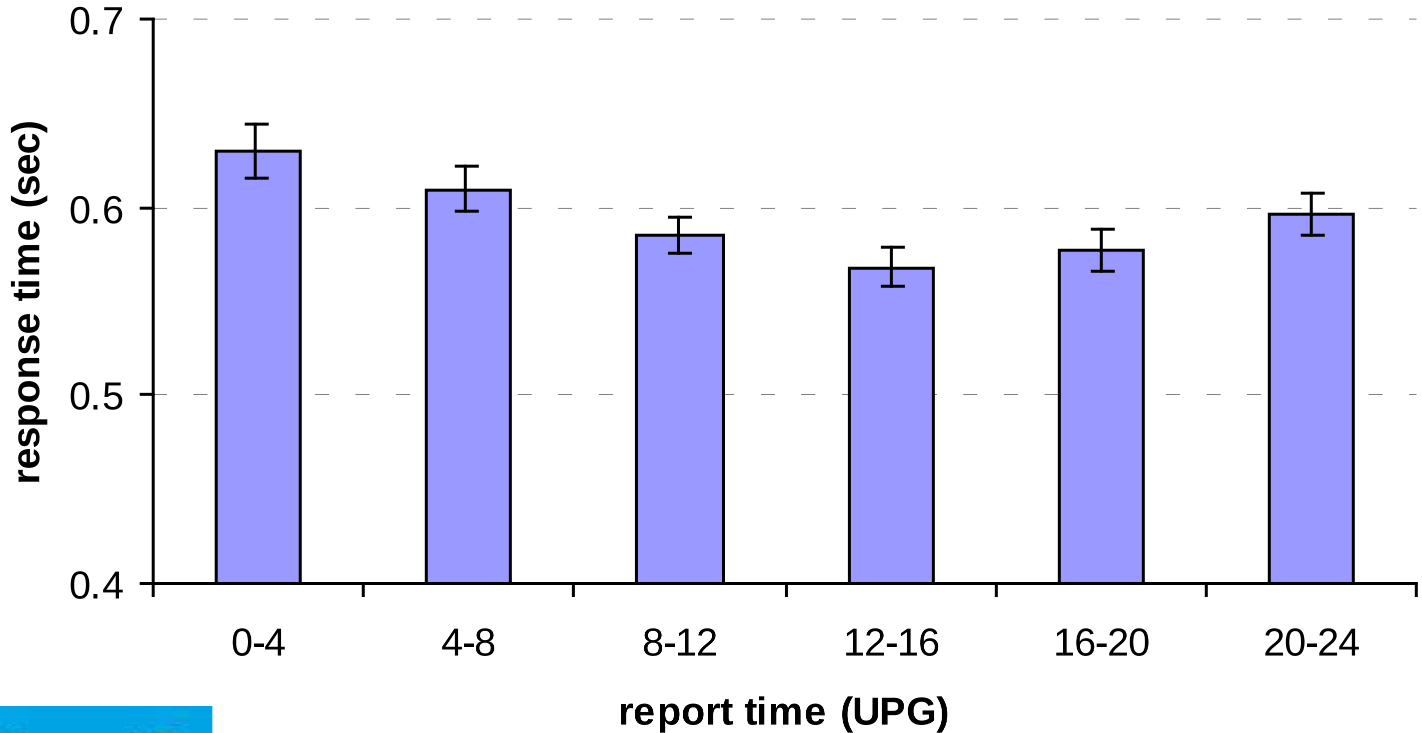
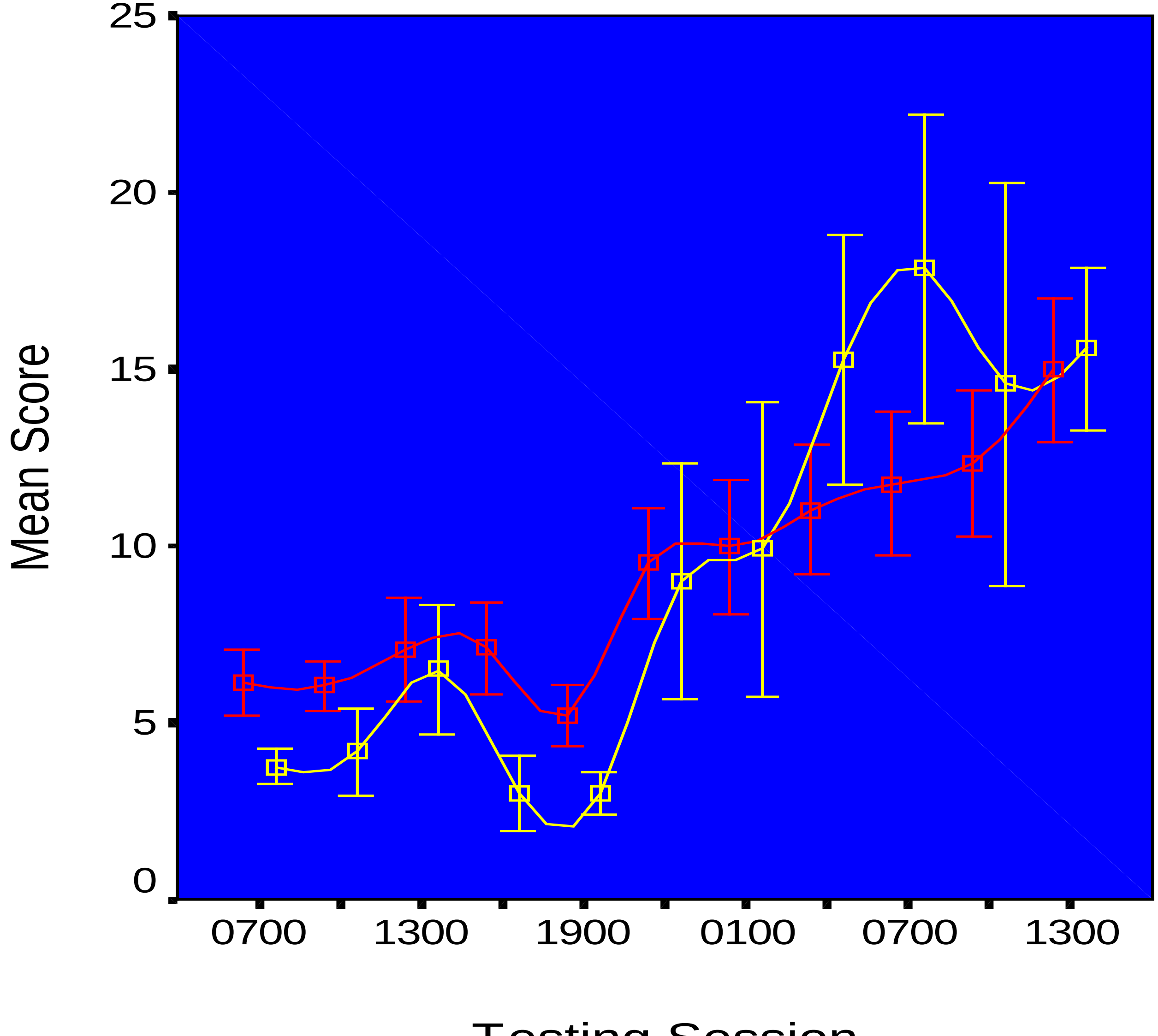
Haj (Palm Validation) - 216 Flights
Same route 2-hourly around the clock

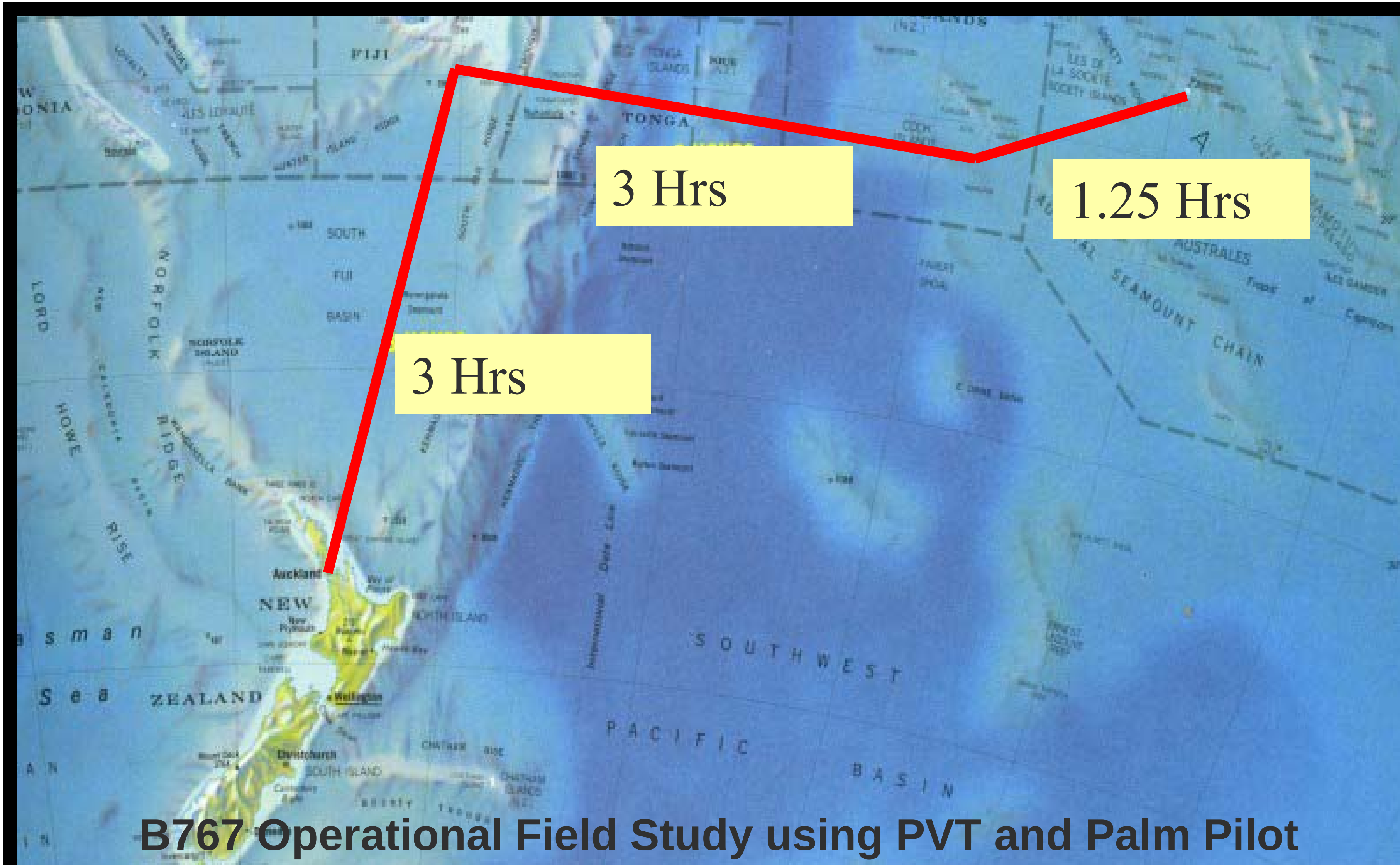


QinetiQ

Sleep Deprivation Study



Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008



B767 Operational Field Study using PVT and Palm Pilot

Cabin Crew

Creation of In-Flight Services Fatigue Study Group

Subsequent incorporation into Crew Alertness Study Group

Challenges of commitment, trust and culture

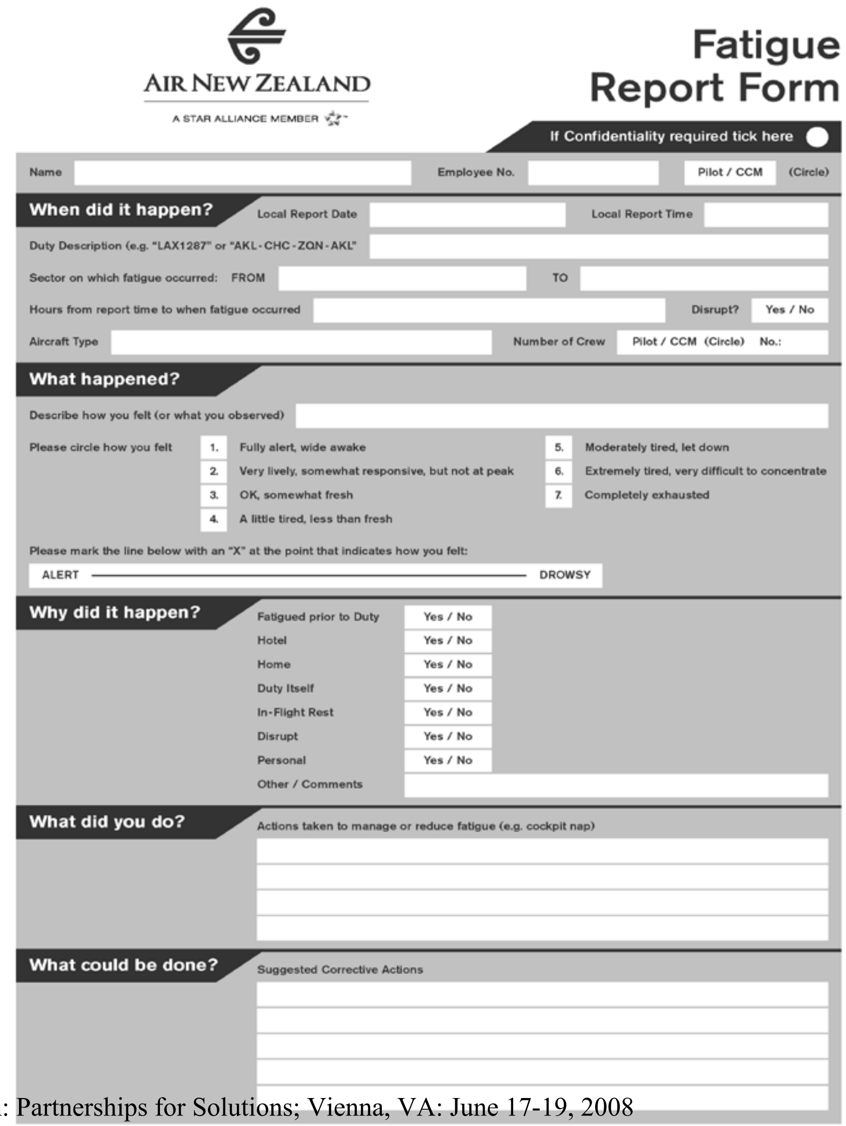
Palm Pilot Studies

(* = Changes Made)

Pilots	Cabin Crew
AKL-LAX-LHR-LAX-SYD	AKL-NAN-RAR-PPT-RAR-NAN-AKL*
SYD-KIX-BNE-SYD (Ansett)	AKL-KIX-CHC-AKL
SYD-LAX-AKL*	AKL-PER-AKL
AKL-LAX-AKL*	AKL-TBU-HNL-AKL*
AKL-LAX-LHR-LAX-AKL	AKL-LAX-APW-AKL
CHC-BNE-CHC*	AKL-LAX-AKL
AKL-HKG-LHR-HKG-AKL	CHC-BNE-CHC

Crew Reporting System

- Kept on aircraft
- Completed by crew member
- De-identified if requested
- To management
- Then to CASG



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A STAR ALLIANCE MEMBER

Fatigue Report Form

If Confidentiality required tick here

Name | Employee No. | Pilot / CCM (Circle)

When did it happen?

Local Report Date | Local Report Time

Duty Description (e.g. "LAX1287" or "AKL-CHC-ZQN-AKL")

Sector on which fatigue occurred: FROM | TO

Hours from report time to when fatigue occurred | Disrupt? Yes / No

Aircraft Type | Number of Crew | Pilot / CCM (Circle) No.:

What happened?

Describe how you felt (or what you observed)

Please circle how you felt

1. Fully alert, wide awake
2. Very lively, somewhat responsive, but not at peak
3. OK, somewhat fresh
4. A little tired, less than fresh
5. Moderately tired, let down
6. Extremely tired, very difficult to concentrate
7. Completely exhausted

Please mark the line below with an "X" at the point that indicates how you felt:

ALERT ———— DROWSY

Why did it happen?

Fatigued prior to Duty	Yes / No
Hotel	Yes / No
Home	Yes / No
Duty Itself	Yes / No
In-Flight Rest	Yes / No
Disrupt	Yes / No
Personal	Yes / No
Other / Comments	

What did you do?

Actions taken to manage or reduce fatigue (e.g. cockpit nap)

What could be done?

Suggested Corrective Actions

"You're doing it wrong"

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

"Powell's Folly"
Top of Descent Survey

Last descent of the duty day

Self rated fatigue (SP, VAS)

Three months

9000 responses

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PILOT ALERTNESS REPORT FORM

Forms to be completed immediately prior to Top of Descent on last leg of duty period.

[ ] Report Time (UTC)

[ ] Time (UTC) at Top of Descent

Name the Sectors operated this duty period.

[ ] [ ] [ ] [ ] [ ]

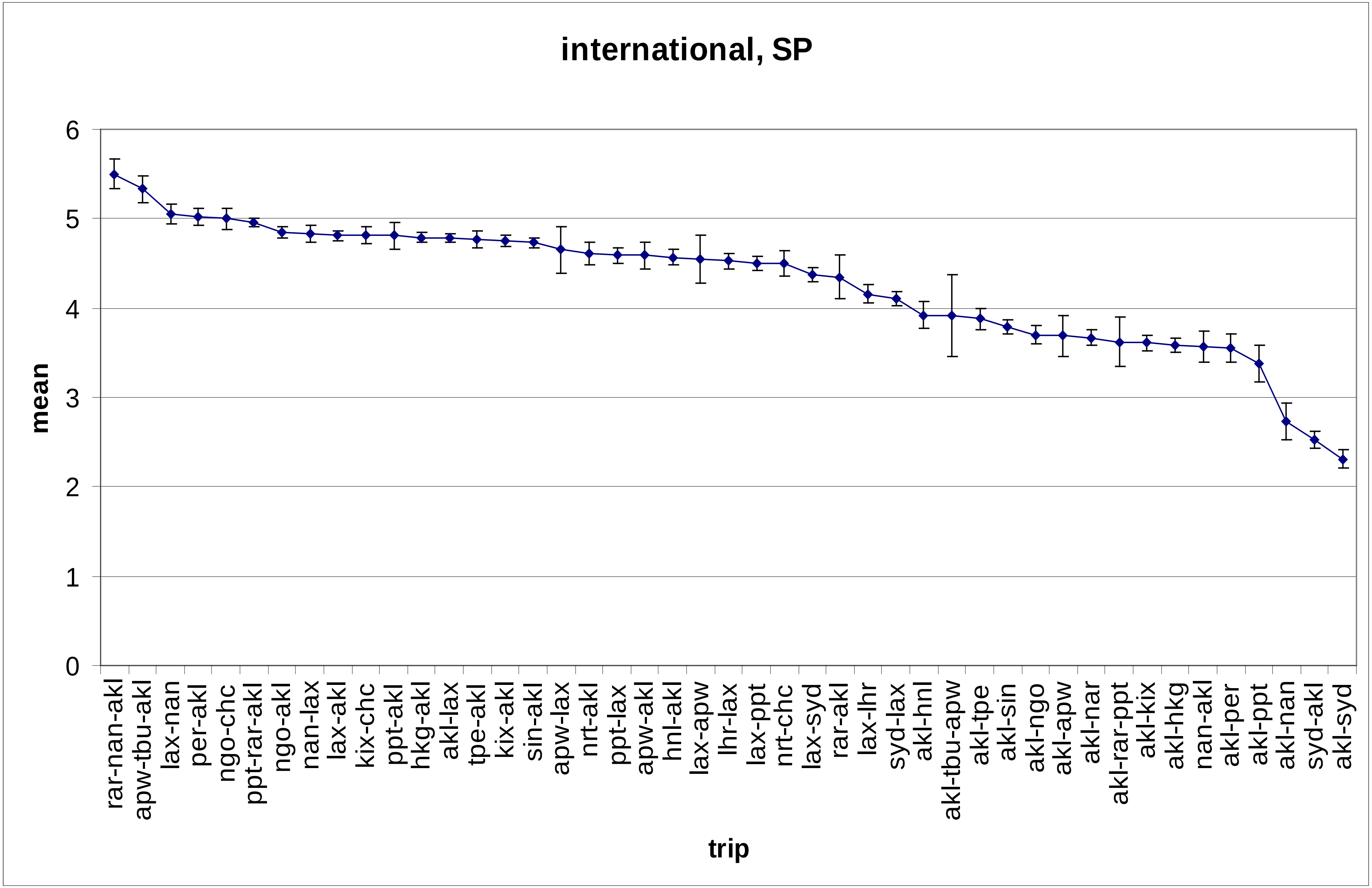
Please circle "How you feel" at Top of Descent

