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CREW DECISION MAKING UNDER STRESSS. J. Orasanu. NASA-Ames Research Center, Moffett Field, CA 94035

INTRODUCTION. Flight crews must make decisions and take action when systems fail or emergencies arise during flight. These situations may involve high levels of risk, information uncertainty, and time pressure, factors that contribute to stress. Full-mission flight simulation studies have shown that crews differ in how effectively they cope in these circumstances, judged by operational errors and crew coordination. The present study analyzed the problem solving and decision making strategies used by crews led by captains fitting three different personality profiles. Our goal was to identify more and less effective strategies that could serve as the basis for crew selection or training. METHODS. Twelve 3-member B-727 crews flew a 5-leg full-mission simulated flight over 1 1/2 days. Two legs included 4 abnormal events that required decisions during high workload periods. Transcripts of videotapes were analyzed to describe decision making strategies. Crew performance (errors and coordination) was judged on-line and from videotapes by check airmen. RESULTS. Based on a median split of crew performance errors, analyses to date indicate a difference in general strategy between crews who make more or less errors. Higher performing crews showed greater situational awareness--they responded quickly to cues and interpreted them appropriately. They requested more decision-relevant information and took into account more constraints. Lower performing crews showed poorer situational awareness, planning, constraint sensitivity, and coordination. The major difference between higher and lower performing crews was that poorer crews made quick decisions and then collected information to confirm their decision. CONCLUSION. Differences in overall crew performance were associated with differences in situational awareness, information management, and decision strategy. Captain personality profiles were associated with these differences, a finding with implications for crew selection and training.

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COGNITION AND PROCEDURE REPRESENTATIONAL REQUIREMENTS FOR PREDICITIVE HUMAN PERFORMANCE MODELS

K. Corker
NASA Ames Research Center, Moffett Field, Ca. USA

Models and modeling environments for human performance are becoming significant contributors to early system design and analysis procedures. Issues of levels of automation, physical environement, informational environment, and manning requirements are being addressed by such man/machine analysis systems. The research reported here investigates the close interation between models of human cogntiion and models that describe procedral performance. We describe a methodology for the decomposition of aircrew procedures that: supports interaction with models of cognition on the basis of procedures observed; that serves to identify cockpit/avionics information sources and crew information requirements; and that provides the structure to support methods for function allocation among crew and aiding systems. Our approach is to develop an object-oriented, modular, executable software representation of the aircrew, the aircraft, and the procedures necessary to satisfy flight-phase goals. We then encode, in a frame-based language, taxonomies of the conceptual, relational, and procedural constraints among the cockpit avionics and control systems,and the aircrew. We have designed implemented a goals/procedures hierarchic representation sufficient to describe procedural flow in the cockpit. We then execute the procedural representation in simulation software and calculate the values of the flight instruments, aircraft state variables and crew resources using the constraints available from the relationship taxonomies. The system provides a flexible, extensible, manipulable and executable representation of aircrew and procedures that is generally applicable to crew/procedure task-analysis. The representation supports developed methods of intent inference, and is extensible to include issues of information requirements and functional allocation. We are attempting to link the procedural representation to models of cognitive function to establish several intent inference methods including procedural backtracking with concurrent search, temporal reasoning, and constraint checking for partial ordering of procedures. Finally the representation is being linked to models of human decision making processes that include heuristic, propositional and prescriptive judgement models that are sensitive to the procedural context in which the valuative functions are being performed.

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BEYOND THE COCKPIT: THE VISUAL WORLD AS A FLIGHT INSTRUMENT. W.W. Johnson, M.K. Kaiser, and D.C. Foyle. NASA Ames Research Center, Moffett Field, CA 94035-1000.

The use of cockpit instruments to guide flight control is not always an option (e.g., low-level rotorcraft flight). Under such circumstances the pilot must use out-the-window information for control and navigation. Thus it is important to determine the basis of visually guided flight for several reasons: 1) to guide the design and construction of the visual displays used in training simulators; 2) to allow modeling of visibility restrictions brought about by weather, cockpit constraints, or distortions introduced by sensor systems; and 3) to aid in the development of displays that augment the cockpit window scene and are compatible with the pilot's visual extraction of information from the visual scene. The authors are actively pursuing these questions. We have ongoing studies using both low-cost, lower fidelity flight simulators, and state-of-the-art helicopter simulation research facilities. Research results will be presented on: 1) the important visual scene information used in altitude and speed control; 2) the utility of monocular, stereo, and hyperstereo cues for the control of flight; 3) perceptual effects due to the differences between normal unaided daylight vision, and that made available by various night vision devices (e.g. light-intensifying goggles and infrared sensor displays); and 4) the utility of advanced contact displays in which instrument information is made part of the visual scene, as on a "scene-linked" head-up display (e.g., displaying altimeter information on a virtual billboard located on the ground).

