-559-

HYPERBARIC PHYSIOLOGY AND MEDICINE

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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.

-560-

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.

-561-

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.

-562-

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.

-563-

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.

-565-

CLINICAL AEROSPACE MEDICINE IN THE 21ST CENTURY.*S.R. Mohler. Wright State University, Dayton, Ohio 45401.

INTRODUCTION. Advanced non-invasive diagnostic techniques will characterize the tools of practice for the 21st Century flight surgeon. Cerebral and cardiovascular disease, even in the incipient stages, will be readily detectable at the time of the periodic physical examination. The same will be true for other potentially disqualifying conditions. Brief highly sensitive and specific cognitive and psychomotor office-based testing will be accomplished at the time of examination, including the assessment of the sensory system. In the 21st century pilot population, the use of addictive substances will be virtually unknown, the result of education and screening (and rehabilitation programs when necessary). The self-destructive, suicidal addictions (including nicotine, alcohol, amphetamines, and others) will be understood as incompatible with those who elect to undertake the privilege of flight. The 21st century approach will be that of individual assessment, emphasizing (1) Freedom from an impairing disease, (2) Capacity to perform as demonstrated by objective flight and high fidelity simulator assessment, and (3) Motivation to fly. CONCLUSION. As a result of advances in medicine, aircraft design and airspace characteristics, various medical standards of the "Golden Age" 20th century will be dropped. These include uncorrected distant vision, color vision, pure tone audiometry (the spoken voice test substituted), upper date-of-birth limits, limits on persons requiring exogenous insulin (insulin pumps will be available), and certain other conditions. The main disqualifying conditions will be in the psychiatric and attitudinal realms.

-566-

Human Space Exploration in the 21st Century: Psychosocial Factors. Harry C. Holloway, Uniformed Services University of the Health Sciences.

The initial explorations of the planetary systems beyond the moon are likely to be undertaken in the first four decades of the 21st century. Preparing for the social, psychological, and psychiatric problems to be faced must be initiated now if we are to adequately establish the risks which these matters pose and the counter measures to deal with those risks. Previous experience tells us that managing these problems would include analysis of complex physiologic, toxicologic, sociological, and psychological variables that may interact within complex technological systems. This paper will emphasize the nature of the work that must be undertaken in the next two decades.

-567-

THERMAL STRESS IN AEROSPACE MEDICINE: HOT ISSUES, COLD FACTS. S. A. Nunneley.* Armstrong Laboratory, Brooks AFB TX 78235.

Heat and cold have beset flight operations since humans first learned to fly. The challenges for today and tomorrow often relate to operational constraints and the subtle effects of thermal stress on performance. Some current concerns: 1) *Protection from climatic extremes.* Survival support for aircrew members implies using only minimal equipment or supplies, and providing them in a manner which avoids interference with normal flying operations. An example is the design of antiexposure suits which prevent immersion hypothermia while maintaining comfort in the cockpit. Possibilities include tailoring insulation to specific person-mission profiles and using variable insulation or active heating instead of bulky, conventional materials. 2) *Extension of physiological tolerance.* Moderate heat or cold may be the "last straw" for human tolerance of a multistress environment. Astronauts landing after an extended shuttle mission might have to undertake emergency egress where environmental heat exacerbates the circulatory decompensation caused by time in orbit; effective countermeasures may include in-flight exercise, plasma volume expansion before reentry, and garments designed to prevent dependent pooling. 3) *Prevention of performance effects.* Elimination of thermal stress may be required to ensure optimal performance of complex tasks and to maintain maximal tolerance for other environmental stressors such as acceleration and hypoxia. Where thermal control of the work space proves inadequate or impractical, personal conditioning may be useful. Conclusion: Elimination of thermal stress as an adverse factor in aerospace operations demands collaboration among specialists in aerospace medicine and aircraft design, as well as experts in clothing and personal conditioning, human factors and sustained operations.