1. Fully alert, wide awake
2. Very lively, responsive, but not at peak
3. OK, somewhat fresh
4. A little tired, less than fresh
5. Moderately tired, let down
6. Extremely tired, very difficult to concentrate
7. Completed exhausted

Please mark on the line below

Alert ______________________________ Drowsy

Please place in brown envelope



Top of Descent Survey Results - Representative

RESEARCH ARTICLE

Pilot Fatigue in Short-Haul Operations: Effects of Number of Sectors, Duty Length, and Time of Day

David M. C. Powell, Mick B. Spencer, David Holland, Elizabeth Broadbent, and Keith J. Petrie

Powell DMC, Spencer MB, Holland D, Broadbent E, Petrie KJ. *Pilot fatigue in short-haul operations: effects of number of sectors, duty length, and time of day.* **Aviat Space Environ Med 2007; 78: 698–701.**

Introduction: There is little research on what factors are associated with fatigue in short-haul pilots. The aim was to investigate how length of duty, number of sectors, time of day, and departure airport affect fatigue levels in short-haul operations. ***Methods:*** Pilots completed Samn-Perelli fatigue ratings prior to descent at the end of each rostered short-haul duty over a 12-wk period. Overall, 1370 usable responses were collected (67% of rostered duties) and fatigue scores were examined in relation to the departure airport, the number of sectors flown, time, and the length of duty period. ***Results:*** The most important influences on fatigue were the number of sectors and duty length. These were associated with fatigue in a linear fashion. Time of day had a weaker influence, with lower levels at midday and increased fatigue later in the

starts as the most important causes (2). Short-haul rosters cause pilots to sleep less, wake earlier, and have less restful sleep over the work period (5). Studies with UK pilots have identified time of day and the number of flights per day as important influences on the development of fatigue during the course of a short-haul duty period (3). It is clear from the small amount of research conducted with short-haul crew that early starts, late finishes, and the high workload caused by multiple sectors are important influencing factors on fatigue levels. However, it is not clear which factors contribute most, particularly at the most critical period for flight safety—the final approach and landing phase. This in-

“Holland’s Mistake”
- Cabin Crew Sector Survey

- Same methodology as pilot survey
- Conducted over entire network – International, Regional and Domestic
- 10,000 responses collected over one month

“Holland’s Mistake”
- Cabin Crew Sector Survey

….analysis still proceeding

Pilot Fatigue Surveys

ERGONOMICS, 15 APRIL, 2004, VOL. 47, NO. 5, 461–468

Taylor & Francis healthsciences

Fatigue self-management strategies and reported fatigue in international pilots

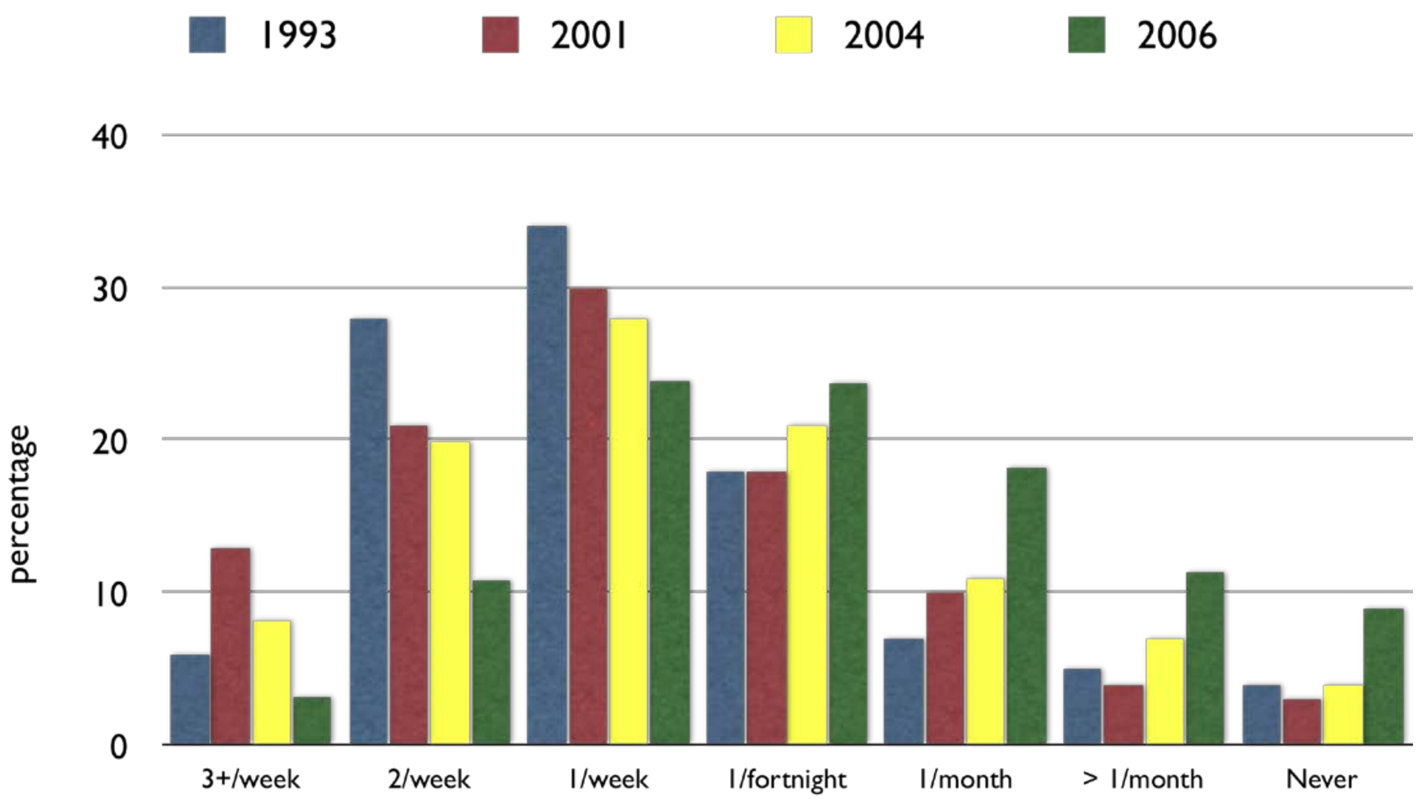
KEITH J. PETRIE,†*, DAVID POWELL‡ and ELIZABETH BROADBENT†

†Department of Health Psychology, University of Auckland

‡Medical Unit, Air New Zealand

Keywords: Fatigue; Aircrew; Pilots; Napping; Mediation.

Significant Fatigue from Job 1993, 2001, 2004 and 2006



Other Components of Company FRMS

- Education
  - Induction Training
  - Periodic Annual Fleet Refreshers / Recurrent Training
  - Reference Manuals, CASG Intranet Website

- Provision of Controlled Rest Procedures in SOPs
  - Along similar lines to JAA provisions
  - Specified protocols for use (cruise, low workload, no planned deviation from track or flight plan etc)
  - Used when other fatigue countermeasures have been ineffective
  - Not preplanned

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External Work / Outreach

- Ansett……
- FSF sponsored ULR Workshops
- ULR Delivery Flights
- External Airline Study
- QinetiQ / UKCAA

Flight Safety Foundation

An International Organization for Everyone Concerned With the Safety of Flight

Safety Regulation Group

Civil Aviation Authority

CAA PAPER 2003/14

Wakefulness on the Civil Flight Deck: Evaluation of a Wrist-worn Alertness Device

From Reactive to Proactive

Domestic – Maximum 5 Sectors out of overnight
Back of the clock AKL - PPT - AKL
B737 augmentation for Niue flights
Shanghai flight crew augmentation
Establishment of Home Rest matrix for International Operations

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Summary of Key Points

- A **"Just Culture"** environment allowing free and open feedback
- Management and Unions working together from the outset establishing agreed processes and procedures
- Focus on a data driven approach and known science
- 3 large data sets - fatigue reports, operational studies, top of descent survey
- Decisions made by management **BUT** there must be a commitment to act where required
- The importance of external review, audit and oversight
- Over time a comprehensive data base can be established – extremely valuable for interpreting and understanding each new study's results
- Ability to make decisions proactively based on previous knowledge & experience
- An important component of the company's Safety Management System, and fulfils company's "duty of care" responsibility required by NZ HSE law

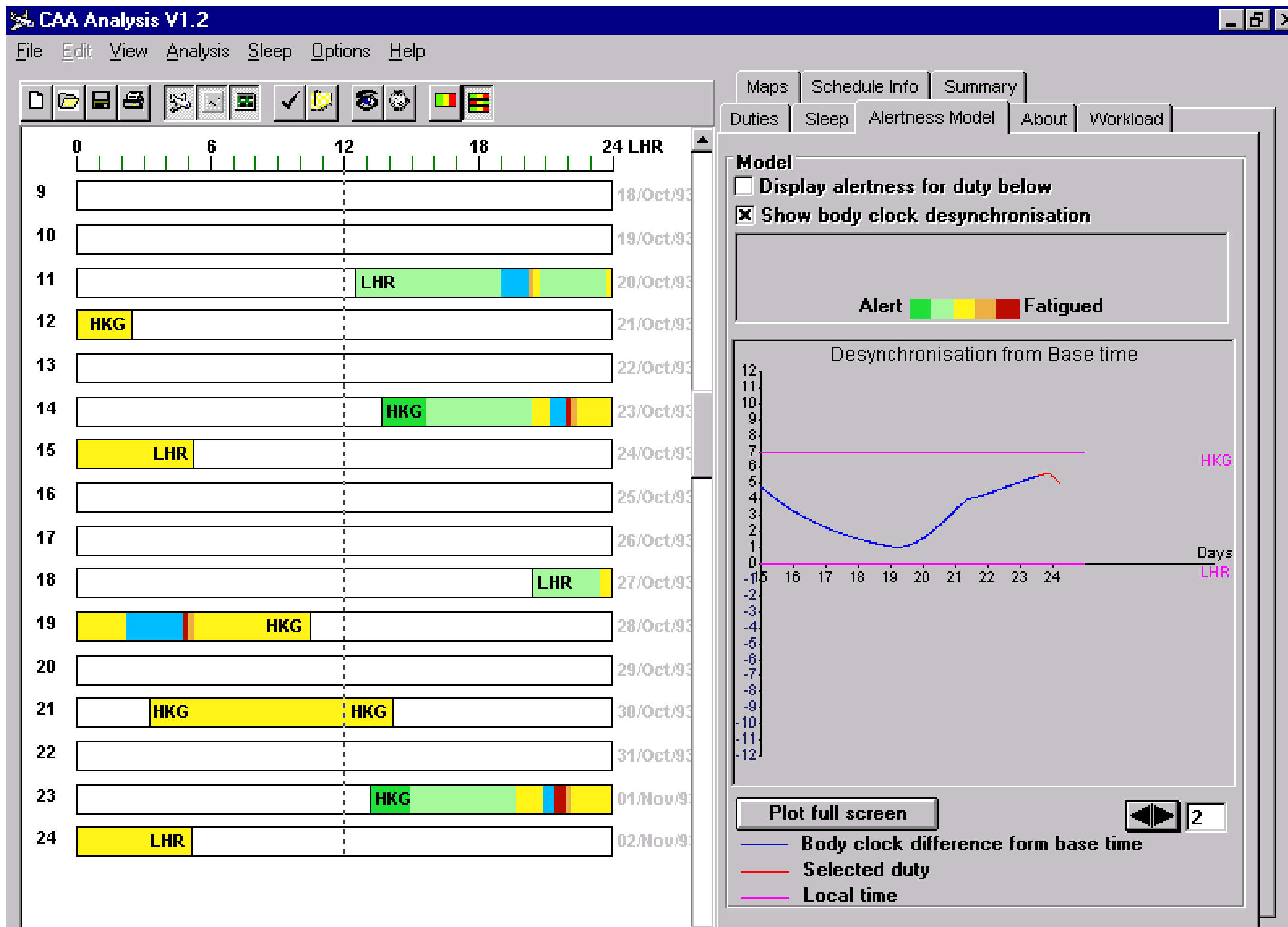
Model Integration

SAFE currently used to evaluate individual "tours of duty"

Aim: To incorporate fatigue model into roster generation process

Proof of concept / initial trialling completed

Working on way forward to reduce rostering optimiser run times



Universal Data Collection

- Use of ACARS to collect pilot alertness status prior to top of descent
- EFB e-documents for on board reporting of fatigue events
- Examine potential use of EFB interface for field study data collection

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Questions?

During Q and A Session

CONTACTS:

david.powell@airnz.co.nz Air New Zealand Chief Medical Officer
greg.fallow@orcon.net.nz NZALPA Representative Crew Alertness Study Group

Palm pilot programme available on application to Dr Powell

Parallel Session

Current State of Mitigation:
Flight Operations

Crewmember Flight, Duty and Rest Requirements: FAA Regulations, Initiatives, and Challenges

Mr. Gregory Kirkland
Federal Aviation Administration

9:25 - 9:50

June 18, 2008

Gregory Kirkland
Biography

Greg Kirkland is currently the Air Transportation Division Assistant Division Manager at Headquarters, Federal Aviation Administration. Greg began his aviation carrier in the United States Air Force where he flew the C-130 A/E/H and the AC-130 gunship. He was also a maintenance and supply officer, held several staff assignments to include a tour of duty on the Joint Staff, and was a C-130 squadron commander.

After retiring from the Air Force, Greg began his carrier in civil aviation flying for both Part 135 and Part 121 air carriers. He is typed in the BA 3100, and the Boeing 737, 757, and 767 aircraft. Greg was a line check airman in the Boeing 737-300/500 at United Airlines and worked both in management and union positions promoting air safety programs.

Crewmember Flight and Duty Limits and Rest Requirements

FAA Regulations, Initiatives and Challenges

Presented to: Fatigue Symposium

By: Greg Kirkland

Date: June 18, 2008

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions;
Vienna, VA: June 17-19, 2008

Introduction

This Fatigue Symposium will cover the broad spectrum of fatigue issues and mitigations.

However, to plan for the future, we need to understand where we are now with current flight, duty and rest requirements.

This presentation will address rulemaking history, significant FAA initiatives undertaken to strengthen and clarify the intent of our regulations, as well as the challenges of regulating appropriate and safe flight and duty limits and rest requirements.

FAA's Statutory Authority

- FAA has broad statutory authority to issue aviation safety rules. Under 49 U.S.C. Section 44701 (a) (5), the FAA has the authority to promote safe flight of civil aircraft by prescribing regulations that the FAA finds necessary for safety in air commerce and national security.

- However, in the area of hours of service the FAA does not have the discretion to decline to issue rules. Specifically, 49 USC 44701 (a) (4) requires the FAA to set "maximum hours or periods of service of aircrew"

- FAA must also "consider the duty of an air carrier to provide service with the highest possible degree of safety in the public interest"

- Aviation safety and the public interest, would be seriously compromised by operations with fatigued crewmembers.

Background

- The aviation industry requires 24/7 activity to meet operational demands. All flights require rested crewmembers to safely support around the clock operations.

- International long haul flights with passengers and cargo, domestic short haul, multi-leg flights and domestic transcontinental flights all present unique challenges to meeting this requirement.

- Current flight time limits and rest requirements for part 121 and 135 crewmembers:

  14 CFR part 121, subparts P,Q, R and S
  (domestic, flag, and supplemental operations)
  14 CFR part 135, subpart F
  (on-demand and commuter operations)

Rulemaking

- In 1985, the FAA published a Final Rule that updated the domestic flight and rest requirements for flight crewmembers titled <u>"Flight Time Limitations and Rest Requirements".</u>

- Prior to the 1985 Final Rule, the rules did not address acute short term fatigue for flight crewmembers in 121 or 135 operations, or long term fatigue in part 135.

  - <u>Acute or short-term fatigue</u> was addressed in both part 121(domestic) and part 135 operations by the introduction of a minimum daily rest requirements. Those known rest periods had to be provided <u>before the beginning of a duty day</u> and had to be <u>recently provided</u> (24 Hour Look Back).

  - <u>Chronic or long-term fatigue</u> was addressed in part 135 by setting weekly, monthly and annual flight time limits that were comparable to part 121, for both scheduled and unscheduled operations

Rulemaking

- In 1992, the FAA established a Flight Crewmember Flight/Duty/Rest Requirements working group under its Aviation Rulemaking Advisory Committee-ARAC

- 1994 Final report – After two years, the ARAC had <u>not reached a consensus on several key issues</u>, but did agree on the major areas that the FAA should address in future rulemaking.

- In 1995, the FAA issued an NPRM with a goal of establishing one set of regulations for flight crewmembers for all operations conducted under parts 121 and 135.

  - The FAA received approximately 2,000 comments on the 1995 NPRM, **mostly negative.**

Rulemaking

(1) Industry- The rule is unnecessary and costly:

- Too expensive (Industry asserted that projected costs were in the billions over 15 years for implementation)
- "The rule would be unsafe as it imposes untested changes in longstanding rules and practices that ensure the current level of safety."
- "The cause of most accidents is pilot error, not fatigue, and that the current rules have provided a good safety record."
- "The FAA should focus on encouraging compliance with the existing rules rather than issuing new ones."

(2) Labor- There are not enough protections for crewmembers.

Issue-The part 121 carriers did not like the proposal of shortening the maximum duty day to 14 hours. Pilots did not like the proposal to expand the 8-hour flight time limit to 10 hours between rest periods.

Rulemaking

- For Flight Attendants, there were no regulations regarding limits on duty and rest periods until the FAA published a Final Rule in 1994 titled “ Flight Attendant Duty Period Limitations and Rest Requirements”

- Established duty limitations and rest requirements in both part 121 and 135 operations, for all types of operations.

- This rule applied to all flight attendants who were assigned to duties in an aircraft for operations that required a flight attendant, including flight attendants in excess of the minimum flight attendant crew requirement

- Also allowed flight attendants to be scheduled under current flight crewmember regulations.

Challenges

- We must find the right balance of safety, science, cost and operational efficiency regarding amendments to our current rules.

- We must ask ourselves if the rules are reasonably balanced to assure that the adverse effects of fatigue do not jeopardize a flight and, at the same time, cost effective and flexible enough for operational efficiency.

- **Balance-**

  Prevent adverse effects of fatigue (look back rest which limits the duty day) vs. Flexibility (Flight time limits may be exceeded during the hard duty day- but only for circumstances beyond the carrier's control)

- We must recognize that this is a very polarizing issue. Work groups and Advisory Committees have not, thus far, reached consensus on part 121 regulations (e.g. the 1998 ARAC submitted 5 different proposals)

Challenges

Different flight environments have different operational requirements

- Different flight environments have different physiological challenges for crewmembers
- “Back-Side-Of-The-Clock” Operations
- Short Haul, Multiple Leg Operations
- Long Haul, Transcontinental, International and ULR Operations
- Can we develop a standard approach to very different operations…or should different limits be established for more fatiguing environments?

Challenges

Crewmembers

- No guarantee that crewmembers are “resting” during the rest period before a trip.
- Crewmembers do not always live in the same city where they work (can fly out of 4-5 different bases in a career)
- People can commute from LAX to PHL (crossing three time zones) to work an international trip that crosses additional time zones

Initiatives

While working to resolve these challenges, the FAA has undertaken many actions to enforce the current pilot rest/duty regulations:

- In **November 2000**, FAA Deputy Chief Counsel James Whitlow issued a letter regarding the look-back rest requirements in 121.471. In **May 2002**, this position was upheld by the U.S Court of Appeals

- Look-back rest requirements are not merely scheduling requirements, but are, in fact, hard requirements that require pilots and air carriers to cease the commencement of a flight, if before takeoff the actual expected block-in time meant that the pilot didn't commence his or her rest period on time.

- If, at the time immediately before takeoff, it is calculated that a pilot will have less than 8 hours of look-back rest in the 24 hours preceding the <u>actual expected block in time</u> for the flight segment, then the flight may not take off.

- "Legal to start, legal to finish" is inaccurate and misleading. It oversimplifies the flexibilities allowed for exceeding flight time limits by ignoring the fact that (1) carriers do not have the unfettered discretion to ignore flight time limits and (2) the look back rest requirements (duty day) are hard.

Initiatives

- In **May 2001**, the FAA announced that we would begin enforcing the 16-hour duty day codified in 14 CFR 121.471.
  - While the FAA declined in the 1985 final rule to explicitly “institute a limit on duty beyond the inherent limits necessitated by the required rest”, that very language reflected the FAA’s recognition that the <u>required rest requirements inherently limit a flight crewmember’s duty time</u>.
  - Adherence to look back and compensatory rest rules will prevent the danger that a person may not recognize the onset of dangerous fatigue.
- In **July 2002**, after the favorable, unanimous decision by a panel of the DC Circuit Court of Appeals, the FAA followed up on this action with briefings and instruction to FAA Principal Operations Inspectors on enforcement of the rest and duty rules and increased inspections of air carrier records.

