INVESTIGATIONS OF G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC) USING THE RUDENT CENTRIFUGE. P.M. Werchan* and A.R. Shahed. Armstrong Laboratory and Operational Technology Division, Armstrong Laboratory, Brooks AFB TX 78235.

INTRODUCTION: The problem of G-LOC continues to exist and could potentially escalate as advancements are made in aircraft maneuverability and speed. In order to investigate this problem and understand the mechanism of G-LOC we have used unanesthetized laboratory rats and mice. The brain extracts were analyzed for G-LOC research are used because of the abundance of literature and proven techniques in their basic energy metabolism. METHODS: A small animal centrifuge (SAC) was fabricated (21") with a centrifugation rate of 20 Gz/sec with the unique capability of brain fixation and tissue freezing and nitric oxide or microwave irradiation. Additional SAC capabilities include monitoring of EEG activity, brain blood flow, blood and intracranial pressure and surgical interventions through a shunt pump. RESULTS: The Gz tolerance was found to be 20-25 Gz and 30-35 Gz for rats and mice, respectively. The times to G-LOC (isoelectric EEG) at these Gz levels are 14.5±2 sec for rats and 17±4.3 sec for mice. The EEG remained isoelectric for an additional 10-30 sec following deceleration. Brain fixation techniques have proved to be effective for measuring metabolic alterations before, during and after the high Gz exposure. The time course of changes in energy metabolism were collected. These data and techniques have proved to be effective for measuring metabolic alterations before, during and after the high Gz exposure. The time course of changes in energy metabolism was measured.


INTRODUCTION: Gz induced loss of consciousness (G-LOC) has been proposed to result from a critical reduction of cerebral blood flow (CBF) during high Gz stress. However, accurate measurement of CBF during high Gz stress has been difficult to accomplish. Methods such as transcranial doppler and radiolabeled microspheres have been used in humans and primates to measure CBF, but neither method can be used in small animals. RESULTS: The present study investigated the effect of high Gz exposure on the carotid blood flow. The times to G-LOC (isoelectric EEG) were measured. METHODS: Rats were exposed to a single Gz with a Gz lasting 10 min at 0.75 Gz to 0.5 Gz with the carotid flow being investigated. Conclusions: The decreases in total protein and Hb are indicators of a decrease in total blood flow to the brain. The presence of Hb suggests that trapped blood remains in the brain. We believe that residual blood acts as an energy pool.


INTRODUCTION: Although G-LOC in pilots is known to have occurred as early as World War I, its mechanism is unknown. Gz-LOC occurs in conjunction with a critical reduction in cerebral blood flow during high Gz exposure. Eye level arterial blood pressure is reduced to zero within 2 sec, but it is observed 7-10 sec after the onset of Gz. This suggests that the reduction in blood pressure is part of a reflex cascade that causes G-LOC. The present study investigates the effect of Gz exposure on net brain lactate production. METHOD: Awake rats with implanted EEG electrodes were restrained and placed on our small animal centrifuge control. Control rats were exposed to base (Gz and experimental group was exposed to +5.5 to +25.2 Gz for 30 min and brain samples were collected 1 min post Gz. Two other groups of rats were exposed to +25 Gz for 0, 15, or 30 sec and brain samples were collected 8 min post Gz. RESULTS: Only paired samples were statistically significant (P<0.05). Lactate content increased 1.4-3.5 fold after the onset of +25.0 Gz with the EEG remaining isoelectric for an additional 15-30 sec. An increase in lactate (6.7 and 1188) level and a decrease in muscle glycogen (23 and 46%) could result in 15-30 sec. A significant increase in lactate (6.7 and 1188) level and a decrease in muscle glycogen (23 and 46%) could contribute to Gz LOC. C-P (52 and 63%) and ATP (49%) were observed 15 sec and ATP was 30 sec after the onset. CONCLUSIONS: These changes in brain energy metabolism within 15 sec of Gz exposure have proved that rat tail area accumulation and resulting acidosis.
USE OF EEG SPECTRAL ANALYSIS TO IDENTIFY G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC) IN THE RAT. S.K. Garcia, J. Barto, D.J. Coffey, and P.H. Merchant. Armstrong Laboratory and KMG Life Sciences, Brooks AFB TX 76655.