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USING AND DESIGNING PROCEDURES; LESSONS LEARNED FROM AVIATION.

A. Degani. San Jose State University Foundation, San Jose, CA 95106.
E. L. Wiener. University of Miami, Coral Gables, FL 33124

Procedures drive almost every task and sub-task on the flight deck of a commercial airliner. Failure to conform to Standard Operating Procedures (SOP) is frequently listed as the cause of violations, incidents, and accidents. Moreover, according to a study of 93 commercial aviation accidents, the leading crew-caused factor in aviation accidents was "pilot deviation from basic operational procedures" (Lautman and Gallimore, 1988). However, in most cases procedures and checklists are designed piecemeal, rather than based on a broad philosophy and on policies for operations. A framework of philosophy, policies, procedures and their relationship to the actual practices on the flight-deck is suggested. Initial results of an ongoing field-study to investigate the usefulness of these concepts will be reported.

Lautman, L. G., & GALLIMORE, P.L. (1988) . Control of the crew-caused accidents. Seattle: Boeing Commercial Airplane Company.

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AIRCREW REACTIONS TO COCKPIT AUTOMATION, E. L. Wiener. University of Miami, Coral Gables, FL 33124

The modern, highly automated taransport cockpit has brought a new era of highly efficient flight. But it has also introduced new problems of situational awareness, remoteness from the basic airplane, and concerns about possible loss of manual flying proficiency. This paper will discuss the "good new/bad news" of cockpit automation.

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MILITARY AIRCRAFT ACCIDENTS, CURRENT SAFETY ISSUES. R. A. Levy* (Air Force Safety Agency) and D. T. Fitzpatrick* (Army Safety Center) Co-chairman.

This panel will consist of five presentations on human factor (operator) issues in military aircraft accidents, focusing on immediate and future concerns. The U.S. Army will discuss the underlying causes of aircraft accidents during Desert Shield/Storm as compared to the non-combat environment. The U.S. Navy will review the trends and causes of Naval aviation accidents and the effect on current training. The U.S. Air Force will present the problem of human factors in the logistical arena. The Canadian Forces will discuss their proposed system to collect and analyze human error data from aircraft accidents. The Royal Air Force will describe recent studies concerning emergency egress equipment.

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CAUSE FACTORS OF U.S. ARMY AIRCRAFT ACCIDENTS FOR FY91: THE IMPACT OF DESERT STORM. D. T. Fitzpatrick*. U.S. ARMY SAFETY CENTER, FT. RUCKER, AL 36362.

INTRODUCTION. With the occurrence of Desert Shield/Storm, the U.S. Army experienced an increase in the number of accidents, fatalities and dollar costs for all classes of aviation accidents during FY91. Human error continued to be a primary cause factor regardless of the environment. METHODS. The Army Safety Center database was queried to obtain cause factors for all Class A aircraft accidents during FY91. A comparrison of Desert Shield/Storm accidents to remaining accidents was then performed. RESULTS. Of the 49 Class A accidents, 25 (51%) occurred in Saudi Arabia. Human error was the most frequently identified cause factor (63%), and individual failure to follow standards accounted for over 70% of the human error accidents. The problem areas associated with crew errors under combat conditions were the same as those experienced during peacetime. CONCLUSION. Regardless of the environment, human error is the most common cause of Army Aviation accidents. Incorporating safety into training and individual adherence to standards will help reduce this factor.

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MISHAP TRENDS AND CAUSE FACTORS IN NAVAL AVIATION, A REVIEW OF NAVAL SAFETY CENTER DATA, 1986 TO 1990. D. W. Yacavone* Naval Safety Center, Norfolk, Virginia 23511-5796.

Introduction. Although the mishap rate in Naval Aviation has declined substantially over the period from 1950 to 1990, there remains a residual number of mishaps per 100,000 flight hours. Many of these mishaps represent human error. There seems to be an additional risk in certain air-frames and in specific missions.