Initiatives

- In **November 2003**, the FAA issued an interpretation which emphasized that <u>transportation that is 'local in nature</u>' means that transportation to the rest facility should not be so time-consuming that a crewmember cannot obtain sufficient rest.

- In **December 2005**, the FAA announced that <u>novel</u> requests for interpretation of flight, duty and rest requirements would be published in the Federal Register before an interpretation was issued.

- FAA continues to make available numerous legal interpretations on flight time, duty time and rest requirements.

Initiatives

- Advisory Circular 121-31 Flightcrew Sleeping Quarters and Rest Facilities —Addresses onboard sleeping facilities for crewmembers

- Advisory Circular 120-51E Crew Resource Management Training -- Establishes importance of curriculums that address fatigue mitigation and fatigue’s effect on performance

Initiatives

- OpSpec A332 to address Ultra Long Range Operations -- This rule of particular applicability is important for at least 3 reasons.
- (1) It fixes a deficiency in the decades-old Flag rules regarding maximum hours of service. In other words, contrary to the FAA's statutory duty to impose maximum hours of service, the existing Flag rules did not set explicit duty limits for pilots or implicit duty limits by means of look-back rest requirements.
- (2) It fixes the deficiency in the existing flight rules regarding the maximum number of scheduled flight time that an air carrier could assign to a pilot between required rest periods on the ground.
- (3) It sets layover rest requirements for pilots and flight attendants who work on these fatiguing flights.
- It is a new approach which incorporates science into crew duty/rest requirements and assures that alertness and performance are monitored

Initiatives

- Flight Attendant Fatigue Study (2007) –
  FAA Office of Aerospace Medicine Technical Report DOT/FAA/AM-07/21

- Contains a literature review on fatigue as potentially experienced by flight attendants, an evaluation of currently used (actual vs. scheduled) flight attendant duty schedules, and a comparison of these schedules to the current CFRs.

- The report concludes with 6 recommendations concerning issues that require further evaluation, including:

  (1) Survey of Field Operations.
  (2) Focused Study of Incident Reports.
  (3) Field Research on the Effects of Fatigue.
  (4) Validation of Models for Assessing FA Fatigue.
  (5) International Carrier Policies and Practices Review.
  (6) Training.

Initiatives

- Joint FAA/Industry Aviation Rulemaking Committee established on April 8, 2003 –
  - Provided recommendations to the FAA regarding the safety and applicability standards of parts 125, 135 and associated regulations.
  - Recommendations were developed for revising the commuter and on-demand flight/rest requirements in part 135.
- FAA Fatigue Symposium June 2008 –

--Aviation Fatigue Management: Partnerships for Solutions

Conclusion

The FAA is committed to promoting safe flight of civil aircraft by prescribing regulations that contain the right balance of safety, science and operational efficiency.

The FAA will continue to move forward to address the challenges of regulating appropriate and safe flight and duty limits and rest requirements.

Thank you for the commitment you have demonstrated by your attendance at this Symposium.

Parallel Session

Current State of Mitigation: Shiftwork Operations

NAV CANADA's Fatigue Management Program

Ann Lindeis, Ph.D.
NAV CANADA

8:35 - 9:00

June 18, 2008

Ann Lindeis, Ph.D.
Biography

Ann obtained her doctorate in Experimental Psychology from York University and has been working in the field of Human Factors for over 20 years. During that time she: investigated pilot survival and performance issues in "next generation" fighter aircraft in support of research at the Defence and Civil Institute of Environmental Medicine in Toronto, Ontario; investigated for Human Factors issues in air, rail, and marine accidents at the Transportation Safety Board of Canada, and; joined NAV CANADA in 2001.

At NAV CANADA, Ann worked as a Human Performance Specialist in the Office of Safety and Quality, where she was responsible for evaluating and recommending tools, methods and techniques to optimize human performance in providing air navigation services (ANS), and developing and delivering Human Factors training for managers and their teams. For the past 4 years, Ann’s responsibilities as Manager, Safety Management Planning and Analysis for the Operational Support department have focussed on enhancing the processes and procedures of the Safety Management System, and on integrating the processes within and across functional groups. Her team is responsible for:

- developing and producing safety performance metrics
- managing the Aviation Occurrence Reporting system
- providing Human Factors guidance and training to investigators
- developing integrated risk management techniques that employ system safety and human factors principles
- leading the national implementation of Just Culture
- leading the national implementation of Normal Operations Safety Survey (NOSS), which is the ATC equivalent of the airlines Line Operations Safety Audit (LOSA)

Ann is a member of the Human Factors and Ergonomics Society, and has published a number of articles in refereed journals and conference proceedings.

NAV CANADA's Fatigue Management Program

Ann Lindeis

Aviation Fatigue Management: Partnerships for Solutions
June 17 – 19, 2008

Overview

NAV CANADA

- Who we are
- Our Fatigue Management Program
- How we investigate for fatigue in incidents
- Continuing challenges

Who We Are

- Canada's provider of civil air navigation services
- 5,300 employees
- 6.5 million IFR movements per year
- Second largest ANS in world
- Regulated by Federal Government (Transport Canada) on safety performance

Fatigue Management Program

NAV CANADA

- Fatigue Management Policy
  - – incorporated into safety management system
- Purpose
  - – to enhance safety and reduce fatigue-related risks in our operations

Fatigue Management Program

Guiding Principles

- scientific basis
- comprehensive approach
- shared responsibility

Fatigue Management Program

NAV CANADA

Program Components

- education
- alertness strategies
- scheduling practices

Fatigue Management Program

Education

- controllers receive a module on the physiological basis of sleep and fatigue, circadian rhythms, personal alertness strategies

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Fatigue Management Program

Alertness Strategies

- preventive alertness strategies
- operational alertness strategies

Fatigue Management Program

Scheduling Strategies

- measures developed to assess schedules for their impact on fatigue
- periodic assessments of units' scheduling practices

Investigating for Fatigue

NAV CANADA

Investigation tool

- questionnaire on 72 hour history
- quantitative/qualitative analysis
- link fatigue to performance

Challenges

NAV CANADA

Balancing scientific principles of fatigue with:

- personal lifestyle preferences
- operational demands of traffic
- collective agreements

Conclusion

- Program provides:
  - solid framework for continuous improvement in managing fatigue
- Investigation tool provides:
  - data for assessing impact of fatigue on safety
- NAVCANADA is committed to actively manage fatigue to reduce risks to safety

Parallel Session

Current State of Mitigation:

Shiftwork Operations

Overview of Fatigue Mitigation Initiatives in the FAA Air Traffic Organizations

Mr. Kenneth Myers
Federal Aviation Administration

9:25 - 9:50

June 18, 2008

Kenneth Myers
Biography

Ken Myers is the Manager for Quality Assurance and Safety for the En Route and Oceanic Service Unit (ATO-E). As Manager for Quality Assurance and Safety, he is responsible for developing tracking initiatives for facility, service area, and service unit performance related to FAA Safety related goals and metrics. He develops, coordinates, implements and evaluates action plans to achieve positive metric movement related to operational errors. He provides quality assurance oversight to service unit developed products, including directives, policies, hardware and software. The ATO-E organization has met their safety targets during each year of Mr. Myer's tenure, reducing their most severe operational errors by approximately 20% from FY-2005 through FY-2007. Additionally, he is so responsible for implementation of the ATO Safety Management System in ATO-E.

Prior to serving in this position Mr. Myers was the Air Traffic Manager at the Washington Air Route Traffic Control Center (Washington ARTCC) in Leesburg, VA. Washington ARTCC is one of the FAA's busiest control facilities, handling more than 2.7 million aircraft operations per year.

Mr. Myers started with the FAA in June 1978. In addition to his most recent positions, he has been the Assistant Air Traffic Manager at the Cleveland ARTCC, and was also Support Manager for Quality Assurance, first line manager, and a certified professional controller at that facility. He also served as an en route instructor in the Center option at the FAA Academy in Oklahoma City, Oklahoma.

Mr. Myers received a Masters of Business Administration from Oklahoma City University in 1988, graduating with honors. Mr. Myers received his Bachelor of Science in Aerospace Technology from Kent State University in 1978 and completed additional coursework in Mechanical Engineering at the University of Akron.

Mr. Myers is married, and has two girls. In his spare time he enjoys reading, music, and open-wheel automobile racing.

Federal Aviation Administration

Fatigue Mitigation Initiatives in the FAA's Air Traffic Organization

(NTSB Recommendations)

Prepared by: Ken Myers
Manager, Quality Assurance and Safety, ATO-E

Date: June 18, 2008

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Today’s Briefing

- Which NTSB Recommendations we are working with?
- How did the FAA respond?
- What have we found out so far?
- What is a potential strategy going forward?
- Next Steps

NTSB Recommendations

- **A-07-30 (FAA)**

To the Federal Aviation Administration:

Work with the National Air Traffic Controllers Association to reduce the potential for controller fatigue by revising controller work-scheduling policies and practices to provide rest periods that are long enough for controllers to obtain sufficient restorative sleep and by modifying shift rotations to minimize disrupted sleep patterns, accumulation of sleep debt, and decreased cognitive performance.

- **A-07-32 (NATCA)**

To the National Air Traffic Controllers Association

Work with the Federal Aviation Administration to reduce the potential for controller fatigue by revising controller work-scheduling policies and practices to provide rest periods that are long enough for controllers to obtain sufficient restorative sleep and by modifying shift rotations to minimize disrupted sleep patterns, accumulation of sleep debt, and decreased cognitive performance.

How did the FAA Respond

- **Accepted all 4 recommendations**
  - **Expanded the scope of the recommendations**
    - Air Traffic Front Line Managers and Operations Managers
    - Airway Transportation Systems Specialists
  - **Formed a workgroup to focused on recommendations A07-30/32**
    - Civil Aerospace Medical Institute (CAMI)
    - ATO-E/T/R/W
    - NATCA
    - PASS
    - NAGE
    - SUPCOM
    - Support from AHR/LR

What We Have Learned So Far:

- **There is no silver bullet**
  - As long as you have non-circadian shifts you have a potential fatigue issue
  - Fatigue, and the person’s response to it ,is personalized
- **Is not peculiar to air traffic control**
  - Long-haul commercial flights
  - Maintenance and ground crews working overnight
  - Is becoming a subject of interest for the industry
- **There are some initial first steps that can be taken**

Possible Strategy for Addressing Fatigue

- Revise the guidance contained in various FAA directives related to scheduling practices
  - **For ATCS/TMC/FDCS: FAA Order 7210.3, paragraph 2-6-6/2-6-7**
    - **Clarify that this guidance applies to all safety related positions**
    - **Time between shifts**
    - **Breaks**
  - **Other organizations (ATO-W) will identify their governing directive**
- Utilize the expertise of CAMI in identifying these good work-scheduling policies and practices
- Training is being developed and implemented by ATO-A/S
  - **Recommendation A07-31 (Fatigue Awareness and Mitigation)**
  - **Recommendation A07-34 (Crew Resource Management)**
- We are working within the Collective Bargaining Agreements

What This Might Look Like:

- **FAA Order 7210.3, paragraph 2-6-7**
  - **Current**

2-6-7. BASIC WATCH SCHEDULE

a. Facility watch schedules shall take into account normal traffic flow, thereby permitting the posting of a continuing schedule for an indefinite period of time. Facility management is responsible for ensuring watch schedules are in accordance with collective bargaining agreements.

b. Air traffic control specialists whose primary duties are those directly related to the control and separation of aircraft must meet the following criteria:

  - **PROPOSAL**

2-6-7. BASIC WATCH SCHEDULE

a. Facility watch schedules shall take into account normal traffic flow, thereby permitting the posting of a continuing schedule for an indefinite period of time. Facility management is responsible for ensuring watch schedules are in accordance with collective bargaining agreements.

b. Air traffic control specialists, front line managers, traffic management coordinators, supervisory traffic management coordinators, and operations managers whose primary duties are those directly related to the control and separation of aircraft must meet the following criteria:

1-3 (no change)

4. Have an off-duty period of at least 10 hours from the time work ends to the start of any subsequent shift

5. Have an off-duty period of at least 24 hours following the last midnight shift in a work rotation.

NOTE A midnight shift is defined as a shift in which the majority of hours are worked between 10 PM and 8 AM (local time)

6-8 (no change)

Guidance on Good Shift Scheduling Practices (Ergometric Principles of Scheduling)

- **Shift Rotations:**
  - Clockwise rotation if possible
  - Six successive shifts at most
  - Four successive of the same shift type at most
  - Avoid shifts that are longer than 10 hours
- **Basis for training for supervisors and managers**
- **Start times for midnight shifts**

Relief Periods

- FAA Order 7210.3, paragraph 2-6-6
- 2-6-6. RELIEF PERIODS

  a. Personnel performing watch supervision duties are responsible for ensuring that breaks are administered in an equitable manner and applied so as to promote the efficiency of the agency. They are also responsible for ensuring that breaks are of a reasonable duration.

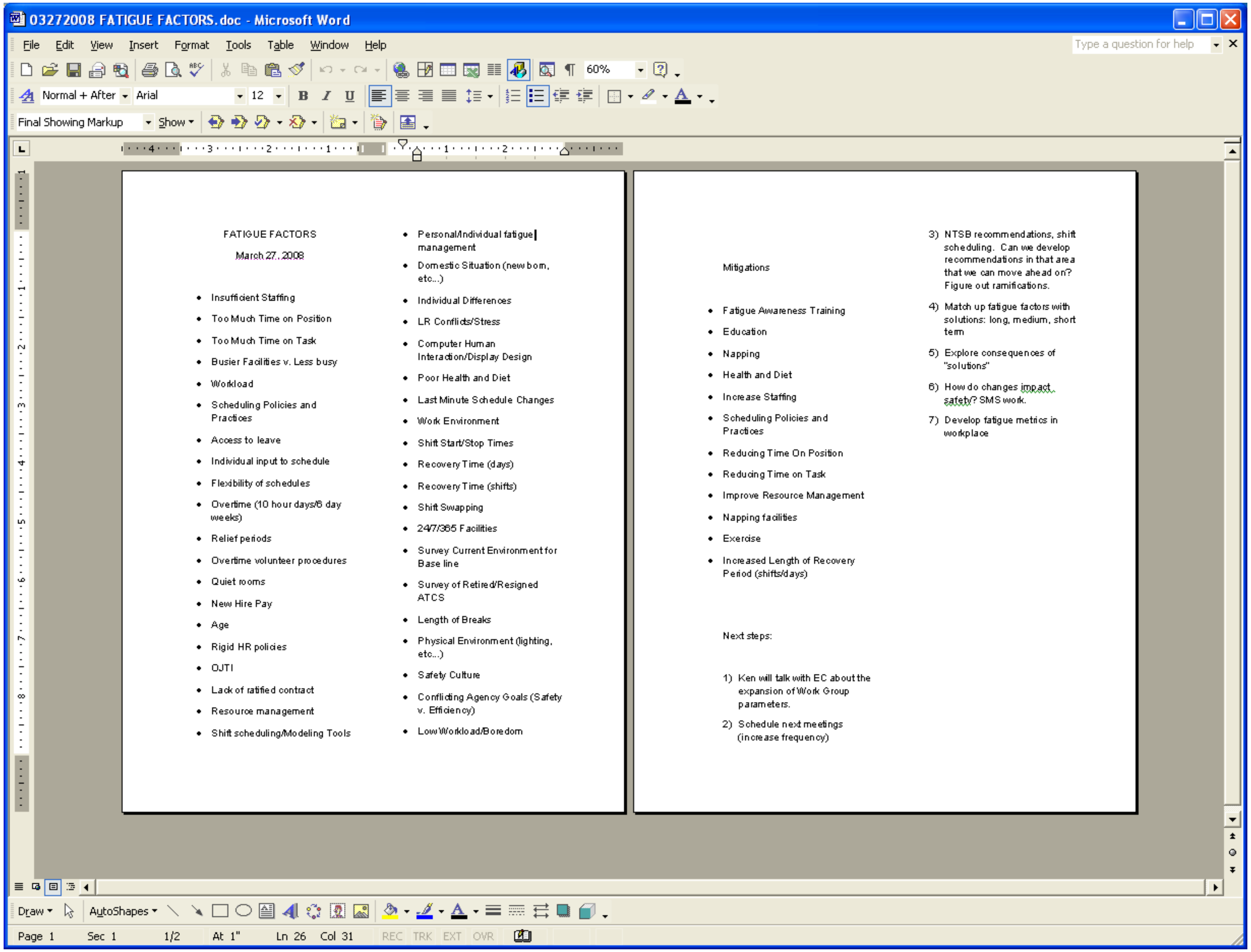
  b. Personnel performing watch supervision duties are responsible for knowing the whereabouts of employees to ensure their availability for position assignments.

  c. Personnel performing watch supervision duties shall not condone or permit individuals to sleep while on duty. Any such instance shall be handled in accordance with FAPM 2635, Conduct and Discipline.

- Proposed change:

  c. Personnel shall present themselves for work assignments in a condition ready to safely perform the assignment.

Other Things that Might Contribute to Fatigue



FATIGUE FACTORS

March 27, 2008

- Insufficient Staffing
- Too Much Time on Position
- Too Much Time on Task
- Busier Facilities v. Less busy
- Workload
- Scheduling Policies and Practices
- Access to leave
- Individual input to schedule
- Flexibility of schedules
- Overtime (10 hour days/6 day weeks)
- Relief periods
- Overtime volunteer procedures
- Quiet rooms
- New Hire Pay
- Age
- Rigid HR policies
- OJTI
- Lack of ratified contract
- Resource management
- Shift scheduling/Modeling Tools
- Personal/Individual fatigue management
- Domestic Situation (new born, etc...)
- Individual Differences
- LR Conflicts/Stress
- Computer Human Interaction/Display Design
- Poor Health and Diet
- Last Minute Schedule Changes
- Work Environment
- Shift Start/Stop Times
- Recovery Time (days)
- Recovery Time (shifts)
- Shift Swapping
- 24/7/365 Facilities
- Survey Current Environment for Base line
- Survey of Retired/Resigned ATCS
- Length of Breaks
- Physical Environment (lighting, etc...)
- Safety Culture
- Conflicting Agency Goals (Safety v. Efficiency)
- Low Workload/Boredom

Mitigations

- Fatigue Awareness Training
- Education
- Napping
- Health and Diet
- Increase Staffing
- Scheduling Policies and Practices
- Reducing Time On Position
- Reducing Time on Task
- Improve Resource Management
- Napping facilities
- Exercise
- Increased Length of Recovery Period (shifts/days)

Next steps:

1) Ken will talk with EC about the expansion of Work Group parameters.
2) Schedule next meetings (increase frequency)
3) NTSB recommendations, shift scheduling. Can we develop recommendations in that area that we can move ahead on? Figure out ramifications.
4) Match up fatigue factors with solutions: long, medium, short term
5) Explore consequences of "solutions"
6) How do changes impact safety? SMS work.
7) Develop fatigue metrics in workplace

Steps Already Underway

- **Fatigue Analysis Tools such as FAST**
  – Graphically depicts the impacts of shift rotations and schedule rotations to highlight areas of concern
  – Already developed and in-use
  – Provide proof of ideas moving to a facility-level application
- **FAA Human Factors Analysis**
  – Time on Task
  – Acquisition/Loss of Situational Awareness

Next Steps

- **Do modeling:**
  - Impacts of a 10 or 12-hour break between shifts
    - Can a schedule be built
    - What are the staffing impacts
  - What are the issues that will need to be trained
    - Determine how training will be accomplished
    - Use of scheduling tools
    - What is a timeline to accomplish
  - What are the LR impacts/obligations
- **Determine how we should address the other factors**

Safety Risk Management

- **In most areas we anticipate that these changes will be documented under an SRM Decision Memorandum (SRMDM):**
  - Maximizing the potential to achieve rest periods specified in agency directives

Ken Myers

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202-267-9157

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions;
Vienna, VA: June 17-19, 2008

Joint Session

Operational Drivers of Fatigue: National Transportation Safety Board Findings

The Evolution of NTSB Fatigue Related Recommendations

Jana Price, Ph.D.
National Transportation Safety Board

11:00 - 11:15

June 17, 2008

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Jana M. Price, Ph.D.
Biography

Jana M. Price, Ph.D. has worked at the National Transportation Safety Board (NTSB) since 2001 as a Transportation Research Analyst in the Office of Research and Engineering. At the Safety Board, she conducts safety studies addressing all modes of transportation as well as providing statistical and human factors support for accident investigations. She leads the safety team addressing the Board's Most-Wanted recommendations concerning operator fatigue, and she helped to develop and coordinate a two-day NTSB Training Center course on investigating human fatigue factors in transportation accidents. Dr. Price also represents the Safety Board as part of the Department of Transportation's Human Factors Coordinating Committee.