INTRODUCTION. Despite numerous technological advances to improve G-tolerance, loss of consciousness due to +Gz stress continues to be a problem with high-G aircraft. In recent years, research has focused on the use of EEG relating G-LOC with cerebral activity. It has been shown that with +Gz EEG amplitude decreases and can become isoelectric. However, the loss of EEG may occur beyond useful consciousness. Thus changes in EEG frequency components during this period may be a more sensitive indicator of the level of consciousness. METHODS. Male rats (250-350g), with surgically implanted bipolar parallel electrodes, were exposed to +25 Gz in a small animal centrifuge until loss of EEG amplitude (G-LOC). EEG recordings were obtained for each rat and subjected to EEG spectral analysis. RESULTS. Preliminary results suggest that during baseline and onset of acceleration EEG activity consisted of all component frequencies from 0 to 15 Hz. Early recovery following exposure was again marked by a pronounced increase in delta activity. CONCLUSION. Spectral analysis provides an objective/sensitive approach to G-LOC detection by identifying changes in component frequencies.


INTRODUCTION. Phenomenon of acceleration or +Gz induced loss of consciousness (G-LOC) is known to occur in pilots of high performance aircraft and has been reproduced in animal models in the laboratory. It has been demonstrated that during +Gz exposure cerebral blood flow is significantly reduced resulting in brain ischemia. This situation could be repeated several times by pilots during flight maneuvers. Unfortunately, we know little about pathological effects on the brain. One of the earliest pathologic changes of ischemic stress is evidenced edema. In the present study occurrence of brain edema in the rat after +Gz exposure was investigated.

METHODS. Male rats (n=4) were exposed to 6, 12, and 24+Gz runs with 5 min rest periods between each run. Brains were removed 15 min, 30 min, 3 hr, and 24 hrs (n=5 in each group), after the last centrifuge run, and weighed (wet weight) and then dried to constant dry weight. The ratio of wet to dry weight was used to assess % change in brain tissue weight. RESULTS. The ratio of wet to dry weight was used to assess % change in brain’s water content (edema). The data show that the wet weight to dry weight ratio increases significantly up to 3 hr after the centrifuge run, but not after 24 hr. The largest increase in water (2%) was observed at 15 min. CONCLUSION. These results show that multiple +Gz exposure can cause brain edema. Edema can result in post +Gz exposure hypoperfusion and could cause secondary ischemia by exacerbating the functional effects related to G-LOC.


The accident rate of civilian helicopter ambulances has been a matter of considerable concern. There are multiple studies of the accidents, but epidemiologic comparisons of accidents to safely completed flights are rare. Our previous study of US and Canadian civilian helicopter ambulances was presented at the Aerospace Medical Association meeting in 1989: at that time the only statistically significant finding was a marked decrease in the accident rate of busy helicopter ambulance programs, compared to the less busy ones. Since then the use of IFR helicopters has doubled from 15% of patients transferred (p<0.005). The accident rate of these IFR helicopters is 11.3/million, compared to 46.4 for helicopters certified only for VFR flight (p<0.005). There have been no accidents involving helicopters certified for IFR flight flown by IFR current pilots who are permitted to fly under IFR at their discretion (p<0.02). Logistic regression shows a safety benefit of IFR capability that is independent of program size (p<0.005). Programs that have had one accident seem to have a lower accident rate than the less busy ones (p<0.005).

INTRODUCTION. Of 127 commuter and 597 non-scheduled air taxi crashes during the period 1983-1988, we categorized 46 as improper IFR procedure; 67% were fatal. METHODOLOGY. NTSB briefs were reviewed for the period. An epidemiological analysis of all cases explored relationships between circumstances, crew factors, and fatalities. NTSB full reports were studied for 11 scheduled commutem and 35 air taxi cases involving improper IFR procedures. RESULTS. Twenty aircraft were below minimums on approach; six were off course. One pilot tried to land without sighting the runway. Six crashed attempting missed approaches, and thirteen used other improper IFR procedures. When ceilings were low, many pilots attempted tailwind landings on runways served by ILS approaches in order to take advantage of lower straight-in minimums. 80% of the crashes were at night. Four pilots mistimed altimeters and avionics. CONCLUSION. Possible interventions that should be explored include night IFR route checks, requiring a given number of day IFR hours in order to qualify for night Part 135 pilot-in-command, establishing a minimum ceiling for all Part 135 night IFR approaches, and setting night minimum visibility at one mile.