Methods. Mishap trends and causes were reviewed for all naval aircraft over a four year period, 1986 to 1990. These were graphically represented and compared, both statistically and with other methods.

Results. The mishap rates were graphically displayed and demonstrated a significant portion of aircrew error mishaps. Over the period in question, there were 308 total Class A mishaps. Of these, 179 (or 58%) were attributed to aircrew error. There were 145 (or 47%) attributed to supervisory error, another form of human mistakes. The most common cause factors were directly related to human failure.

Conclusions. Human error has emerged as the most common cause of naval aviation mishaps. The effect on training is already being seen with the establishment of aircrew coordination training as one of the top priorities in the Fleet Replacement Squadrons. Studies, both underway and in press, appear to indicate a positive response to this training.

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HUMAN FACTOR ACCIDENTS IN USAF AIRCRAFT; THE LOGISTICS MASQUERADE. R.A. Levy*, Air Force Safety Agency, Norton AFB California 92409

A review of 67 recent consecutive Air Force mishaps revealed the associated Safety Investigation Boards concluded 26 of these accidents were due to logistical factors. A second look at these 26 revealed that only 6 could be considered purely logistical and that human factors had played a significant role in the generation of the other 20. This paper will present the microanalysis of an A-7 aircraft mishap considered by the investigating authority to be logistical but was, in fact, the logistical outcome of a series of human errors and performance failures. The problem of human factors in the logistical arena will be discussed from the perspective of recognition and prevention.

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CURRENT FLIGHT SAFETY ISSUES IN THE CANADIAN FORCES

E.A. Brook*, Canadian Forces Directorate of Flight Safety, National Defence Headquarters, Ottawa Canada K1A 0K2

The Directorate of Flight Safety (DFS) is the central agency responsible for investigation of all aircraft occurrences in the Canadian Forces (CF). Each year approximately 2500 incidents and 15 accidents are reported. Human Factors continue to be the prime cause of accidents in the CF as they are in military and civilian flying worldwide. A recent study of Human Factors in the CF-18 recommended that a Human Factors database be established and maintained for flight safety purposes. This presentation will review some recent significant aircraft accidents and discuss a proposed system to collect and analyze human error data from occurrences. The current methodology of Human Factors investigation and the development of a Human Factors database will be emphasized.

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SAFETY ISSUES IN AIRCRAFT ACCIDENTS - RECENT RAF INTERESTS

Group Captain TM Gibson RAF
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WASHINGTON DC 20008

Several recent civil crashes in the United Kingdom have had features thst are of relevance to military aviation. The presentation describes work carried out by the Royal Air Force Institute of Aviation Medicine. In particular, 3 areas have been reassessed: first, the original experiments carried out 40 years ago on rear-facing seats are reviewed and the recommendations discussed; second, experimental assessments of 2 smoke hoods for emergency egress are described and the results evaluated; and finally, studies are described into the provision of underwater lighting and breathing equipment to aid escape from ditched helicopters. In this situation, the major contribution that could be made to survivability remains the prevention of the helicopter from sinking.

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CURRENT AEROMEDICAL CONCERNS IN OPERATIONAL MILITARY AVIATION.

Moderator: T. M. McNish. President, International Association of Military Flight Surgeon Pilots (IAMFSP).

BACKGROUND: The membership of the IAMFSP consists of flight-surgeon pilots from the US Army, Navy and Air Force, and from serveral allied countries. These individuals are involved in many aspects of military aviation, from research to operations.

PURPOSE: This panel will include presentations representative of the challenges being met by pilot-physicians in their role as human factors observers. Each presenter will address a human-factors issue pertinent to their current or recent flying responsibilities. The presentations will be followed by a panel of active pilot-physicians from the US Air force and Navy, as well as from Canada and Sweden. Each will give a brief synopsis of their current activities and issues, followed by a question and answer session.

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HUMAN FACTORS ISSUES IN A T-38 NEAR-MISHAP: AN OVERVIEW AND CASE STUDY. D.A. Holland.* University of Virginia School of Medicine, Charlottesville, VA 22908.