Dr. Price received her M.A. and Ph.D. at the University of Connecticut in human factors psychology where her graduate research focused on break-taking patterns among commercial truck drivers, and hazard perception in expert and novice drivers.

NTSB National Transportation Safety Board

The Evolution of NTSB Fatigue Related Recommendations

Jana M. Price, Ph.D.

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

NTSB Fatigue Recommendations

- Over 100 recommendations since 1970s
- 34 recommendations in aviation
  - Pilots
  - Maintenance workers
  - Air traffic controllers

Most Wanted List

- Fatigue included since 1990
- Original DOT recommendations
  - Research
  - Education
  - Hours of service
- 7 current aviation fatigue recommendations

Most Wanted Aviation Recommendations

- Flight crews
  - Modify and simplify flight and duty time regulations
  - Prohibit assigning “tail-end” Part 91 flights
- Maintenance personnel
  - Establish science-based duty time limits
- Air traffic controllers
  - Revise work scheduling policies/practices
  - Develop fatigue training for controllers

Fatigue Risk Factors

- Sleep deprivation
- Circadian variability
- Time awake
- Sleep disorders/health
- Workload/environment

Fatigue Management Systems

- Employ multiple countermeasures to mitigate fatigue, errors, and accidents
- Continuous evaluation, validation and improvement

NTSB Fatigue Management Recommendations

Develop guidance, based on empirical and scientific evidence, for operators to establish fatigue management systems, including information about the content and implementation of these systems.

NTSB Fatigue Management Recommendations

Develop and use a methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents.

Future Directions

- Assess operational issues
- Identify specific countermeasures
- Determine whether the countermeasures
  - Mitigate fatigue
  - Improve performance
  - Reduce errors and incidents

NTSB National Transportation Safety Board

The Evolution of NTSB Fatigue Related Recommendations

Jana M. Price, Ph.D.

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

NTSB

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Parallel Session

Current State of Mitigation: Flight Operations

Correlation between Fatigue Reports and Flight Performance Deviations

Jack Rubino, M.D.
United Airlines Flight Center

9:00 - 9:25

June 18, 2008

Jack Rubino, M.D.
Biography

Jack Rubino, M.D. has been the Manager of Human Factors at the United Airlines Flight Center since 1999. He is a former United Air Force Flight Surgeon and served in Operation Desert Storm and was awarded a Medal of Meritorious Service. He also was a Board Certified Ob-Gyn and a Fellow of the American Board of Obstetricians and Gynecologists.

Dr. Rubino is a pilot with a Type rating on the B-737, B-747-400, B-757/767 and B-777. He is also type rated on the Airbus A-320 and A-330. He has been an instructor pilot on the B-757/767 and B-777 and also an instructor on the A-320. He is a partner and pilot for Global Flying Group, which does test flights and ferry flights for the major aircraft leasing companies.

Education: Villanova University, B.S in Biology, Temple University School of Medicine, Medical Degree, Thomas Jefferson University, Philadelphia, PA completed residency in OB-GYN, The United States Air Force School of Aerospace Medicine, Brooks Air Force Base, TX.

Fatigue Seminar

June 18, 2008

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Stress and Fatigue

Dr. Jack Rubino

Why talk about it?

- Raise awareness of safety-related issues regarding fatigue
- Provide tools that can be used to defeat fatigue

Stress and Fatigue
Overview

Contributing factors of fatigue

- Increased productivity requirements necessitate longer hours
- Schedules of flight operations require odd work hours
- Commuting to and from domicile adds to work time
- Cockpit is dry, noisy, complex and sometimes stressful
- Stress of social and family pressures

Stress and Fatigue
by the numbers

- Less than six hours of sleep is Acute Fatigue.
- The average sleep you need each night, less the actual sleep you get is your Sleep Debt.
- Sleep debt of more than six hours without recovery produces Cumulative Fatigue.

Stress and Fatigue
By the numbers

- Window of circadian low - 0200 to 0500 body time
- Hours on duty $\geq$ 12 hours
- Hours awake $\geq$ 16 hours
- Medical conditions
  - Sleep apnea
  - Medications
  - Depression
  - Etc.

Stress and Fatigue
What United is Doing

- A Safety Review Team meets monthly to review all FSAP Reports, FSIs, and Crew Desk calls
- Group consists of:
  - VP of Flight Operations
  - VP Safety
  - Crew Planning
  - Managing Director of Domicile Operations
  - Managing Director of Flight Standards and Training
  - Human Factors
- One result of this group is to eliminate late night calls from the Crew Desk

Fatigue Risk Management Strategy (FRMS)

- The FRMS is an apolitical, joint UAL/ALPA effort whose focus is improving safety through the understanding and development of relevant fatigue mitigation strategies for UAL worldwide flight operations.

- The FRMS is a three-part program, using a scientific, evidence-based approach to risk posed by fatigue.

FRMS Elements

- A training and education program geared towards pilots, schedule builders, flight managers, and crew schedulers or anyone else whose decisions directly impact fatigue related risk operations;
- The use of scheduling software to identify fatigue inducing pairings and monthly schedules; and
- The development of an audit metric to measure whether or not the mitigations are effective.

Training and Education

- Tiered, multi-level training, directed towards individuals whose decisions impact fatigue-related risk operations.
- Promote knowledge about the risks, causes, and consequences of pilot fatigue.
- Varied delivery modes and formats
- Responsibilities of management and pilots
- Competency based assessment?

SAFETE-FAST

The software that we are looking at uses a biomathematical model called the Sleep, Activity, Fatigue, and Task Effectiveness or SAFETE model and is embedded in software known as Fatigue Avoidance Scheduling Tool (FAST), developed by Dr. Steven Hirsch.

Parallel Session

Operational Evidence of Fatigue: Flight Operations

Sleep and Psychomotor Performance during Commercial Ultra-Long Range Flights

Leigh Signal, Ph.D.
Massey University

14:45 - 15:10

June 17, 2008

Leigh Signal, Ph.D.
Biography

Dr. Leigh Signal is a Senior Research Fellow and the Associate Director of the Sleep/Wake Research Centre, Massey University, New Zealand. Leigh initially trained as Commercial Pilot. She has completed a Masters Degree in Industrial and Organizational Psychology and a Doctorate in Public Health, which investigated strategic napping in the Air Traffic Control environment. Her current research focuses on understanding the factors that influence sleep and the circadian biological clock and, in turn, how these physiological processes influence waking functioning, particularly for individuals working in the aviation industry. She conducts research in both laboratory and applied settings.

Sleep and Psychomotor Performance during Commercial Ultra-Long-Range Flights

Dr. Leigh Signal
Ms. Margo van den Berg
Prof. Philippa Gander

Sleep/Wake Research Centre
Research School of Public Health
Massey University

Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

SLEEP / WAKE RESEARCH CENTRE
MOE TIKA, MOE PAI

Background

- **Ultra-long-range = planned flights in excess of 16 hours (duty periods of 18-22 hours)**
- **CAAS task force validation programme**
  - » SIA applied to operate SIN-LAX non-stop using A340-500
  - » Task force established (CAAS, SIA, ALPA-S)
  - » Prediction of flight crew alertness (QinetiQ/ECASS)
  - » Update of model using existing SIA long-range flights (QinetiQ/ECASS)
  - » CAAS Air Operator Certificate Requirements (Chapters 2 and 4, Appendices C1 and C2)
  - » ULR data collection SIN-LAX-SIN (ECASS and Massey University)

Overview of Studies

2004	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
SIN-LAX-SIN Diary study	X	X				X				
SIN-LAX-SIN PSG study			X		X					

Measures

Sleep

- **Polysomnography (PSG)**
  - » "Gold standard" measure
  - » Brain activity (EEG)
  - » Eye movement (EOG)
  - » Muscle tone (EMG)
- **Actigraphy and sleep diary**

Performance

- **Psychomotor Vigilance Task (PVT)**

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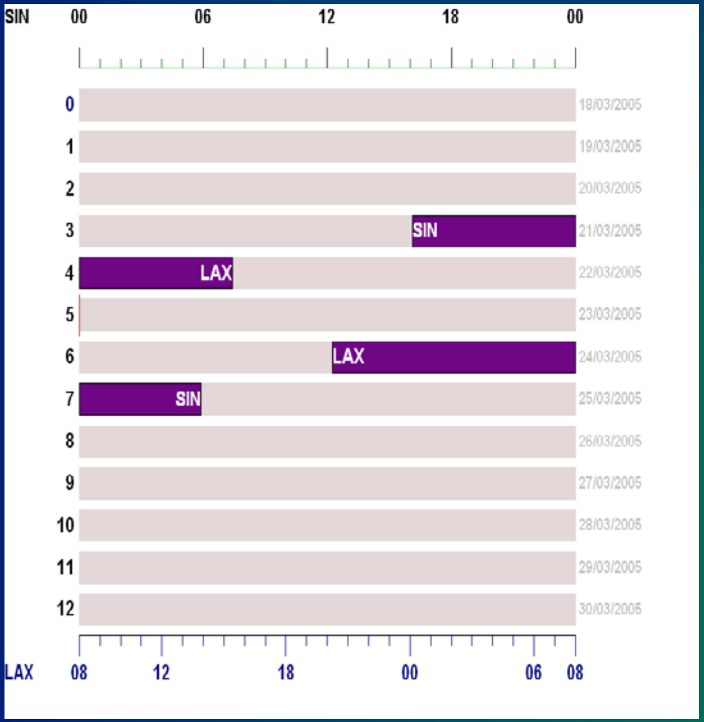
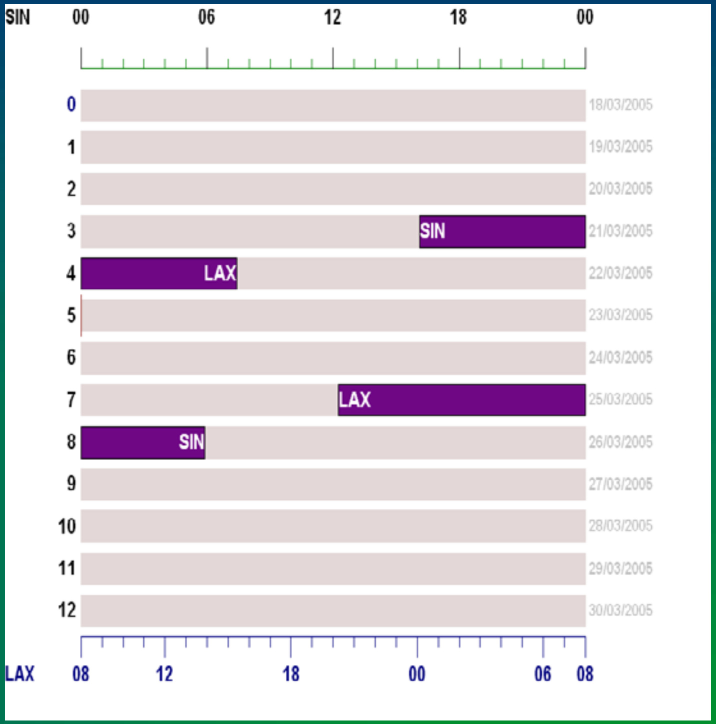
SIN-LAX-SIN Schedule



Four day pattern (two-day layover)



Five day pattern (three-day layover)

SIN-LAX = 15:30 (15:06-16:03)

LAX-SIN = 17:00 (16:12-18:02)

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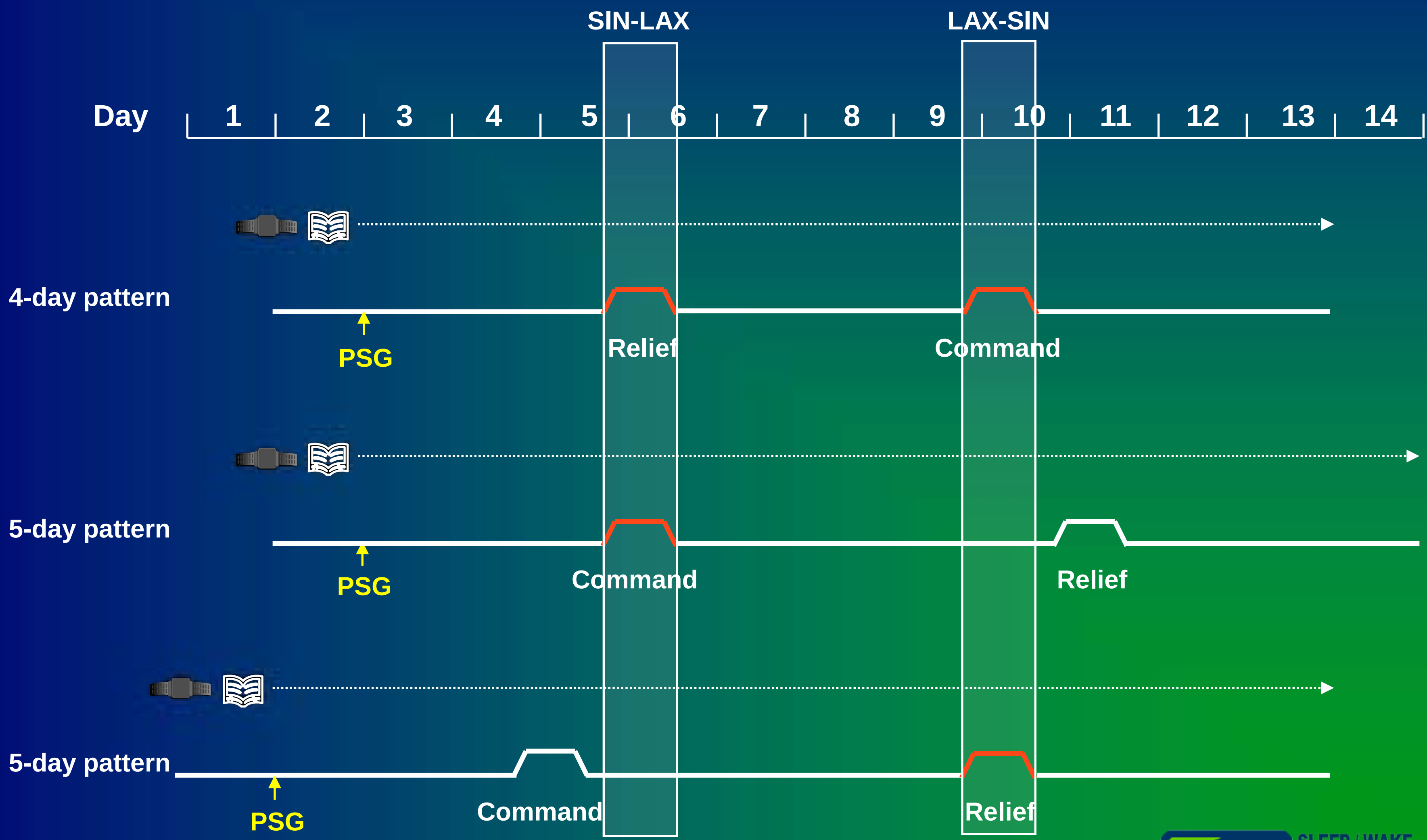
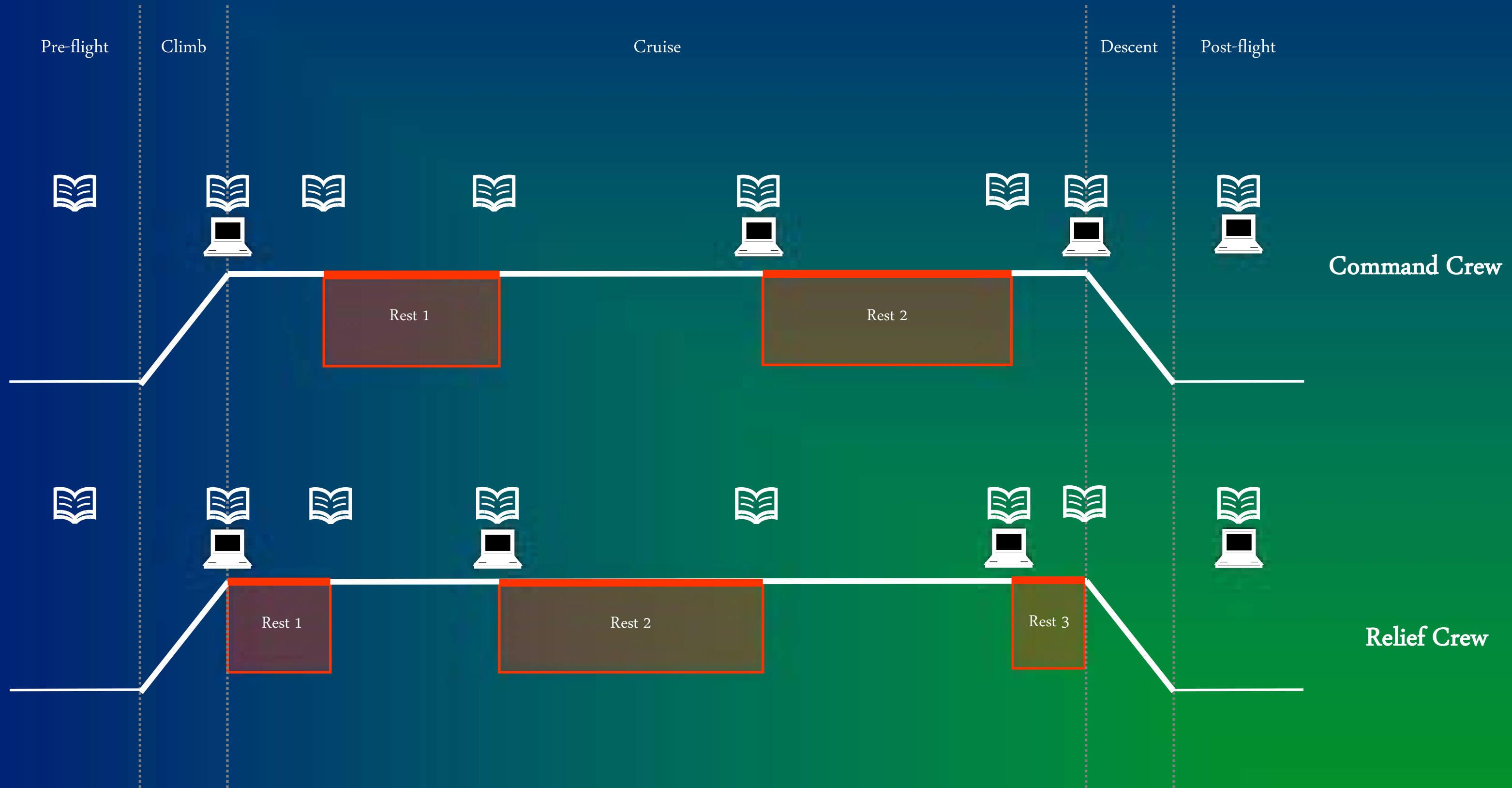
Data Collection



In-Flight Data Collection



Crewmembers

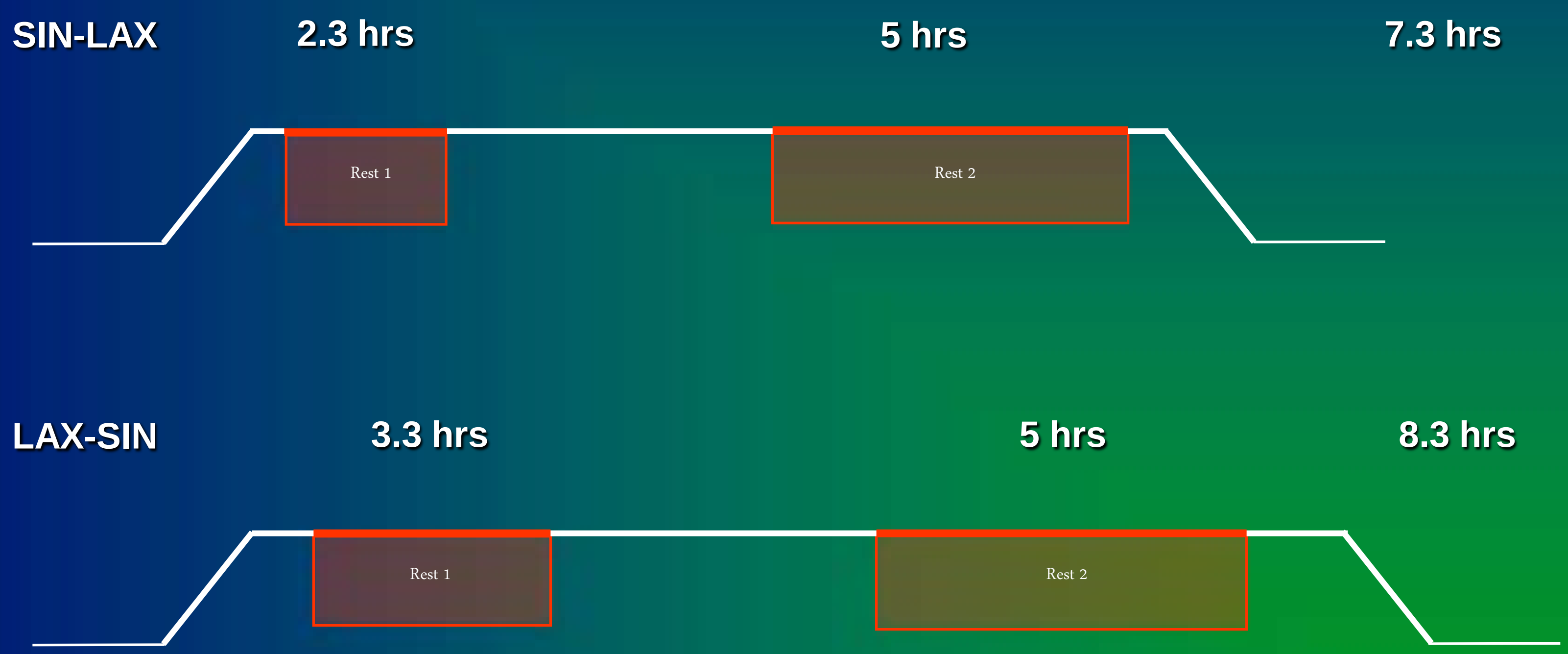
- 23 Captains, 18 First Officers (6 participated twice)