INCIDENCE OF INFLIGHT MEDICAL EMERGENCIES IN BUSINESS AIRCRAFT. R.T. Carrington§ Wright State School of Medicine, Dayton, Ohio 45461-0297.

INTRODUCTION. An analysis of inflight illness and death in business aircraft was undertaken using a mailed survey of six hundred eighty nine members of the National Business Aircraft Association. METHODS. Twenty two point one percent (87/395) of the members reported one or more inflight illnesses or death in their corporate aircraft. Sixty nine point four per cent were male whereas 30.6% were female. There were three reported fatalities. The most common presenting signs or symptoms were shortness of breath, diarrhea, chest pain and loss of consciousness. CONCLUSION. The findings of our survey indicate there are a significant number of medical incidents on board business aircraft. The pattern of illness follows closely the findings of other studies of airline medical incidents done over the years.

SEASICKNESS SUSCEPTIBILITY, SALIVATION AND PERSONALITY FACTORS. C.R. Gordon*, O. Spitzer, I. Dowek*, A. Holilick, A. Shupak and Y. Melamed. Motion Sickness and Human Performance Laboratory, IHU Hebrew University, Jerusalem, Israel.

INTRODUCTION. We previously reported a significant correlation between motion sickness susceptibility (MSS) and salivary protein concentration. Other authors have reported correlations between MSS and personality factors, while yet others have described a relationship between personality and salivation without mentioning MSS. The present study evaluates the relationships between MSS, salivation and personality in trained and non-trained subjects. METHODS. Using a standardized questionnaire, we selected a group of 29 Sns and a group of 25 Ss to seasickness. Nasal and stimulated whole saliva were examined. Personality factors were evaluated by the Eysenck Personality Inventory. RESULTS. Salivary amylase levels were significantly higher in Ss than in Sns. Sns had significantly higher scores on the psychotism scale than Ss. A significant positive correlation was found between psychotism and the amount of the increase in salivary flow in response to stress among Ss. CONCLUSION. Significant differences in salivary amylase levels and psychotism scores were reported for subjects at the two extremes of the MSS scale. These measurements might be recommended as additional predictors of MSS.


INTRODUCTION. MD is the transient sensation of uncomfortable and/or disorienting experienced on land after disembarking from a ship. In a previous study, we reported the high incidence of MD among naval crew members. When a healthy subject is exposed to MSea, it shows a significant correlation to seasickness susceptibility, but not to experience at sea. The present study evaluates the relevance of MD habituation to seasickness susceptibility. METHODS. 116 crew members completed a questionnaire on MD and/or motion sickness, with emphasis on their experience on their current cruise and on a range from 1 to 120 months (mean = 10). RESULTS. 72% of the subjects had experienced MD: 29% (34) only once, 26% (32) occasionally, and 15% (17) were often. Although the appearance of MD was not related to experience at sea, most of the subjects (66%) reported a high incidence after their first sea voyages. A significant positive correlation was found between MD and seasickness susceptibility. CONCLUSION. MD was found to be a frequently experienced motion sickness that high incidence during initial voyages and its reduced occurrence over time can be partially explained by long-term habitation to sea conditions.

DDAVP INHIBITS THE DIURESIS INDUCED BY IMMERSION IN COLD WATER. S. Farkas*, I. Kaschak, A. Nava*, and E. Bokhove. Wayne State University School of Medicine, Detroit; VAMC, Allen Park; and the University of Michigan Medical School, Ann Arbor, MI, and Naval Health Research Center, San Diego, CA.

INTRODUCTION. We previously reported 1-deamino-8-D-arginine vasopressin (DDAVP), an analog of antidiuretic hormone, significantly decreased the diuresis and natriuresis induced by immersion in thermal-neutral water (31°C). Immersion in comfortable water reduces catecholamines and since cold increases circulating catecholamines, we tested the hypothesis that DDAVP can also decrease the diuresis and natriuresis induced by immersion in water sufficiently cold (22°C) to increase [catecholamines]. Methods. After receiving 20 ug DDAVP or placebo intranasally, 15 sodium replete subjects were seated quietly in a room. RESULTS. We reported that DDAVP not only reduced urine flow but also sodium excretion (in mEq/hr, placebo, 16.7 ± 1.8; DDAVP, 14.5 ± 3.5, p<0.05). CONCLUSIONS. DDAVP inhibits the diuresis induced by immersion in cold water.