INTRODUCTION. The T-38 is a high-performance twin-engined jet aircraft used for the advanced portion of USAF Undergraduate Pilot Training. The F-5 derivative of this aircraft has also been used in an "aggressor" role. The incidence of T-38/F-5 mishaps due to human factors problems such as loss of situational awareness (LSA) and spatial disorientation (SDO) is examined. A systems perspective is helpful to fully assess why mishaps may occur. METHODS. Records from the Air Force Safety Agency were obtained and evaluated for T-38/F-5 mishaps for the period 1980-89. Records have also been obtained from a "near-mishap" to which this case study refers. The records of both are evaluated in terms of human factors issues that may be contributing factors to the incidents in question. RESULTS. During the period from 1980-89, there were 9 F-5 Class A mishaps that involved LSA/SDO as one of the contributing factors to the incident. This represents 75% of the total F-5 Class A LSA/SDO associated accidents during that time from a total of 12 mishaps. The T-38 had 15 Class A mishaps with an association to LSA/SDO of 18 Class A mishaps occurring, resulting in 83% of the accidents being LSA/SDO related. The case study of a "near-mishap" will attempt to reveal some of the human factors relevant to an impending mishap from a systems perspective that includes aircraft malfunction, fatigue, and psychosocial issues. Environmental factors play a role as does the task regime that exists at a particular time. CONCLUSIONS. To fully appreciate the causality of a mishap, a systems approach to examining the human factors issues is helpful.

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HUMAN FACTORS OF LANTIRN OPERATIONS. P.F. Demitry*, Pilot Physician, Tactical Air Command, Myrtle Beach AFB, SC.

Introduction: With the introduction of FLIR and other sensors, there has been a tremendous increase in nocturnal tactical operations over the past few years. Many problems associated with night ops have been well documented in the past (WW II, Vietnam, F-117, Desert Shield and Storm). Despite these experiences however, squadrons engaged in routine nocturnal training still face significant human factor risks due to fatigue, sleep loss, SDO and circadian dysrhythmia. Safety statistics reveal a disproportionally high percentage of night mishaps per total hours flown. Methods: Pilot Physicians have been assigned to wings engaged in peacetime and combat night operations over the past 72 months. Each pilot physician reported at least semiannually on observed human factors adversely affecting flight operations. In addition to observing their own wings, they were invited to at least 7 other Tactical Fighter wings in USAFE and TAC over a three year period providing briefings and consultation while studying each wing's unique situation. Results: Aircrews flying routine peacetime night sorties reported problems sleeping and associated fatigue. There was little insight as to the consequences of circadian dysrhythmia and the associated degradation of certain essential flying skills. (Most noticeably-complacency, communication and calculative abilities). Wings were provided with concrete methods minimizing recognized hazards. Conclusion: Although the new FLIR technologies make night look like day, human physiology continues to make night flying more difficult than daytime flying. Our understanding of the human factors associated with these new technological breakthroughs has unfortunately lagged behind the hardware. In the future, systems development must allow the human factors discipline to mature with the emerging technology before becoming operational. Pilot Physicians offer a unique perspective in contributing to this task.

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DIGITAL FLIGHT DATA RECORDINGS OF PRECISION APPROACHES IN THE C-141: EFFECTS OF ACUTE AND CUMULATIVE FATIGUE ON PERFORMANCE DURING OPERATION DESERT STORM. R.U. Bisson,* Armstrong Laboratory, Brooks AFB, TX 78235.

INTRODUCTION. Other investigators have relied on subjective observations, performance analogues, and simulations to evaluate fatigue and aircrew performance. Digital Flight Data Recorders (DFDR) offer a high fidelity record of pilot performance. METHODS. We developed procedures to use DFDR data to evaluate fatigue during Operation Desert Storm. Aircrew maintained activity logs, fatigue ratings, and profiles of mood data which were coupled with flight deck observations. DFDR recordings were analyzed for airspeed, heading, rate of descent, pitch, roll, and power control during final approach. Five crews (12 pilots) volunteered to exceed peace-time limits of 125 flight hours per 30 days. Over 100 precision approaches were analyzed for deviations nearing decision height RESULTS. Analysis to date does not reveal significant performance differences attributable to fatigue; however, differences in piloting precision between individual approaches were observed in both graphic plots and in standard deviations. Airspeed exhibited less precise control when fatigue was a factor. Further analysis will assess how these variations relate to other measures of fatigue, pilot experience, or other factors. CONCLUSION. This is the first study to use the C-141 DFDR to evaluate pilot performance during operational missions. DFDRs offer an accessible method to assess inflight performance and may relate to deteriorations detected by other performance analogues. Additional controlled studies to exploit DFDR performance data are indicated.