	Median	Range
Age (yrs)	44	29-58
Flight time (hrs)	10,500	800-20,000
LR (yrs)	6	0-32
ULR (mths)	2.1	0-5.1

Data Analysed

	Number of data sets
PSG SIN-LAX	43
PSG LAX-SIN	45
PVT SIN-LAX	30
PVT LAX-SIN	29

In-Flight Rest Command Crew



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In-Flight Rest Command Crew

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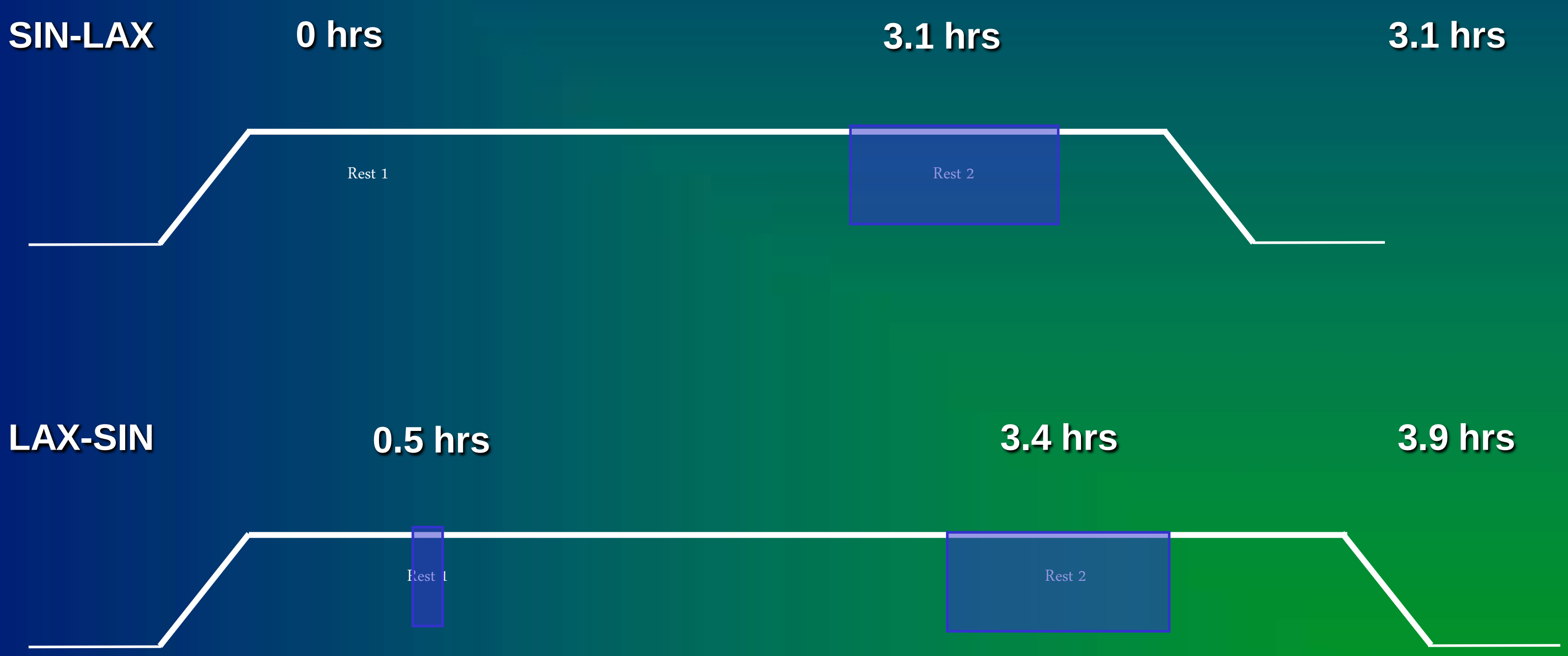
In-Flight Rest Command Crew



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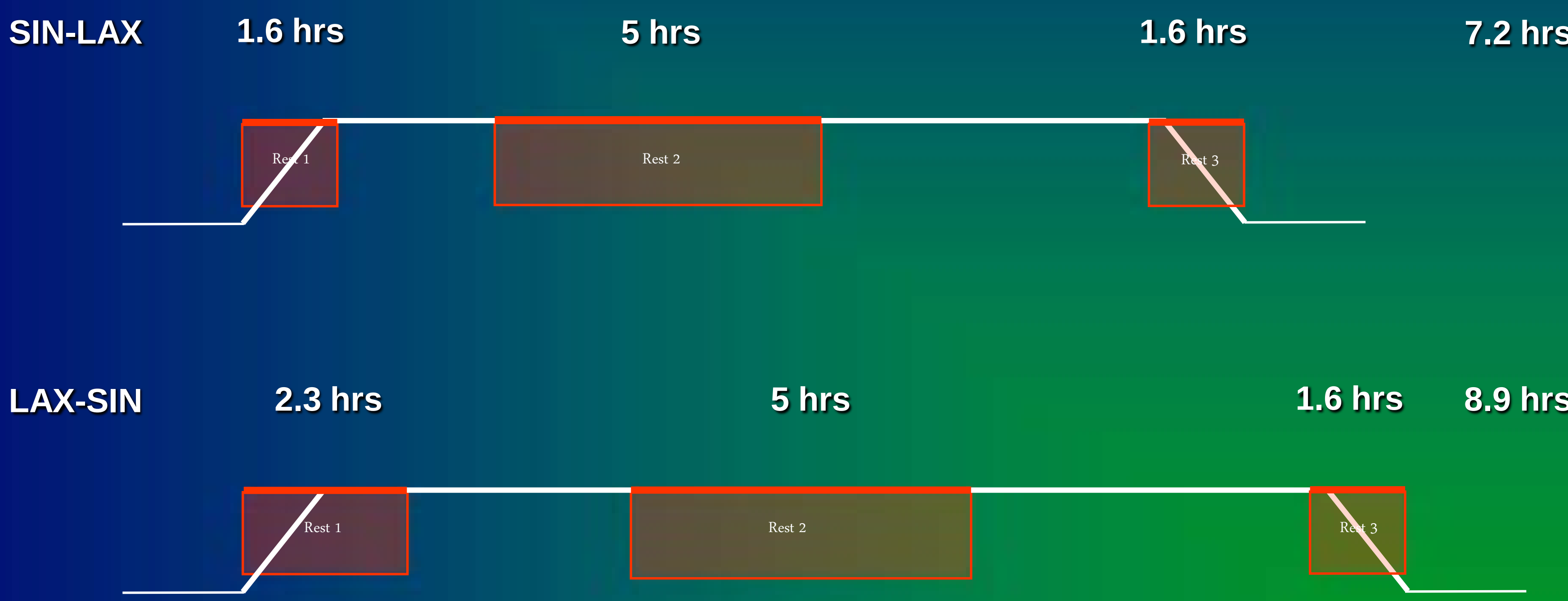
In-Flight Rest Relief Crew



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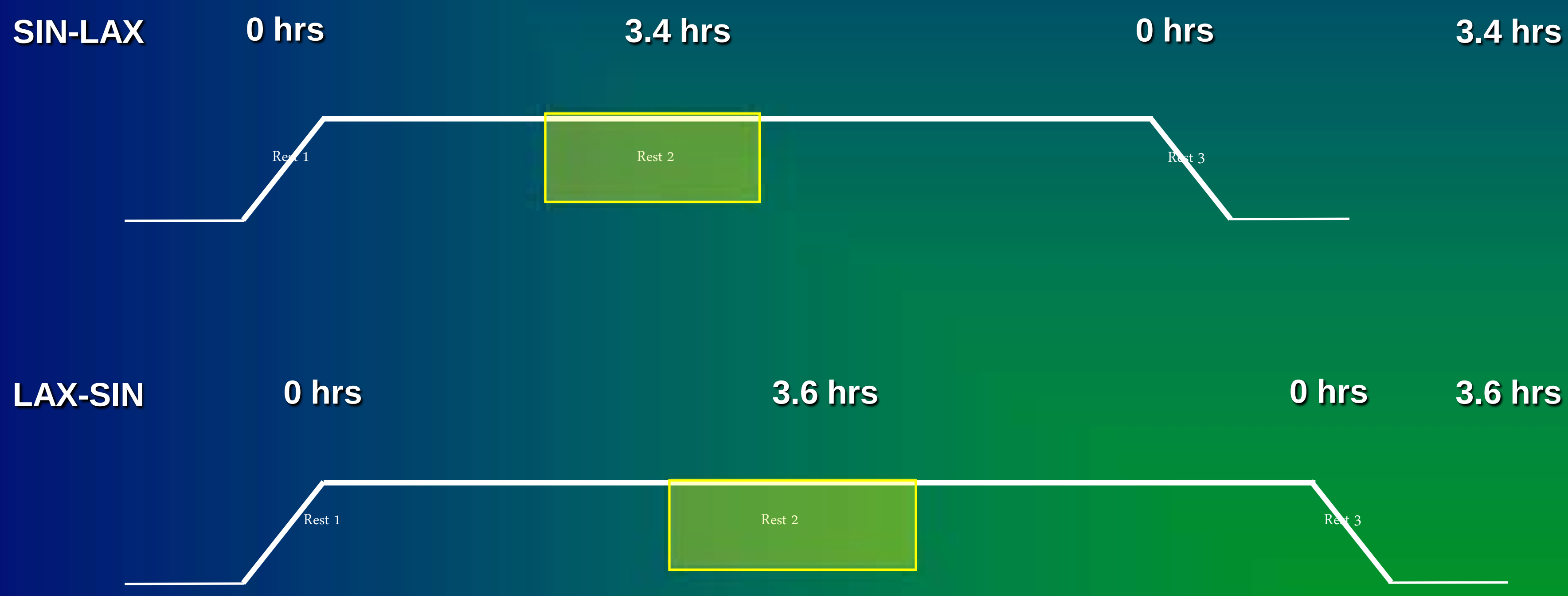
In-Flight Rest Relief Crew



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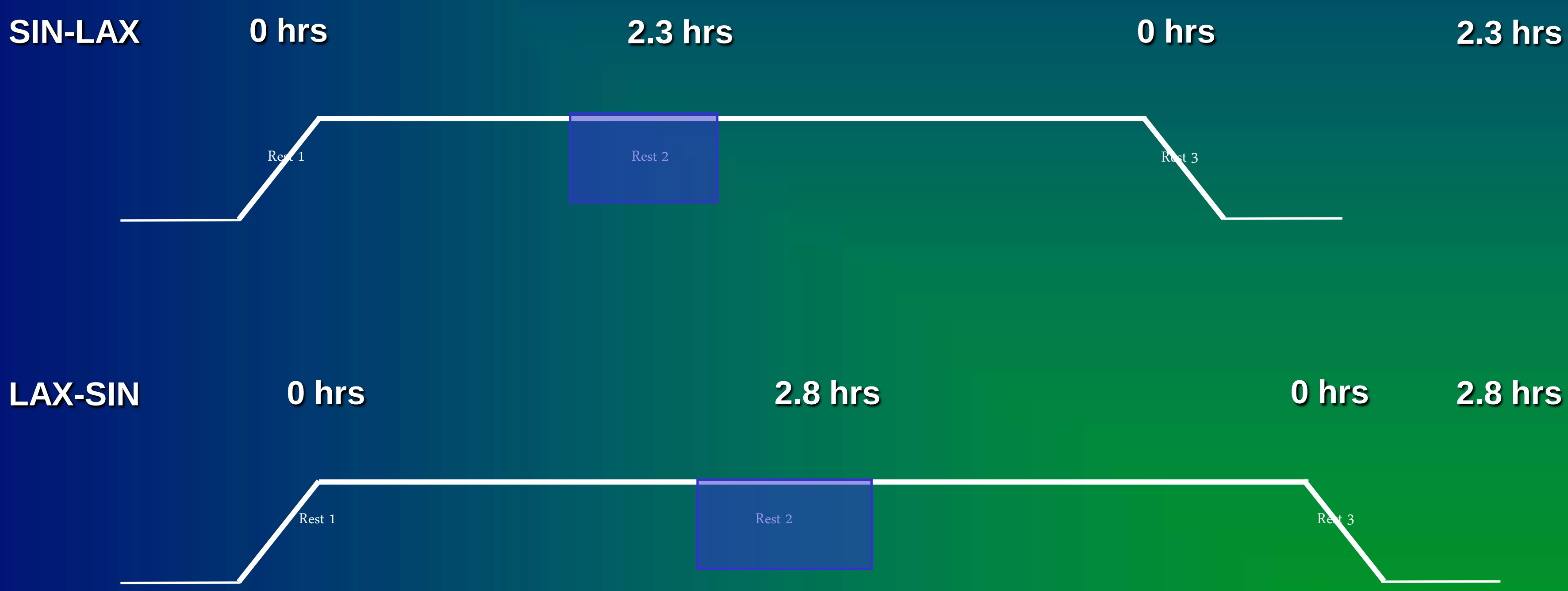
In-Flight Rest Relief Crew



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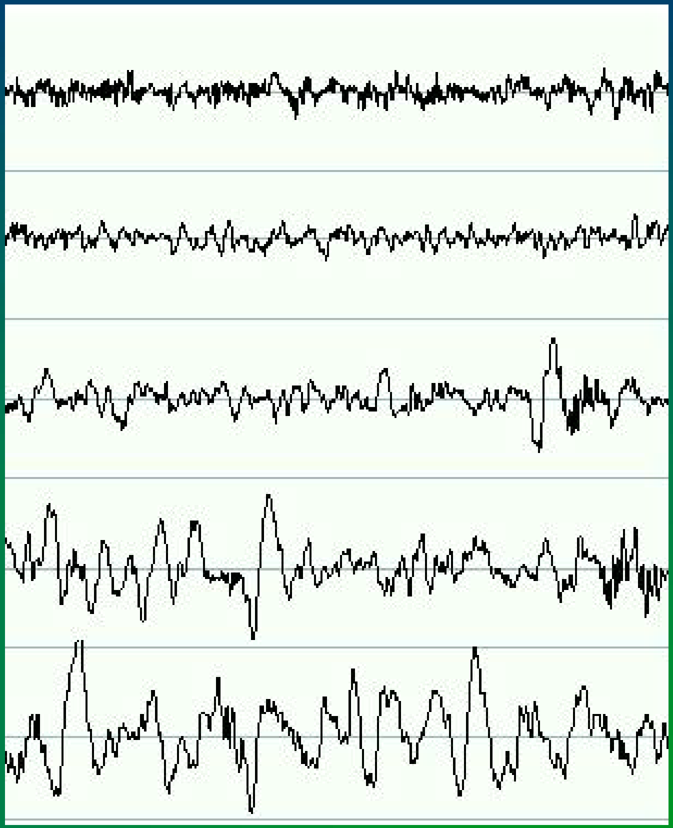
Sleep Structure

- **Latencies range widely (1-84 min)**
- **Most sleep NREM S1 and S2**
- **Long rest opportunity (second rest)**
  - » More efficient sleep, more SWS, more REM
- **Crew sleeping twice tend to obtain more sleep**
  - » Main crew 4 hrs vs. 3.2 hrs
  - » Relief crew 3 hrs vs. 2.5 hrs
- **Amount of sleep in 2nd rest not reduced by sleeping in first rest**

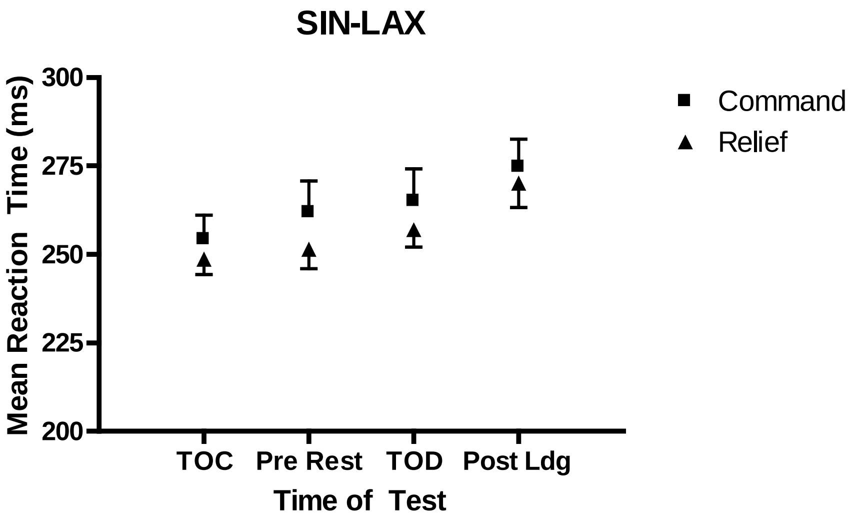


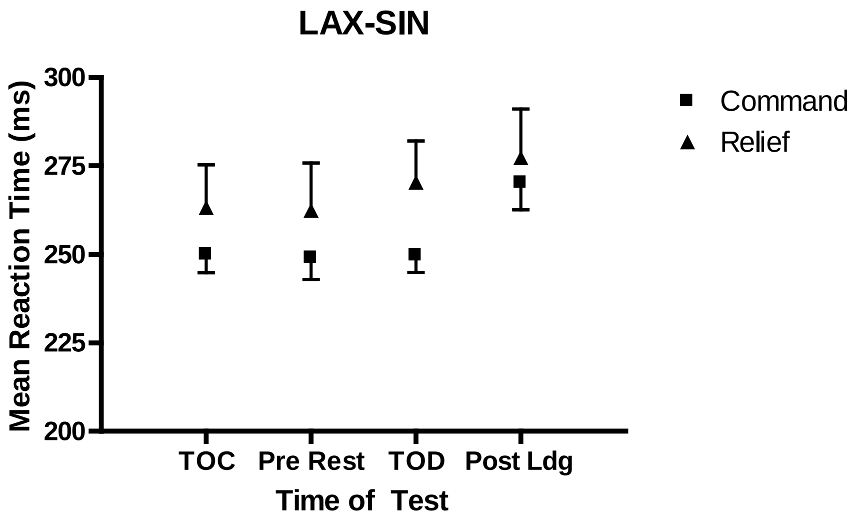
Adaptation vs. In-Flight Sleep

- Comparison made between longest in-flight sleep and adaptation night sleep

	Adaptation	SIN-LAX	Adaptation	LAX-SIN
Sleep Latency (mins)	10	16	10	13
Sleep Efficiency (%)	87	73	85	77
Wake (%)	13	27	15	23
Awakenings (/hr)	7	7	7	6
Arousals (/hr)	23	22	23	23

Psychomotor Performance





Summary

- **In-flight rest opportunities**
  - » All flight crew slept at least once in-flight
  - » Large individual variability in total sleep obtained
  - » Relatively low utilisation of short rest opportunities
  - » Sleeping twice not a disadvantage
  - » Important to measure how rest opportunities are used and how much sleep is actually obtained.
- **Multiple measures required to determine functional status of flight crew**

Acknowledgements

- SIA flight crew
- SIA management
- CAAS
- ALPA-S
- Researchers from DLR
- Researchers from ECASS

Parallel Session

Operational Evidence of Fatigue: Flight Operations

Effects of Fatigue on Threat and Error Management Behavior of Long-Haul Flight Crew

Matthew Thomas, Ph.D.
University of South Australia

15:10 - 15:35

June 17, 2008

Matthew Thomas, Ph.D.
Biography

Dr. Matthew Thomas is a Senior Research Fellow and Program Director of Human Factors at the University of South Australia. His research interests focus on Human Error and Training Systems Design and is currently involved in a range of industry projects across aviation, rail, healthcare and other high-risk domains. He has been developing innovative approaches to simulation-based training and assessment and specializes in the area of Non-Technical Skill development and Error Management. He has taught in the area of Human Factors in Australia, New Zealand and Singapore, and is the President of the Australian Aviation Psychology Association.