INTRODUCTION. During the ascent of an airplane the atmospheric pressure decreases. Consequently, the volume of all immersed cavities of the middle ears and the paranasal sinuses increases, whereas the volume of the nasopharynx decreases. The descent of the airplane results in a slow decrease in the nasopharynx, whereas the middle ear and paranasal sinus volume remains constant. The pressure difference causes symptoms of barotrauma to appear. Last three years several airlines who operated the Boeing 737 noticed our clinic with symptoms of otic or sinus barotrauma. Surprisingly, they all had flown a Boeing 737 aircraft. METHODS. To test the hypothesis that flying a Boeing 737 aircraft increases the chance of a barotrauma, the cabin pressurization schedule of a Boeing 737 was compared with the schedule of both a Boeing 747 and a DC 10 aircraft.

RESULTS. The maximum cabin altitude of all three airplanes is 37000 feet. The maximum cabin pressure of the Boeing 737 is 8000 feet. This is considerably above the levels of the aircrafts of the type Boeing 747 and DC 10. Respectively 5350 and 6100 feet.

CONCLUSION. The pressurization schedule of the Boeing 737 aircraft is less comfortable than the schedules of the Boeing 747 and the DC 10 aircraft. Flying a Boeing 737 aircraft seems to increase the chance of a barotrauma.

PANEL ABSTRACTS

THE AGING PILOT DILEMMA: E. Altekruse, Johnson, SC 29812

INTRODUCTION. Historically pilots emerged from WWII with reputations as fast living reckless daredevils. On the Big Screen they smoked, drank, and caroused. Now we know these unhealthy life styles can have disastrous consequences. In the 1940s and 1950s, it was common to attribute these consequences to aging. As a result, the stigma of age has lead to discrimination in many forms. In 1960 the U.S. FAA established a mandatory retirement age of 60 for airline pilots. Prior to that time the retirement age for pilots varied amongst airlines. Presently pilots are required to undergo an extensive and long examination by a medical doctor. The examination is biannual and can not be equalled by the cabin pressure, symptoms of barotrauma appear. Last three years several airlines who operated the Boeing 737 noticed our clinic with symptoms of otic or sinus barotrauma. Surprisingly, they all had flown a Boeing 737 aircraft. To test the hypothesis that flying a Boeing 737 aircraft increases the chance of a barotrauma, the cabin pressurization schedule of a Boeing 737 was compared with the schedule of both a Boeing 747 and a DC 10 aircraft.

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PHYSIOLOGIC "AGE" VERSUS CHRONOLOGIC AGE IN PILOT MEDICAL STANDARDS. B. J. McIvor, Naval Aerospace Medical Institute, Pensacola, FL 32506-4800.

INTRODUCTION. In 1959 the Federal Aviation Administration (FAA) set into place the "AGE 60 RULE". The "AGE 60 RULE" requires mandatory retirement of commercial airline pilots at age 60. The intent was to reduce "human factor" in air accidents due to the age related deterioration in pilot performance. This has proven a highly controversial regulation in view of recent age discrimination legislation. The FAA defends the regulation on the basis that no other method has been proven accurate enough to screen pilots who wish to fly for commercial airlines after the age of sixty. The Thousand Aviator Study data is being reviewed, to determine if a physiologic standard can be derived through present medical screening modalities that can replace the present chronologic standard. METHODS. Retrospective chart review of the Thousand Aviator Study subjects examining annual exercise stress test results as a predictor of cardiovascular health and performance. RESULTS. Chart review presently on going, results not yet available. CONCLUSION. Sufficient data exists within the Thousand Aviator Study data base to determine if physiologic standards are a better indicator of age related decline in performance as compared to a chronologic standard.

STUDIES ON MANDATORY RETIREMENT AGE FOR PILOTS. P. S. Della Rocca and P. S. Schroeder. Human Resources Research Division, FAA Civil Aeromedical Institute, Oklahoma City, OK 73121.