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IN FLIGHT VERIFICATION OF THE INVERSION ILLUSION. G W MCCARTHY*and J R R Stott. Royal Air Force Institute of Aviation Medicine, Farnborough, Hants, England.

INTRODUCTION. Reports on the perception of the theoretical rotation of the G vector while pushing over (bunting) are conflicting. In 1990, Money et al subjected 5 passengers in a T-33 to a transition from +1 to -1G in 3 seconds to search for perception of this Inversion Illusion. Two perceived a backwards rotation of the G vector and inversion. METHODS. Each of ten subjects was flown in the IAM Hawk or Hunter through this manoeuvre: With sun visor down and eyes closed, the subject was asked to report what the aircraft was doing. Flight profile: stabilise 30 seconds, accelerate level from 200 to 250K (+ 0.15 - 0.25G_X), gently pull to 250K, 3000 ft/min climb. After 30 sec, push over to -1G in 3 sec and hold 3 sec. RESULTS. Eight of 15 manoeuvres produced sensations of inversion in 7 of 10 subjects. Two subjects reported backwards rotation of the aircraft to the inverted; one other felt a rotation of indeterminate direction, 4 felt sudden inversion. 2/2 naive non-pilots, 5/6 pilots, and 0/2 test pilots experienced this illusion. CONCLUSIONS. The Inversion Illusion exists; the postulated rotation of the G vector is often not perceived.

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AEROMEDICAL TRANSPORTATION TODAY: A.D. Yates.* Air Safety Consultant, Alexandria, Virginia 22307.

INTRODUCTION. The Panel will discuss the various modes of Aeromedical Transportation, such as Fixed-Wing, Helicopter, Multi-Patient Transports, ICAO Standards, Assistance Programs, State of Insurance Practices and Regulations covering Aeromedical Transports.

DEVELOPMENTS. The Aeromedical Transport Industry is in the throes of changes that may achieve some cohesion of the fragmented industry in the not too. distant future.

PROBLEM. While the Federal Aviation Administration in the United States has issued Advisory Circulars that address the needs for uniform standards throughout the industry, they have steadfastly refused to address the real issues of patient care in the air. Because the Advisory Circulars are just that, advisory, there is no way of enforcing them.

NEED. There is a serious need for uniform standards. A poll of the fifty-one United States Attorneys General indicate a willingness to develop a Uniform Code of Regulations for the Aeromedical Industry to which all states can subscribe. This would be similar in nature to the Uniform Commercial Code that presently exists in the United States, to which all but one state I believe has subscribed.

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AA/ST JOHN ALERT SCHEME: F.S. Preston, M.D.* & M.D. Glandfield, M.D.. Automobile Association:, Basingstoke, Hants RG21 2EA & St. John Ambulance Brigade, London SW1X 7EF ENGLAND.

INTRODUCTION: The St. John Ambulance & the Automobile Association have since 1988 run a world-wide service in the repatriation of sick and injured patients from any part of the world, using scheduled, air ambulance or air taxi aircraft. Some 1100 calls are dealt with annually, many covered by the patient's insurance. Volunteer doctors and nurses trained in aerospace medicine provide the expertise and specialised equipment.

CONCLUSION: The paper describes the operational aspects of the scheme and the results over the last three years.

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FIXED-WING AEROMEDICAL TRANSPORT: W.W. BARE,* North American Air Ambulance. Blackwood, New Jersey 08012

INTRODUCTION. Fixed-wing aeromedical transportation is an extension of hospital and medical care. Tremendous technologic advances in both medicine and aviation make transportation stretcher patients extremely safe. Accreditation and certification of services is now a reality. Quality Control and Quality Assurance are not only available - they're mandatory to maintain standard of care.

PROBLEM. Despite years of study, though, there still are no federal regulations to protect patients medically in the air. State laws are of limited value. The "Yellow Pages Peril" still exists, and ill-equipped, ill-staffed airplanes continue to fly critically ill patients every day. Malpractice suits have been and are being filed.

DEVELOPMENTS. The Air Ambulance Subcommittee of Aerospace Medical Association has been active in urging standards of care as evidenced by its close cooperation in writing DOT Guidelines for Air Ambulances, and more recently working closely with organizations such as the Professional Aeromedical Transport Association and international assistance groups.

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PRE-PAID QUALITY MEDICAL AIR CARE WORLDWIDE: D.H. Geil, International Medevac Transport Corp., Phoenix, AZ 85020.