Australian Long-Haul Fatigue Study

Fatigue and Threat and Error Management

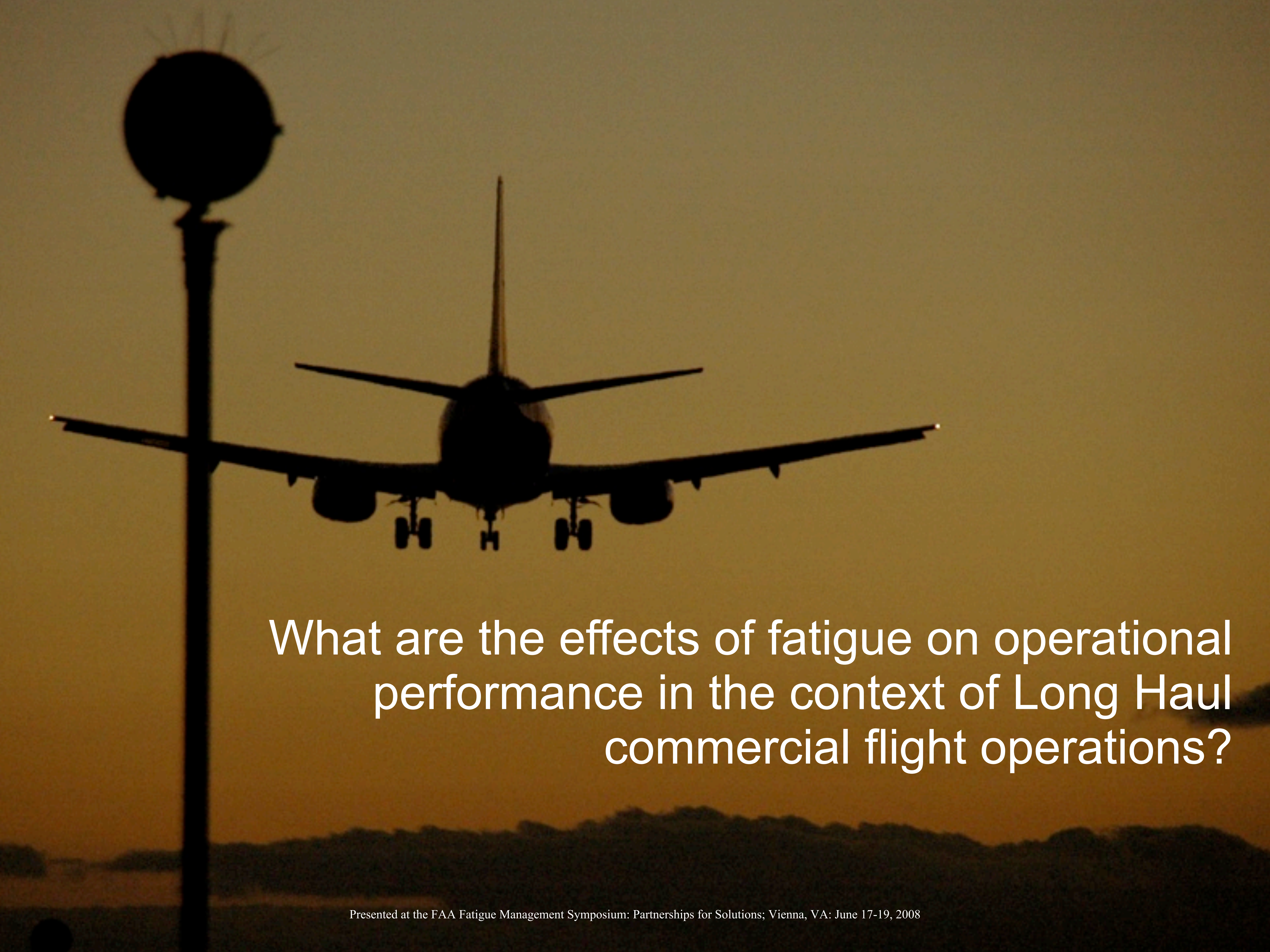
FAA Aviation Fatigue Management
Partnerships for Solutions June 17-19 2008

UniSA

Qantas
Civil Aviation Safety Authority
Australian and International Pilots Association
Australian Research Council

Scientific Reference Panel

The Research Team



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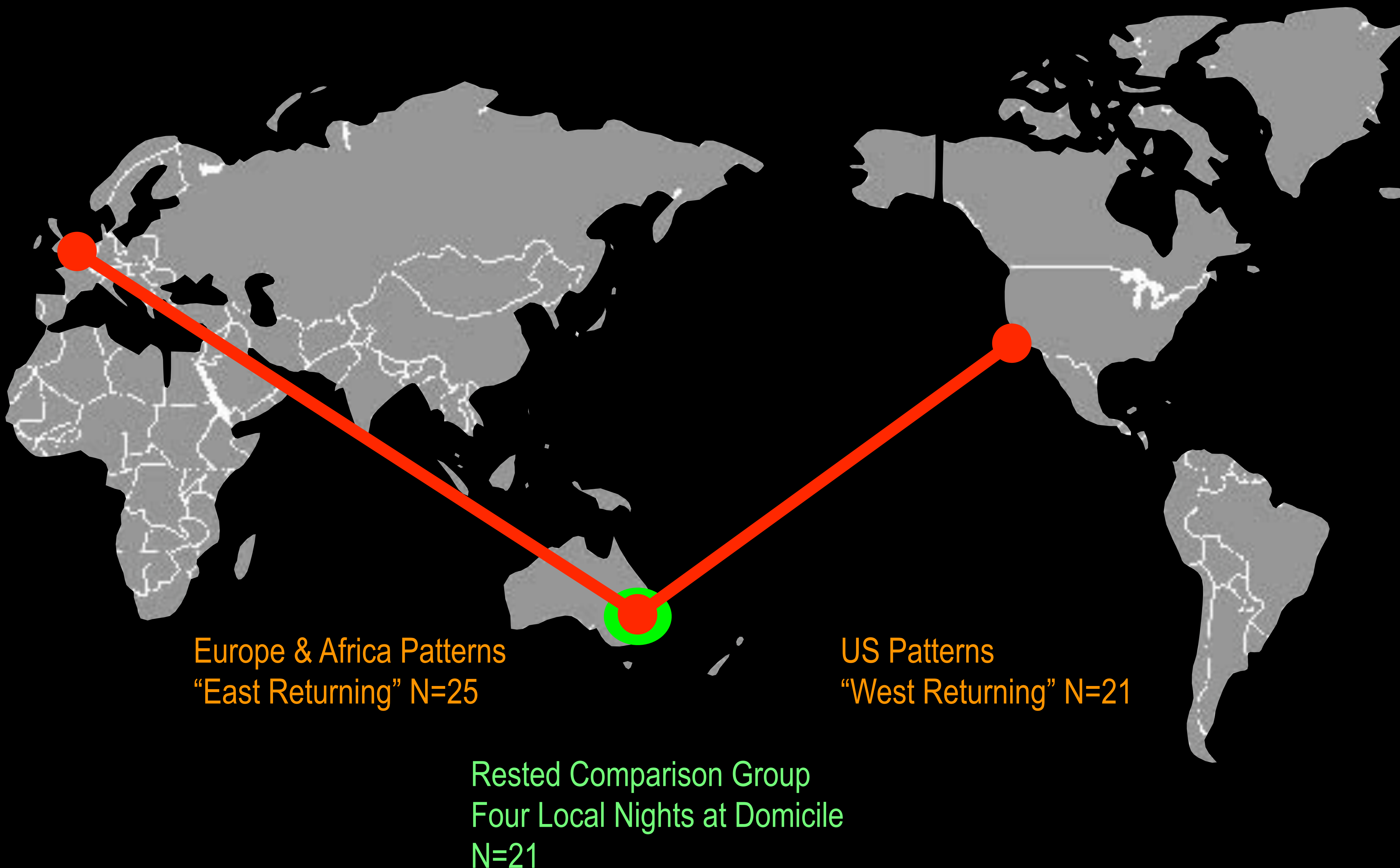
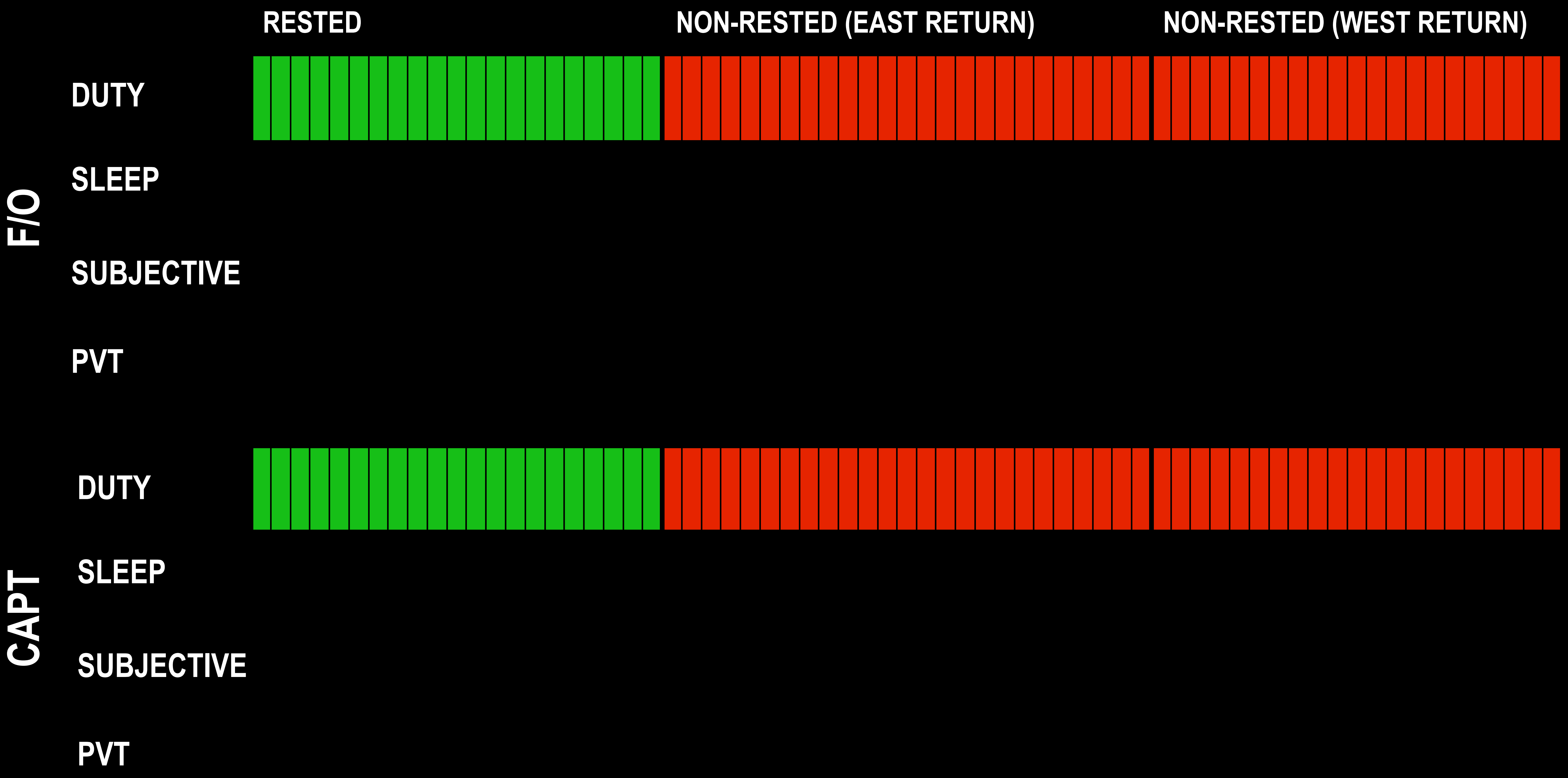
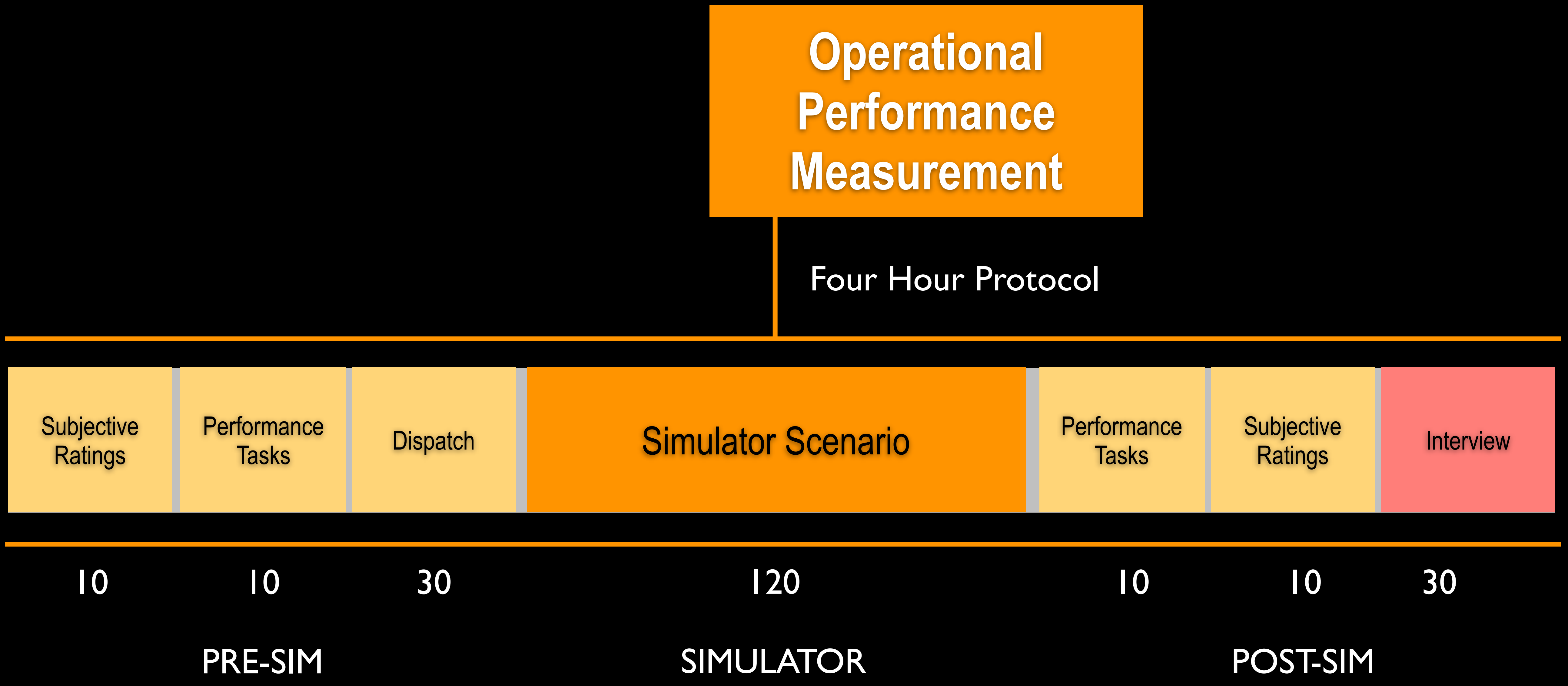
Method



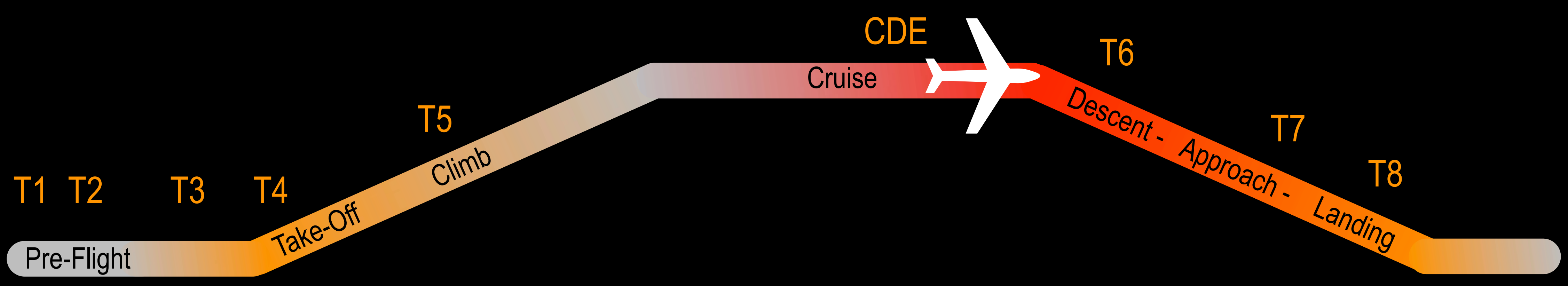
Europe & Africa Patterns
"East Returning" N=25
US Patterns
"West Returning" N=21
Rested Comparison Group
Four Local Nights at Domicile
N=21

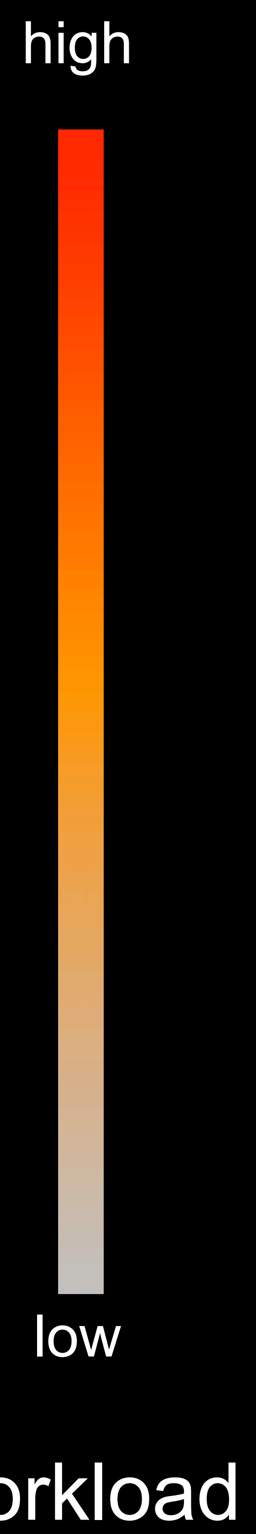

RESTED
NON-RESTED (EAST RETURN)
NON-RESTED (WEST RETURN)
F/O
DUTY
SLEEP
SUBJECTIVE
PVT
CAPT
DUTY
SLEEP
SUBJECTIVE
PVT

Experimental Protocol



Scenario Structure





T1 Dispatch with Thrust Reverser "Locked Out"