-568-

ACCELERATION PHYSIOLOGY AND COUNTERMEASURES. R.W. Krutz*. KRUG Life Sciences, San Antonio, TX 78279-0644.

Methods to enhance man's survivability in the sustained high or low G environments continue to be at the forefront of aeromedical research. Several acceleration protection research efforts are being actively pursued in programs with high visibility. A new reentry G-suit for NASA which employs uniform pressure (UP) to the lower extremities promises to increase G-protection during shuttle reentry without the discomfort of an abdominal bladder (AB). This suit concept should also be adaptable for the National Aerospace Plane's (NASP) reentry G-protection requirements. It is hypothesized that the low G levels encountered in these environments do not significantly increase heart-to-eye distance and thus the requirement for an AB is negated but the need to prevent blood pooling in hypovolemic crewmembers is critical. The same G-protection principle used in these suits, i.e., lower body uniform pressure, is also the basis for a new advanced technology anti-G suit (ATAGS) soon to be flight-tested by the USAF. The AB is an absolute necessity in ATAGS since it is to be worn in fighter-type aircraft with high G onset rates which cause a rapid increase in heart-to-eye distance, decreased eye-level blood pressure and subsequent G-induced loss of consciousness (G-LOC). The USAF is now in the process of fielding COMBAT EDGE, an ensemble which uses positive pressure for G-protection (PBG) in combination with the current anti-G suit. PBG offers relief to tactical aircrews from the fatiguing effects of acceleration in air-to-air combat. Preliminary studies have demonstrated that PBG is even more effective when used with ATAGS.

-569-

AEROSPACE MEDICINE RESEARCH IN THE 21ST CENTURY - AIRCREW PROTECTIVE EQUIPMENT. R M Harding.* RAF Institute of Aviation Medicine, Farnborough, Hampshire, United Kingdom.

In the 21st century, the hazards associated with flight by humans will be just as they have always been, and aircrew protective equipment will still be part of the aeromedical armory. Thus, protection against pressure changes, hypoxia, accelerations, and other flight motion effects will still be needed; and research in these areas will continue to refine our already substantial body of knowledge. In this discussion paper, examples will be presented of the research needs for advanced oxygen systems (eg the innovative aircraft of the next century will depend for their life support systems upon our understanding of more efficient on-board oxygen delivery), for advanced head-mounted devices (eg the relatively simple protective helmet of today could so easily become a behemoth if the requirement for additional systems proceeds unchecked and uncoordinated), for advanced personal protective clothing (eg the needs of pressure garments for altitude and G protection), and for advanced warning systems for disorientation and other human factor influences. But how is all this to be achieved? As human and economic resources continue to be in short supply, there will be an increasingly important place for collaborative research: no longer will it be possible, or desirable, for each laboratory to "go it" entirely alone. Standardization of research tools and methodologies will be essential, and the part played by memoranda of understanding and international bodies such as AGARD, ASCC and AsMA will be vital.

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SLS-1 THE FIRST DEDICATED LIFE SCIENCES SHUTTLE FLIGHT. Robert W. Phillips, NASA Headquarters Code SB, Washington D. C. 20546.

OVERVIEW. Spacelab Life Sciences 1 was the first Space Laboratory dedicated to life sciences research. It was launched into orbit in early June 1991 aboard the space shuttle Columbia. The data from this flight have greatly expanded our knowledge of the effects of microgravity on human physiology as data were collected in-flight, not just pre and post. Principal goals of that mission were the measurement of rapid and semichronic (8 days) changes in the cardiovascular and cardiopulmonary systems during flight and then to measure the rate of readaptation following return to Earth. Results from the four teams involved in that research will be presented in this panel. In addition to the cardiovascular-cardiopulmonary research extensive metabolic studies were conducted on the payload crew. These studies encompassed fluid, electrolyte and energy balance, renal function, hematology and musculoskeletal changes. Finally, the crew participated in several neurovestibular studies. Overall, the mission was an outstanding success and has provided much new information on the lability of human response to the space environment.