INTRODUCTION. New insurance and association programs are being introduced every year in the U.S. and in foreign countries to facilitate access to air ambulance services. Increasingly, companies and individual travelers are seeking reimbursement type plans as protection against extended liabilities or catastrophic expenses.

PROBLEM. Currently, most coverages offered, both domestically and overseas, are frequently limited to restricted geographic areas or maximum services to be rendered. "Cost containment" often takes precedence over optimal care for the patient. To date, there exists little to no national or international standards that address the needs of the patient, the provider and third party administrators.

DEVELOPMENTS. Increasing business and leisure travel has precipitated a renewed interest from insurers and associations in developing minimum aeromedical, and contractual guidelines. Industry and professional associations such as PATA with its certification (COE) program will become more actively involved in further developing these relationships.

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ROLE OF THE U.S. AIR FORCE IN MULTIPLE PATIENT TRANSPORTS: S.I. Rothfuss,* USAFSAM/AN, Brooks AFB, TX 78235

INTRODUCTION. The United States Air Force's (USAF) involvement in worldwide aeromedical evacuation has made a significant impact on patient transport. This presentation is an overview of how that expeditious movement continues to be accomplished.

PRESENTATION. The use of fixed-wing aircraft has resulted in increased survival rates and decreased recuperation times. The USAF has been designated as the military branch to provide global aeromedical evacuation support to all beneficiaries eligible for medical care and individual civilian cases approved by the Department of Defense. Scheduled and special missions are utilized to support the required multiple patient transports and examples of each will be presented by discussing the airframes that are routinely used. Representative slides of the airframes will be shown for visual clarification. A synopsis of USAF sponsored courses required for nurses and technicians will be explained.

CONCLUSION. Centralization of the medical specialties has resulted in a demand for timely medical support transportation modes that link the patient and physician to attain the goal of survival. Through increased awareness of civilian and military aspects of that transportation, the patient will be the beneficiary.

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DEVELOPMENT AND CONTROVERSIES OF HOSPITAL-BASED EMS HELICOPTERS: F.O. Thomas,* Life Flight, LDS Hospital, Salt Lake City, UT 48143

INTRODUCTION. The purpose of this presentation is to give the audience an overview of the development, mission profile, types of helicopters, medical crew mix, and controversies surrounding USA hospital-based EMS helicopter services (HEMS).

DEVELOPMENTS. Prior to 1970, few civilian medical helicopter services existed. On October 12, 1972, St. Anthony's Hospital in Denver, Colorado, began the nation's first successful and longest operating hospital-based helicopter service. Now there exist over 170 similar programs.

CONTROVERSIES. Despite the relative medical success of HEMS, this industry has come under criticism for it's safety record. Adverse weather conditions and obstacle strikes account for a majority of these accounts. More recently HEMS has been viewed as escalating healthcare costs with unnecessary transports.

SUMMARY. This industry has made a remarkable turnaround in it's safety record. However, under DRGs and managed healthcare plans, providers of these services will have to be able to demonstrate clear healthcare benefits with this mode of transport over less costly transport modes.

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AEROSPACE MEDICINE RESEARCH IN THE 21ST CENTURY. PARTS 1 & 2. Sponsored by the Science & Technology Committee and Chaired by M.J. Antunano* and B.J. Stegmann*. KRUG Life Sciences, San Antonio, Texas 78279-0644.

The overall objective of our symposium (Parts 1 & 2) is to identify specific areas where more research (basic and/or applied) is required, as well as to identify those areas where opportunities for collaborative research exist. An additional goal is to educate and motivate our young colleagues who are interested in pursuing a career in aerospace medicine research. Our speakers will discuss the following topics: 1) Current research areas (general & specific) which are being actively pursued in their fields of expertise; including a general description of relevant problems and limitations (methodological & technological), 2) New research areas (general & specific) previously identified that deserve detailed study, but have had limited or no investigation, 3) Recent breakthroughs in research technologies and/or methodologies which are promising in helping to find solutions to fundamental research issues, 4) Future research issues of relevance to the design, development, and utilization of new aerospace technology in the 21st Century, and 5) Personal points of view on how collaborative research can be accomplished in a more effective and efficient manner at the local, national, and international levels.