T2 Change in Loadsheet

T3 Change in Duty RWY

T4 Clearance to Lower Altitude on Departure

T5 Higher Cruise Level & Expedite Climb

CDE Critical Decision Event

T6 High Speed Descent & Track Shortening

T7 ATC QNH Error

T8 Failure to Provide Clearance to Land

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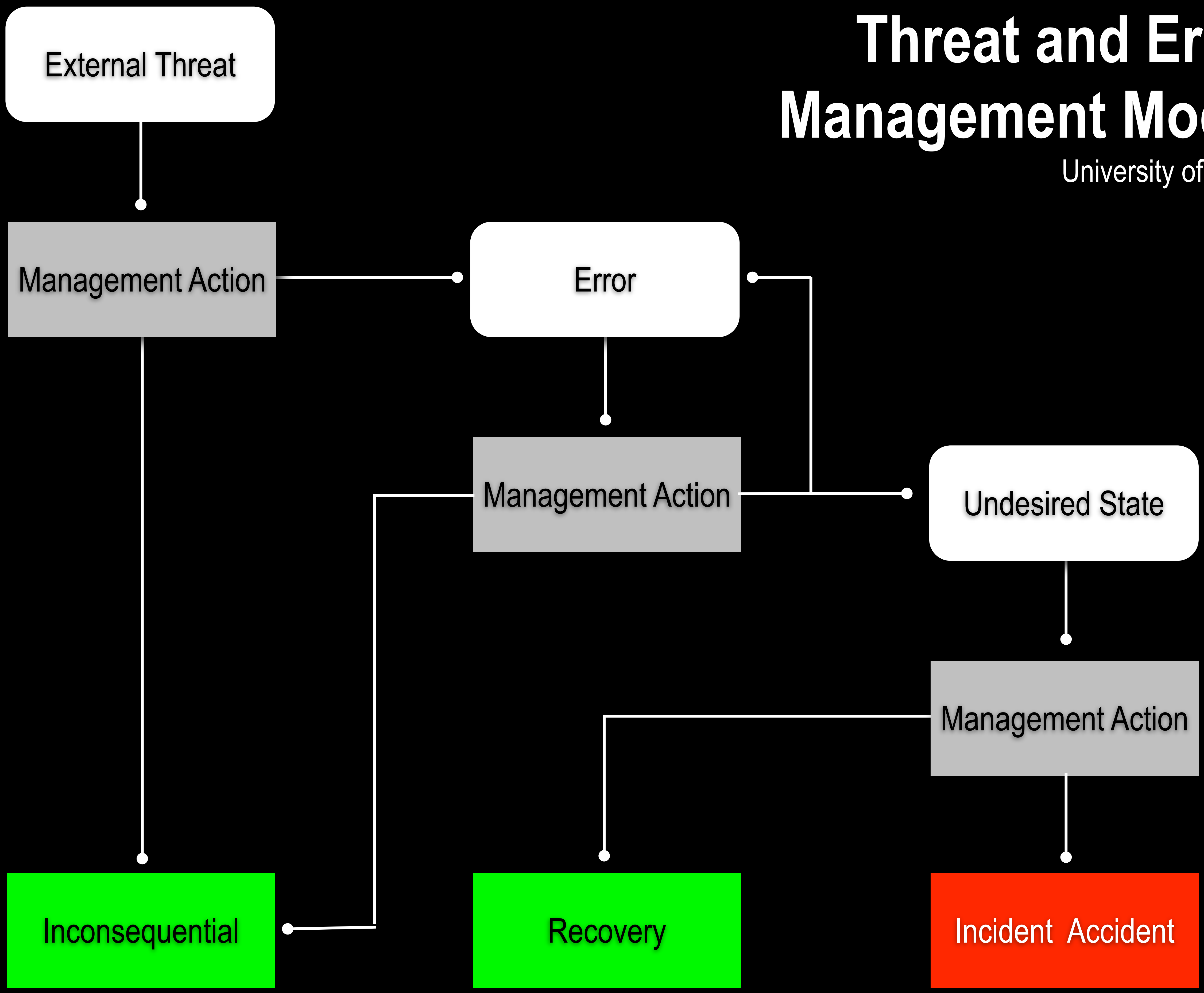
Threat and Error Management Model

University of Texas



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Results - TEM

Threat Management

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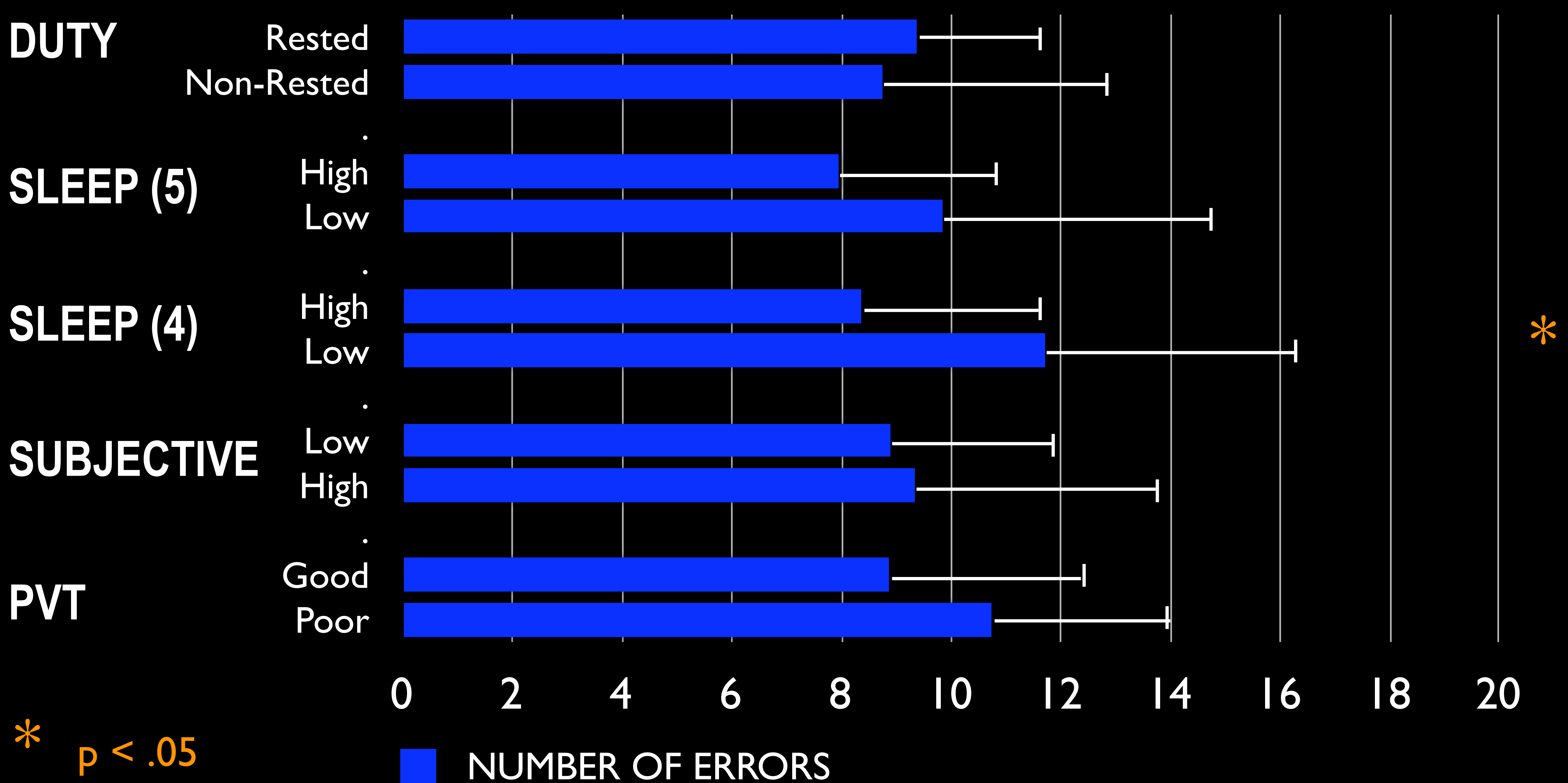
Overall Error Rate



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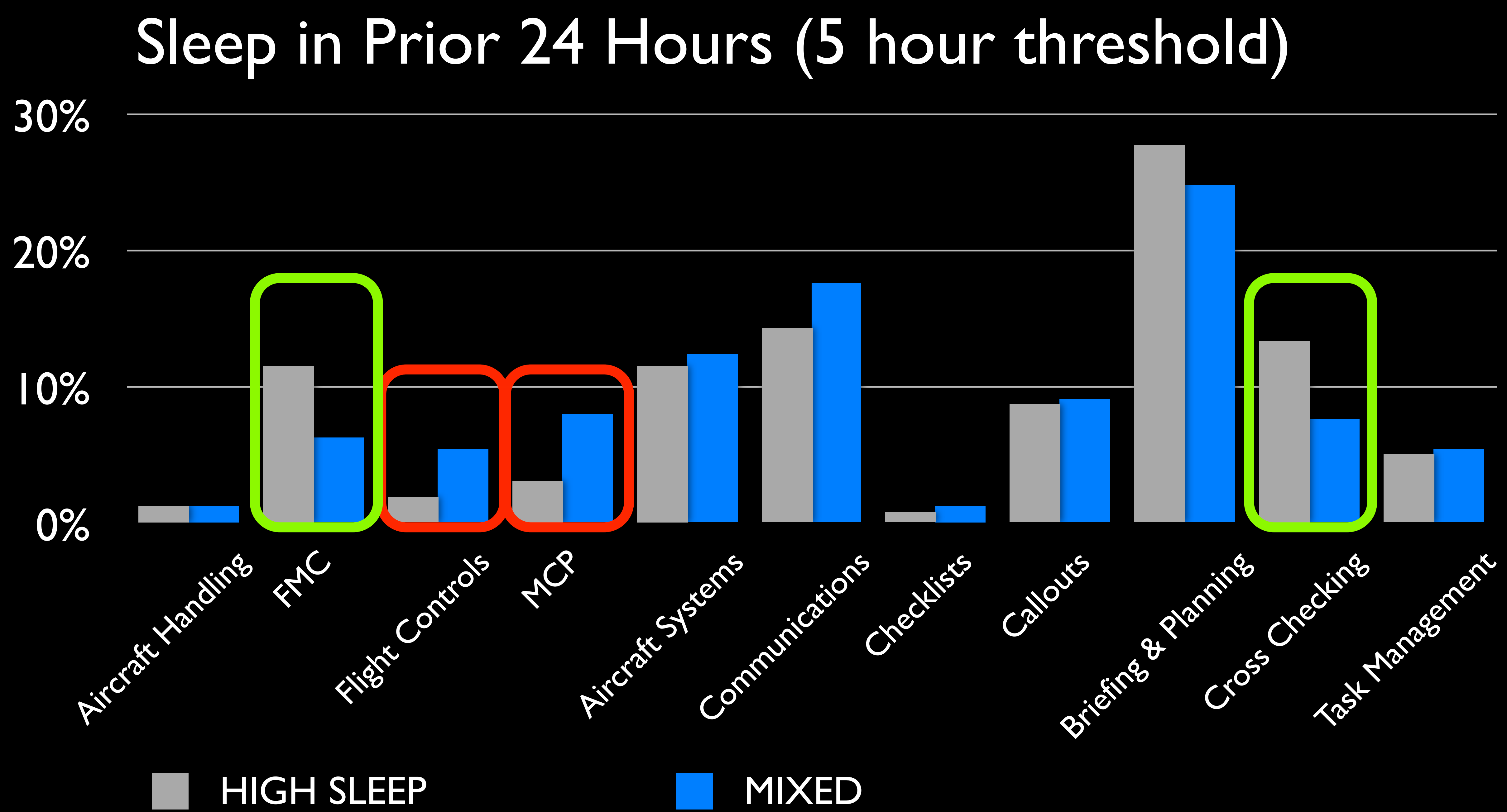
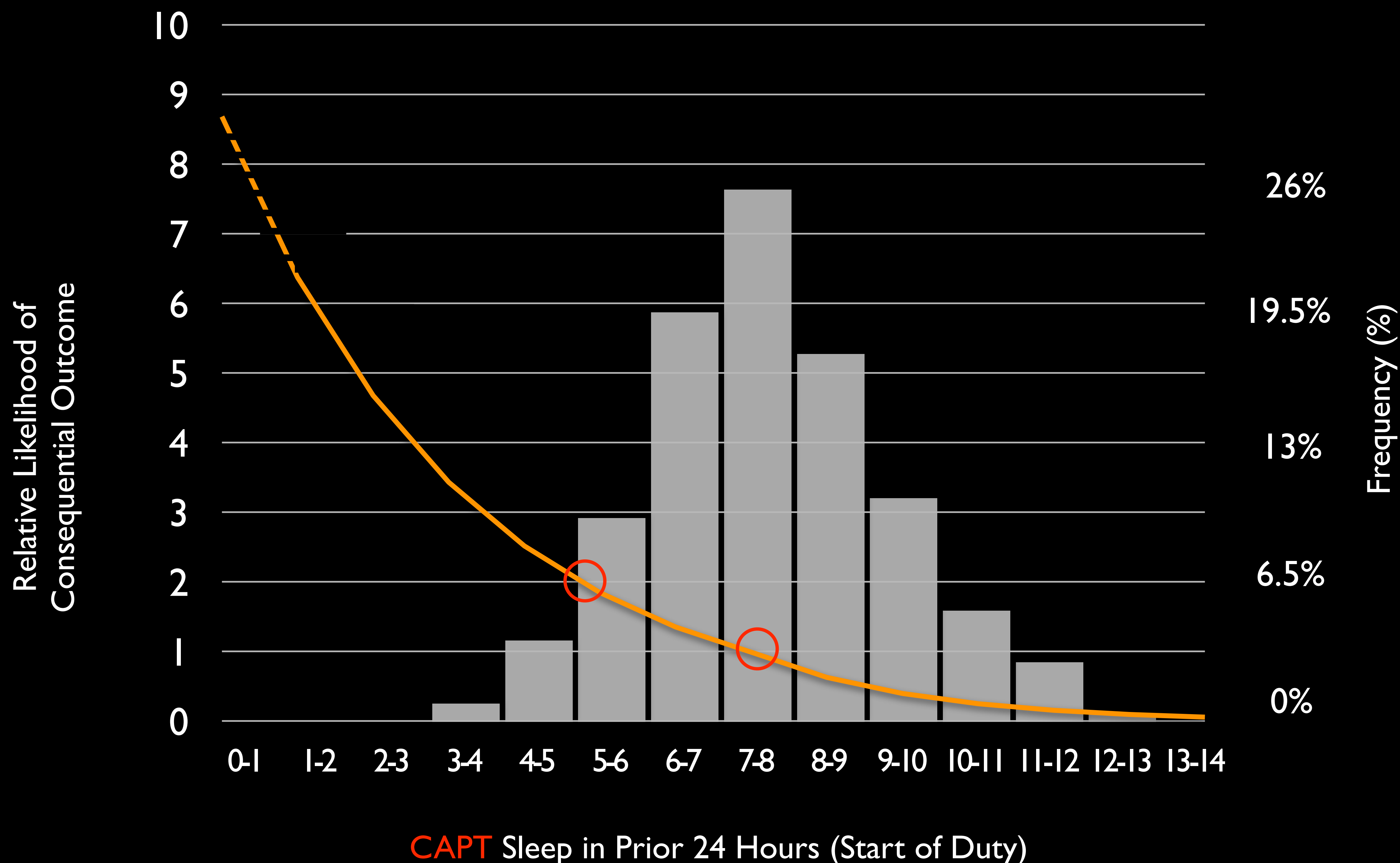
Error Type


Sleep in Prior 24 Hours (5 hour threshold)
30%
20%
10%
0%
Aircraft Handling
FMC
Flight Controls
MCP
Aircraft Systems
Communications
Checklists
Callouts
Briefing & Planning
Cross Checking
Task Management
HIGH SLEEP
MIXED

Likelihood of Error Mismanagement



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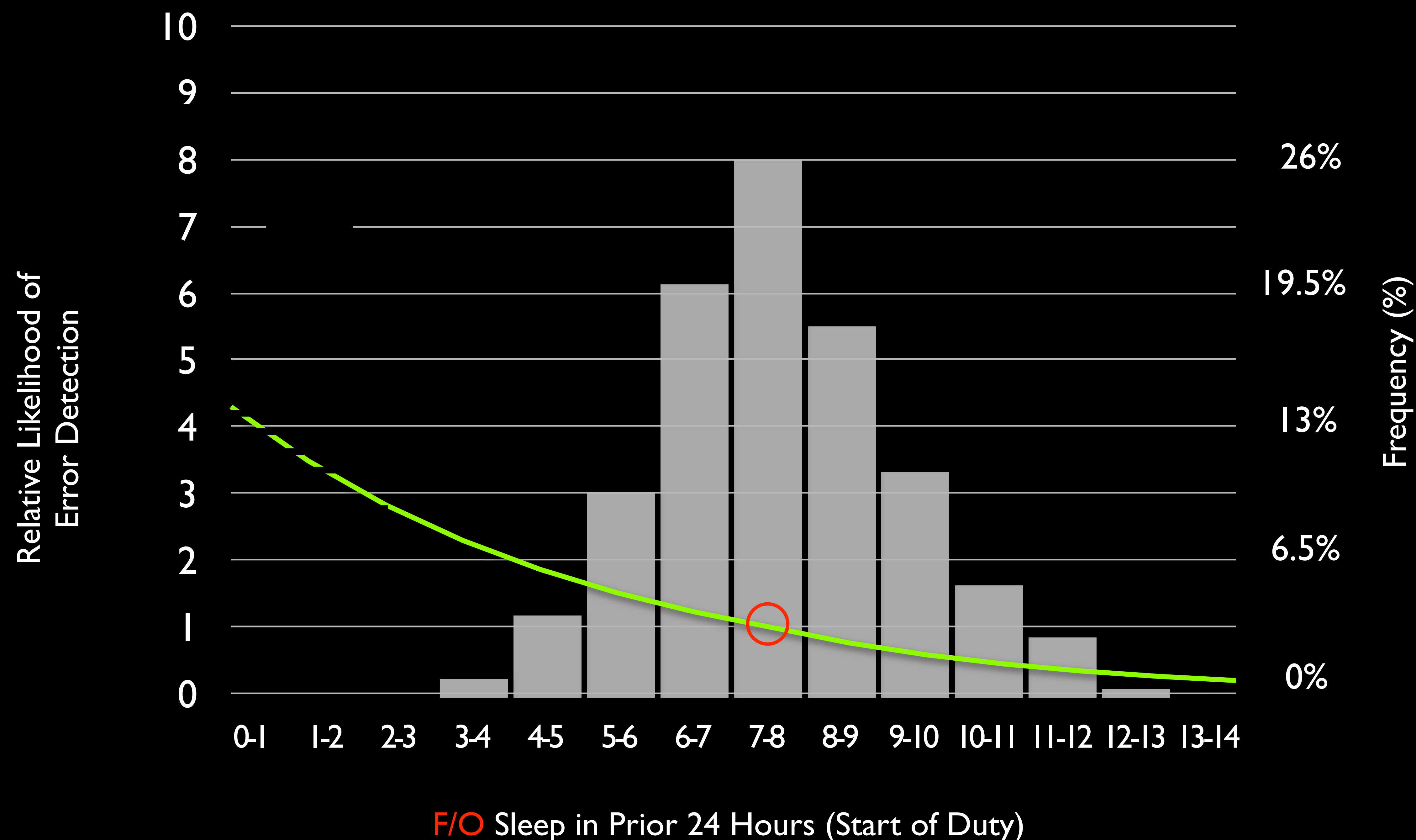
Likelihood of Error Detection



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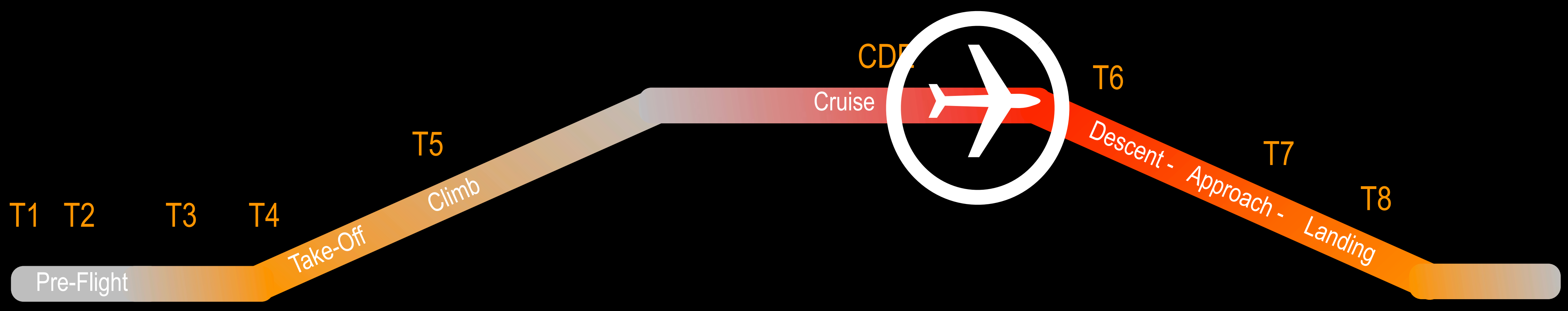
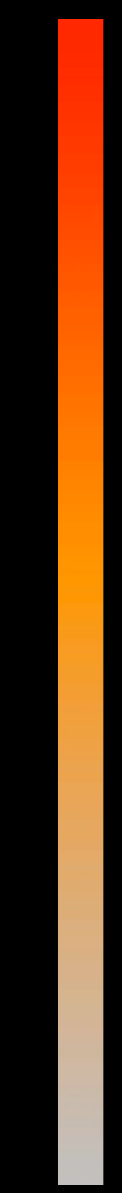
Scenario Structure