INTRODUCTION. The "Age 60 Rule" (14 C.F.R. Part 121) has generated varying levels of controversy during its 30 year existence. Research by Golaszewski (1983) has been used to support the conclusion that pilots of age 60 and older have higher accident rates. Questions concerning these findings and other issues surrounding the regulation led the FAA Associate Administrator for Regulation and Certification to renew research efforts on the relationship between age, qualification and reirement. APPROACH. Information will be presented about the status of ongoing, research within the FAA concerning the "Age 60 Rule". Research studies have designed to improve methods of investigation, as well as to pursue research recommendations from groups of experts that had previously reviewed the question. The first study consolidates existing historical databases (the National Transportation Safety Board's Accident database, the FAA Airmen Certification database and the National Aerospace Medical Institute database) in replication and extension of the Golaszewski study. Analyses of pilot age at accident occurrence were conducted to determine if there is a relationship. Subsequent studies assess the feasibility of using new or existing psychological and performance assessment methodologies for predicting subtle age-related cognitive deficits in pilots. CONCLUSIONS. The purpose of these studies is to improve upon historical research methodologies that have purposed to find a relationship between age and accidents. Findings from the three investigations will be used to reassess the status of the "Age 60 Rule".


As fliers age, their attitude toward flying changes. The nature of this change is shaped by the original motivation to fly, and also by experience: aircraft accidents, deaths, other losses, marriage, divorce, children, job tension, finances, etc. Aging takes its own toll of perception of health, loss of "invulnerability," physical endurance, sense of slow reaction time or inability to respond to sudden novel stimuli. The rate of lessened functions differs, as does the sense of their loss and the utility of coping skills. If these skills fail, the results may be dangerous denial, depression, counterphobic activity, fear of flying, or other pathology. Aeromedical practitioners should be familiar with these patterns, and should know how to use careful history-taking and skilful mental status evaluations to elicit information about possibly harmful patterns of adaption and behavior.

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PILOT AGING POLICIES IN INTERNATIONAL AIRLINES

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INTRODUCTION: For decades regulatory agencies adhered to an arbitrary upper age limit for pilots engaged in passenger operations. Based on these regulations, international airlines set up contractual agreements with unions and/or individual pilots. With the advent of modern diagnostic techniques and operational monitoring these rules and contracts were recently challenged.

DEVELOPMENT: Stress should be put on medical-physiological criteria rather than purely chronological age limitations. Performance capability is essential in determining one's fitness as a pilot. Medical technology provides new diagnostic techniques which enable us to predict with better confidence that a pilot will not become suddenly incapacitated especially where the cardiovascular system is concerned. The degradation of a pilot’s perceptual, psychomotor and intellectual functioning which is expected in the aging process may be detected and assessed with a great measure of confidence by physicians, crew leaders and family members during simulation and line checking.

In a relatively small airframe like EL-AL, the medical officers and flight operation supervisory staff know each pilot personally and in many cases are familiar with the family environment. This enables them to detect occasionally some hidden symptoms. EL-AL maintains the long-established mandatory reinforcement of operating crew members above the age of sixty. However, it was recently agreed (as first officers only) on a yearly contract provided they fulfill the medical and operational criteria. This meets the current government regulations and we feel confident that no undue risk is involved. Similar arrangements exist in a few other airlines. Our first-year’s experience will be discussed.

REVIEW OF PERFORMANCE, MEDICAL, AND OPERATIONAL DATA ON PILOT AGING ISSUES

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Introduction: An extensive review of the literature and studies relating to performance, medical, and legal data regarding pilot aging issues was performed in order to determine what evidence there is, if any, to support mandatory pilot retirement.

Popular misconceptions about aging, including the failure to distinguish between the normal aging process and disease processes that occur more frequently in older individuals, continue to contribute to much of the misunderstanding and controversy that surround this issue. Results: Review of medical data related to the aging pilot issue indicate that recent improvements in medical diagnostic and treatment technology have made it possible to identify a high degree of individuals who are at risk for developing sudden incapacitating stress and for those treated with disqualifying medical conditions. Performance studies revealed that after controlling for the presence of disease states, older pilots are able to perform as well as younger pilots on many performance tasks. Review of accident data showed that older, healthy pilots do not have higher accident rates than younger pilots. Indeed, evidence suggests that older pilots have an advantage in the cockpit due to higher experience levels. The Man-Machine-Mission-Environment interface of factors can be managed through structured, supervised, and enhanced operations, maintenance, flight, reviews, and safety procedures in order to ensure safe and productive operations by reducing the margin of error and by increasing the margin of safety.