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HYPOBARIC PHYSIOLOGY. A.A. Pilmanis* Armstrong Laboratory, Brooks AFB, TX 78235-5000

Reduced ambient pressure in both aircraft and spacecraft can result in the potentially hazardous conditions of decompression sickness (DCS), hypoxia, and ebullism (vaporization of tissue fluids). Hypobaric research in the recent past has especially focused on the DCS hazard associated with extravehicular activity (EVA) from the shuttle and the future space station, and with high altitude military aircraft. Currently, rapid developments in ultrasound imaging systems are enabling researchers to better define intravascular and extravascular bubble formation, to quantify and size these bubbles, and to relate these bubbles to symptoms. Basic pathophysiological mechanisms, both acute and chronic, associated with the clinical manifestations of DCS are yet to be clearly defined. Powerful modelling techniques are being used for both real-time and predictive risk assessment capabilities. Improved DCS databases and reporting of DCS with impunity will help in the validation of these models. For hypoxia protection, the physiological stresses associated with positive pressure breathing need to be studied and will determine the threshold altitude compatible with extended exposure. Accidental exposure to the vacuum of space is inevitable in the space program. The potential hazard of ebullism cannot be "engineered out." Medical treatment protocols and new protective measures are needed for increased survival potential from accidental decompressions to very low pressures. New concepts in EVA suit design are needed for beyond space station. In particular, the Mars atmosphere and gravity dictate the development of a new lightweight suit. New research on DCS, ebullism and hypoxia is vital in this design development. This same information will also reduce risk in future aircraft such as the National Aerospace Plane and its derivatives.

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HYPERBARIC PHYSIOLOGY AND MEDICINE

E.P. Kindwall, M.D.*, Medical College of Wisconsin

Clinical hyperbaric oxygenation is becoming much more common with a 10 fold growth in less that 15 years. Areas undergoing intensive research at the present time are the intracellular effects of carbon monoxide, and the effects of HBO on free radicals and reperfusion injury. Preliminary evidence indicates reperfusion injury may play a role in CO poisoning as well as graft survival and crush injury. The mechanism whereby HBO mitigates this phenomenon needs further investigation. Transcutaneous pO_2 measurement needs to be further refined and made more accurate. The adjunctive use of HBO in the thrombolytic therapy of myocardial infarction shows great promise and human series are in progress. Work needs to be done in the area of optimal treatment protocols. Currently, dosage of hyperbaric oxygen is empiric with very little information as to the relative efficacy of different treatment frequencies and optimal treatment pressures. Magnetic resonance imaging may provide important information concerning biochemical changes within the tissues following HBO. Randomized clinical studies are needed which seek to define cost effectiveness as well as wound healing. HBO will not become a standard of care unless it can be shown to reduce costs. Looking far in the future, if cheap energy sources can be found for boosting large payloads into orbit on a routine basis, the effect of microgravity on pressure sores, circulatory problems and diabetic ulcers combined with hyperbaric oxygenation can be studied.

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AEROSPACE HUMAN FACTORS IN THE 21st CENTURY. S. G. Schiflett* Armstrong Laboratory, Crew Technology, Brooks AFB, Texas 78235.

At the threshold of the 21st Century, the DOD is challenged with maintaining a superior fighting force in the context of worldwide events leading to accelerated nuclear disarmament and drastic reductions in military personnel. A conceptual strategy will be discussed for identifying research and development requirements to ensure support and performance enhancement of the human element in aerospace systems well into the next century. The predominant role that Human Factors, as a scientific discipline, will assume responsibility for in future decades in the acquisition of sophisticated aerospace systems, will be outlined. Specific examples of missions requiring a thorough understanding of basic human capabilities in aerospace environments will be highlighted. Critical questions will be postulated by the discussant in such diverse research areas as behavioral processes, performance capabilities, fatigue/sleep, team composition, human computer interaction, automation, habitability, and environmental stressors. The research questions will be requirements-driven, empirically based, focused on specific objectives, and definitive enough to lead to well designed experimental studies.

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SPATIAL ORIENTATION IN FLIGHT. K.K. Gillingham.* Armstrong Laboratory, Brooks AFB TX 78235-5000.