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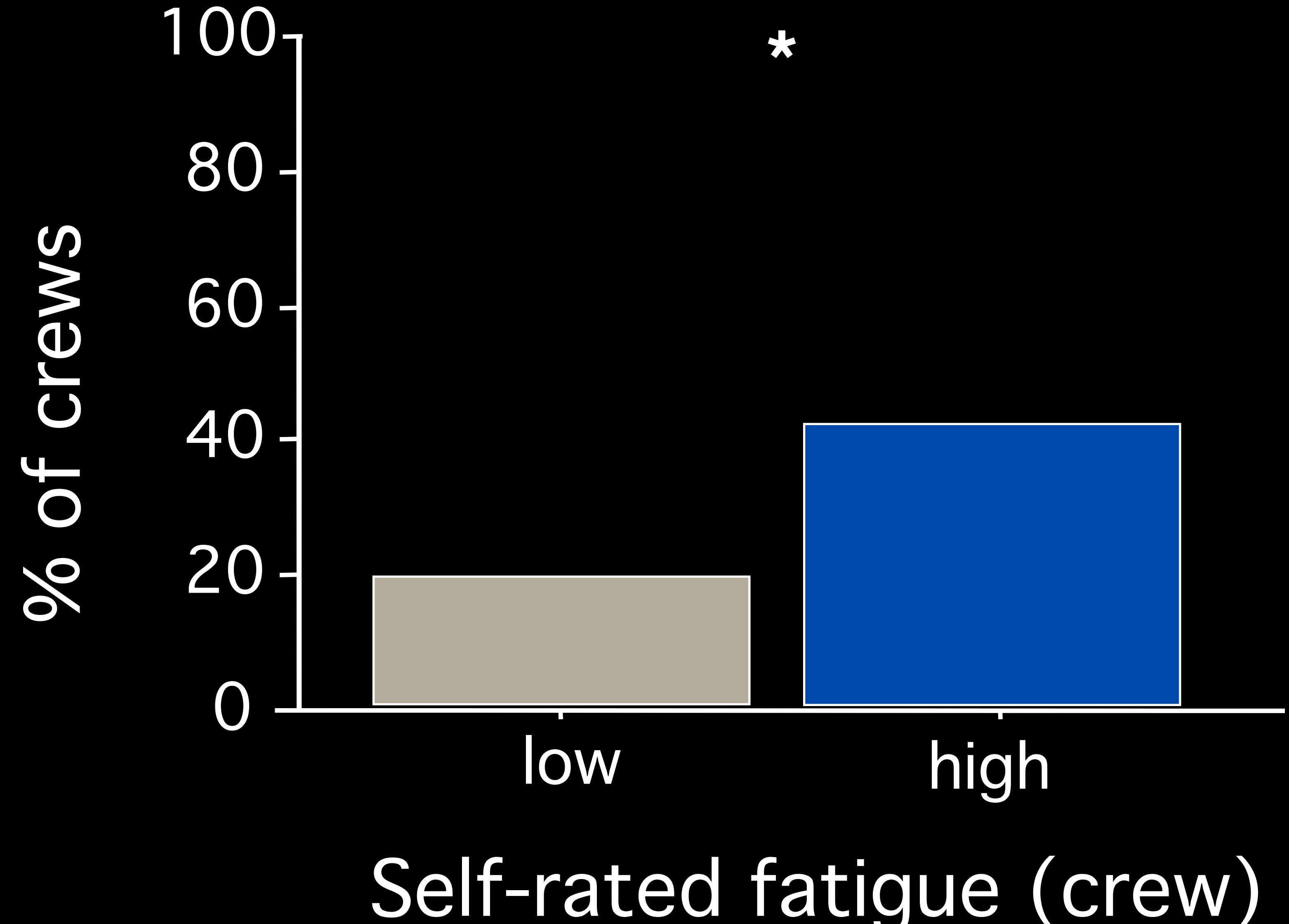
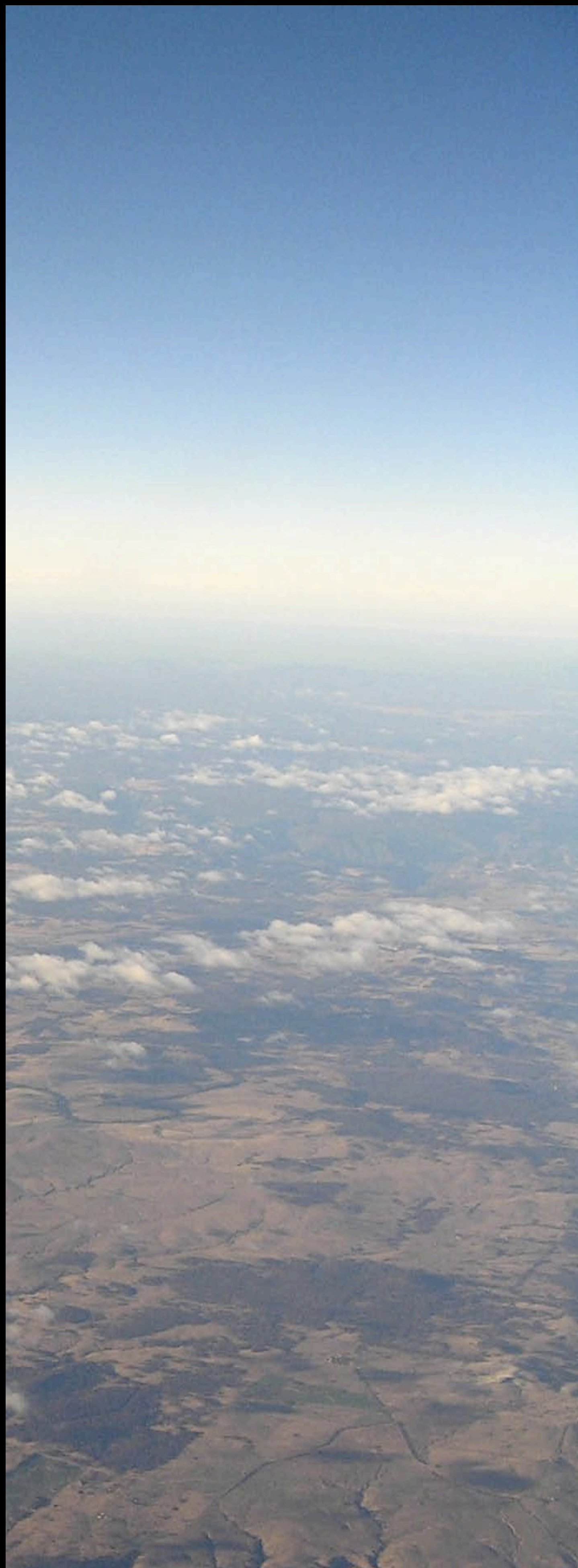
T8 Failure to Provide Clearance to Land

Diversion





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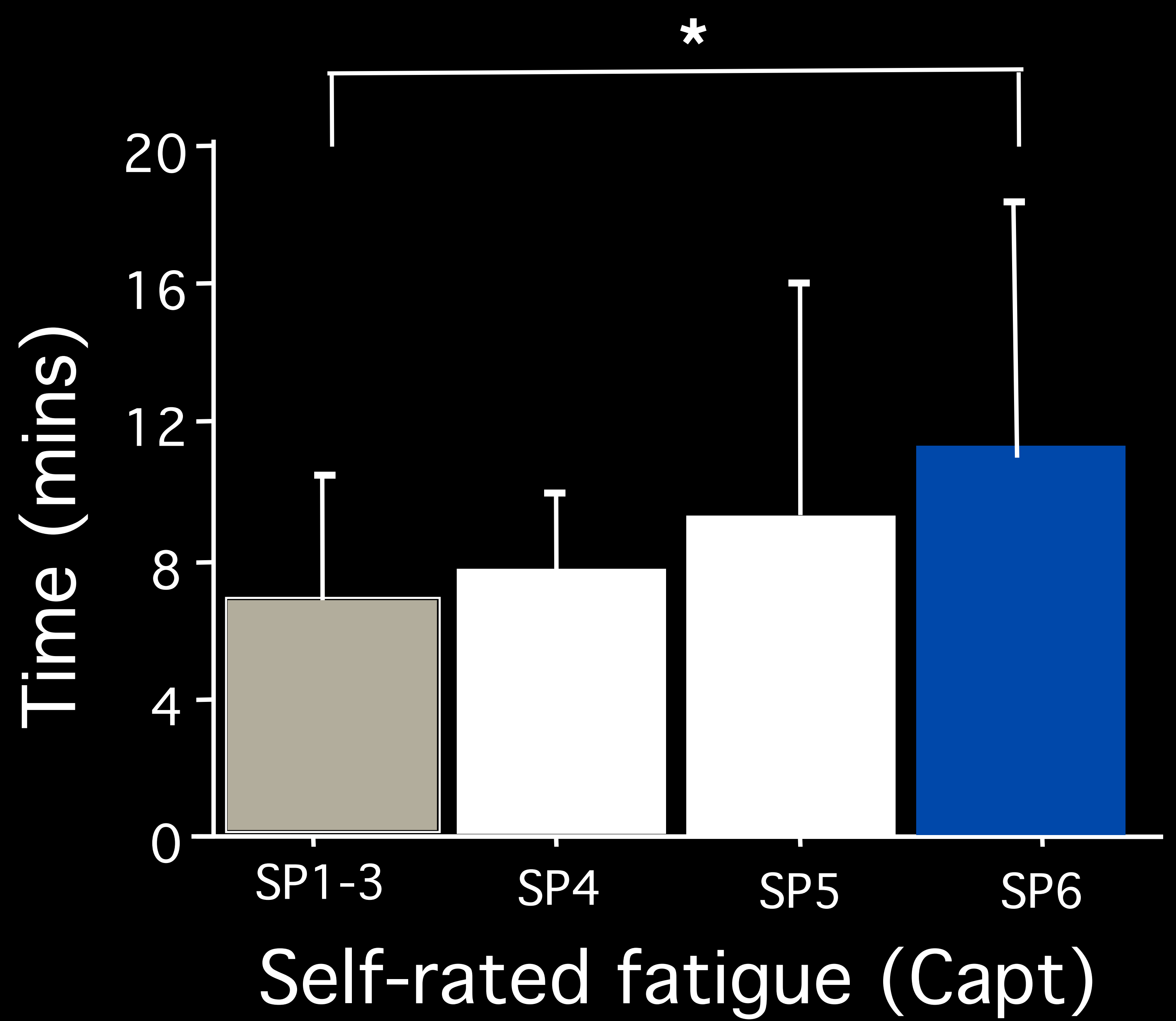
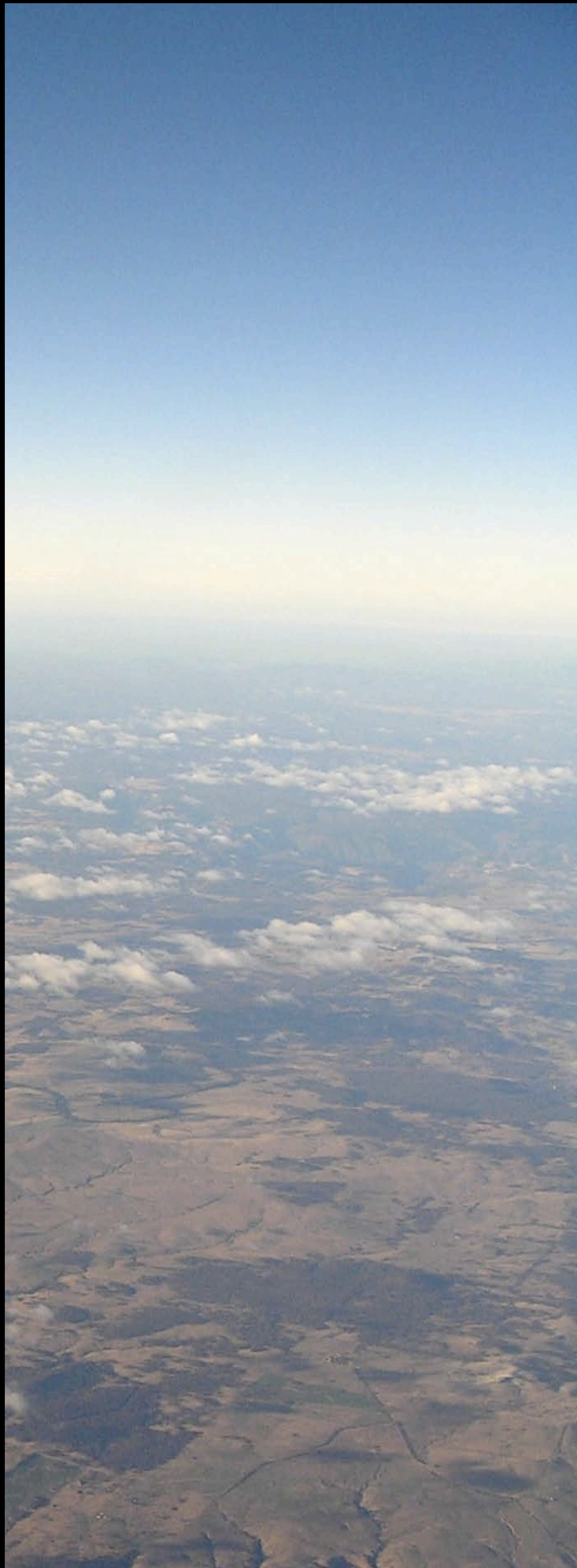
Time to decision





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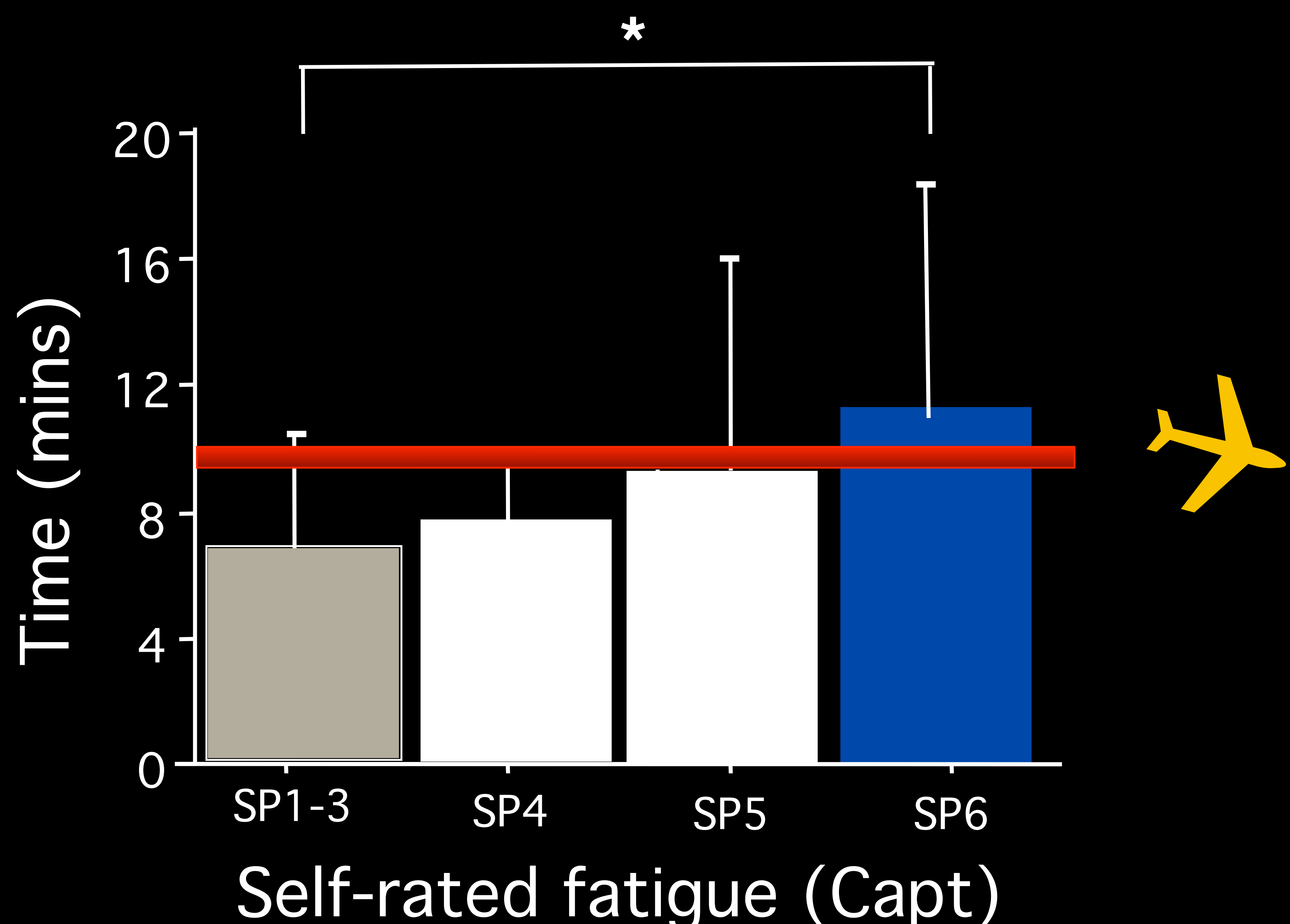
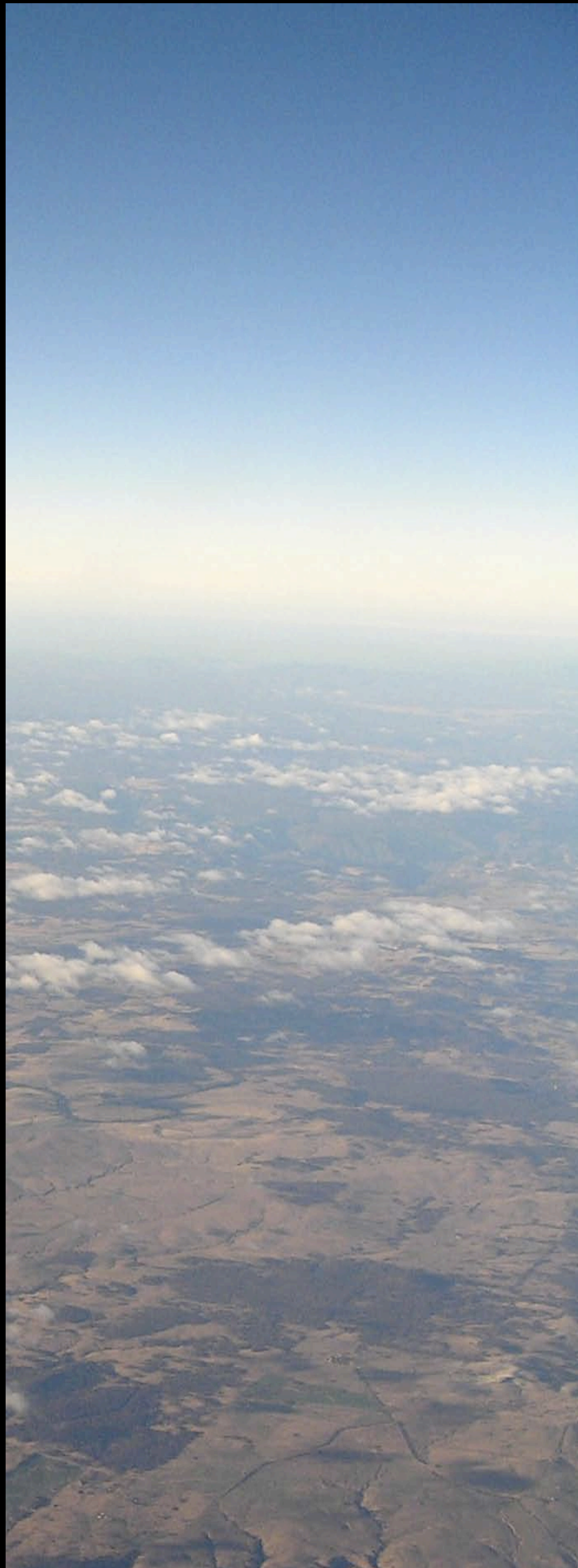
Time to decision





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Key lessons...


ALTITUDE
VERT SPEED
A/P ENGAGE
COURSE
10000
335
CMD A
CMD B
CWS A
CWS B
DN
UP
F/D
ON
DISENGAGE
ALT HLD
V/S
MINS
FPV
MTRS
RST
STD
VOR 1
OFF
ADF 1
VOR 2
ADF 2
MAP
CTR
TFC
WXR
STA
WPT
ARPT
DATA
POS
TERR

Key lessons...

Fatigue is not simply equated with impaired performance

Performance Protection

- Improved Cross-Checking
- Higher rates of Error Detection
- Reallocation of cognitive resources?

Performance Impairment

- Higher rates of error occurrence
- Higher rates of error mismanagement
- Longer decision-making time
- Limits of compensatory mental effort?

Key lessons...

Sleep was the most consistent predictor of changes in performance

Its all about sleep...

- Significant differences in performance when sleep in prior 24 hours drops below 5 hours
- Reinforces sleep as a critical component of FRMS

Tasks appear to be differentially "vulnerable"

Its not all about time available...

- When time is available - tasks appear to be more resilient
- However, changes in decision-making were also evident

Key lessons...

Important Lessons for Error Tolerant Design and "Fatigue Markers"

Vulnerabilities

- Prospective Memory
- Susceptibility to Expectation Bias
- Degraded External Situation Awareness

Just the beginning of a much greater understanding of fatigue

Current and future work

- LOSA, FOQA, and other data sources
- In the truest sense of SMS, bringing together multiple data sources

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Thank you...

http://www.unisa.edu.au/safety