Conclusion: There is no evidence indicating any specific age as an arbitrary cut-off point for pilots to perform their flight duties. A combination of regularly scheduled medical screening, performance evaluation, enhanced operational maintenance, and safety procedures can more effectively ensure a safe pilot population than can a mandatory retirement policy based on arbitrary age restrictions.

FLIGHT CREW FATIGUE IN ADVANCED LONG-HAUL COMMERCIAL AIRPLANES: P.C. Graeber. Boeing Commercial Airplane Group, Seattle, WA.

The rapid increase in two-crew glass cockpit airplanes operating on long-haul routes has generated international interest in better understanding how fatigue affects crew performance on advanced commercial flight decks. This topic provides an unique opportunity for human factors experts to focus on a combination of biomedical, operational, and equipment design issues that directly impact human operators. The panel will examine the issue from the different perspectives of individuals who are actively involved in the ongoing debate. The presentations will emphasize the physiological basis for long-haul crew fatigue.

The contribution of the flight deck environment to crew alertness, and the operational factors unique to such airplanes in the long-range environment. Panelists will also discuss both regulatory, operational and design approaches for mitigating the potentially negative effects on overall crew performance. A general discussion will follow completion of the individual papers.

ALERTNESS MANAGEMENT IN TWO-PERSON LONG-HAUL FLIGHT OPERATIONS: M. R. Rosekind and P. H. Gander. NASA Ames Research Center, Moffett Field, CA and San Jose State University Foundation at NASA Ames Research Center.

Long-haul flight operations involve cumulative sleep loss, circadian disruption, and extended irregular duty schedules. These factors reduce pilot alertness and performance on the flightdeck. Conceptually and operationally, alertness management in flight operations can be divided into preventive strategies and operational countermeasures. Preventive strategies are utilized prior to a duty period to mitigate or reduce the effects of sleep loss, circadian disruption and fatigue during subsequent flight operations. Operational countermeasures are used during operations as acute techniques for maintaining performance and alertness. Results from previous NASA Ames field studies document the sleep loss and circadian disruption in two-person long-haul flying and illustrate the application of preventive strategies and operational countermeasures. One strategy that can be used in both a preventative and operational manner is strategic napping. The application and effectiveness of strategic napping in long-haul operations will be discussed. Finally, long-haul flying in two-person highly automated aircraft capable of extended range operations will create new challenges to maintaining pilot alertness and performance. Alertness management issues in this flight environment will be explored.

A PILOT'S PERSPECTIVE ON LONG HAUL OPERATIONS IN TWO CREW COCKPITS: Paul D. Gallacher. Northwest Airlines, Minneapolis, MN.

A comprehensive approach to the issue of flight crew fatigue must address crew performance requirements as well as psychophysiological factors such as sleep loss and circadian rhythm. Emphasis on the former has increased with the relatively recent introduction of advanced two-crew airplanes where the accompanying growth in flight deck automation and CRT displays. This paper will address these factors from a pilot's perspective, included will be a description of typical flight profiles and crew duties along with the associated occurrence of boredom and fatigue. One topic of particular concern is the programming of automated flight systems in terminal areas at the end of long-haul flight segments. The discussion will also focus on the use of augmented crew during extended range operations and the problems encountered in the scheduling of rest breaks in onboard sleep facilities.


Commercial air operators are moving toward greater use of advanced-technology aircraft with increasing levels of automation. Frequently, this transition entails a reduction in the size of cockpit crew; specifically, from 3 to 2 pilots, eliminating the position of flight engineer. This reduction is being accomplished in the context of a dramatic increase in commercial traffic, no revision in FAA Flight Time/Duty Time regulations and efforts by commercial carriers to exploit the full potential of the new, long range aircraft coming into service. Professional pilot groups are very concerned that human factors considerations, i.e., fatigue, circadian rhythm, scheduling parameters and the human/automation interface are not being adequately addressed.