Spatial disorientation (SD) has been, is, and will continue to be one of the leading causes of aircraft mishaps, currently costing on the order of a billion dollars and numerous lives annually. The real contribution of SD to mishap statistics is clarified by use of an operational definition of SD: "an erroneous sense of flight parameters displayed by control and performance instruments." R&D to promote spatial orientation in flight has three directions: (1) elucidate basic sensory and cognitive mechanisms of orientation and SD; (2) develop ground-based and inflight training to increase pilots' awareness of SD and to enhance their ability to avoid or cope with SD; and (3) create flight instrument displays that provide efficiently processed, continuous, orientational cues. Although some vestibular research still needs to be done, visual-vestibular interaction, visual attention, and auditory orientation are becoming fertile areas of investigation in orientational mechanisms research. Exploring the full potential of the Advanced Spatial Disorientation Demonstrator for reducing SD-related aircraft mishaps will occupy SD training R&D for years to come. Efforts at optimizing and standardizing head-up and head-down flight instrument displays are ongoing; but the eventual solution to the SD problem is a helmet-mounted display of a computer-generated, virtual, visual and auditory spatial environment.

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NONIONIZING RADIATION IN AEROSPACE OPERATIONS. R.G. Olsen.* Naval Aerospace Medical Research Laboratory, Pensacola, FL 32508-5700.

In the past, issues related to nonionizing radiation were mostly concerned with radars and microwave energy. Early research in this area was, therefore, conducted with commonly used radar frequencies above 1.0 GHz (30-cm wavelength). Promulgation of ANSI C95.1-1982, however, widened the spectrum of concern and added protection in the frequencies of human resonant energy absorption. In addition, questions concerning hazards to personnel due to radiofrequency (RF) body currents have been raised during the past few years. Moreover, the characterization and quantitation of the RF-burn phenomenon remains essentially unstudied. A new ANSI standard has been drafted to correct former weaknesses, but it is a voluminous, two-tiered document with many frequency- and time-dependent features. Considerable technical effort remains to adapt the ANSI draft to meet the special requirements of the aerospace industry and the military services. Additional collaborative research is needed to better characterize the important parameters of near-field irradiation and RF body current.

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AIRCRAFT ACCIDENT INVESTIGATION IN THE 21ST CENTURY. S.J.H. Veronneau.* Civil Aeromedical Institute, Oklahoma City, OK 73125-8066.

This endeavor is a most diverse and multidisciplinary scientific effort. Much research remains to be undertaken in accident investigation within the men-machine-environment interface that is aviation. Most mishaps involve human factors in their causation; all accidents involve human concerns.

Current research includes health outcome analysis of disqualified airmen, toxicological analyses, sudden and subtle incapacitation of aircrew, the postcrash environment, cabin safety issues and aircrew/ flight attendant performance.

Recent breakthroughs in automated cognitive function testing, simulator-workstation comparisons, a new medical accident investigation order and mandate, along with a new NTSB relationship are assisting the medical accident investigator.

Research areas receiving new attention include the effect of medications on flight performance, and toxicological advances in assessing diabetes and alcohol determinations postmortem.

Future research will include further development of human performance test capability to study medications and flight tasks in a simulated flight environment and to initiate a relationship between the FDA and the FAA regarding drug studies. Challenges arising from mishaps in the aerospace envelope available to the National Aerospace Plane and space vehicles or habitations will need to be anticipated and met.

Collaborative research in medical accident investigation is a necessity in dealing with these rare, sporadic events in order to deal with the numerous research avenues available to medical accident researchers. Engineers, psychologists and physicians need to coalesce their talents in the field and the lab to provide a comprehensive examination of the factors operant in aerospace mishaps. At the local and national level the renewed FAA Office of Aviation Medicine approach to medical accident investigation will require individuals selected, trained and motivated in the efforts described above in addition to the traditional medical approach to accident investigation. At the international level ICAO should be encouraged to serve as a repository of pooled data for dissemination and provide online storage for constant access. The FAA intends for its medical accident investigation/research activities to serve as an example for such an international collaboration.

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SPACE MEDICINE RESEARCH: NEEDS FOR THE 21ST CENTURY L.J. Pepper* Medical Operations Branch, NASA-Johnson Space Center, Houston, TX 77058.

Space Medicine research in the 21st century will continue to focus on the four major areas including 1) expansion of the current incomplete knowledge base of clinical and subclinical physiological changes due to microgravity, 2) development of countermeasures to extend the capabilities of the human performance envelope in extended duration flights, 3) developement of novel methods for delivering all aspects of a comprehensive health care system in extreme remote conditions, and 4) further research and application of systems for biological materials processing. New space transportation vehicles will place unique physiologic and human factors demands on the human system, while providing better access to platforms for materials processing. Success in meeting the demands in each of the noted research areas will require an extensive, interactive team approach. Personnel from the medical research, operational, developmental, and basic science communities will be essential to success.