

- Participants will be able to identify components of ambient air pollution and describe the role of PM 2.5 as a known cardiovascular toxicant and independent risk factor for cardiovascular disease.
- Participants will be able to recognize sources of water pollution and challenges to achieving and maintaining water quality.

WEDNESDAY, May 3, 2017

Wednesday, May 03
Plaza A/B

8:30 AM

S-051: PANEL: RESIDENT GRAND ROUNDS I

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Mark Coakwell
Dayton, OH

PANEL OVERVIEW: This panel will consist of pairs of Aerospace Medicine residents presenting clinical cases of aeromedical interest or significance. During their residency practicum years, residents conduct evaluations of patients with diverse medical problems. Residents prepare and present a case report based on a patient encounter undertaken during their practicum experience. One resident from each pair presents the history of the presented problem. The other resident presents the physical findings and a discussion of the aeromedical policies associated with the condition. Learning Aerospace Medicine at the specialist level involves understanding the impact of medical conditions on aircrew health and mission accomplishment. The cases presented will not only be of academic interest but will also illustrate aeromedical decision making in the operational environment.

Wednesday, May 03
Plaza D/E

8:30 AM

S-052: PANEL: ROCKY MOUNTAIN HIGH: CIVIL MEDICAL OPERATIONS IN A MOUNTAIN ENVIRONMENT

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Aaron Parmet
Keystone, CO

Chair: Allen Parmet
Kansas City, MO

PANEL OVERVIEW: Summit County Colorado is the highest county in the United States, with altitude ranging from 8,000-14,270 feet (2,440-4,450 m). Originally inhabited by Native Americans, first trappers and then miners explored and settled in the 19th century. The 20th century saw the change from silver and gold to snow as a source of major revenue. Today there are 30,000 permanent residents and over 3 million visiting skiers annually. There are numerous medical challenges in this unusual environment.

[246] SUMMIT COUNTY COLORADO - A UNIQUE ENVIRONMENT FOR WORK AND RECREATION

A.J. Parmet
Aviation Safety & Security, University of Southern California, Kansas City, MO

Summit County Colorado is the highest county in the United States, with altitude ranging from 8,000-14,270 feet (2,440-4,450 m). Originally inhabited by Native Americans, first trappers and then miners explored and settled in the 19th century. The 20th century saw the change from silver and gold to snow as a source of major revenue. Today there are 30,000 residents and over 3 million visiting skiers annually.

There are numerous medical challenges in this unusual environment. This presentation will summarize the history, geography and physiologic challenges of this area.

Learning Objectives:

- Understand the physiologic challenges of living in a high altitude/mountain environment.
- Understand the geography and the opportunities as well as challenges of living in a high altitude/mountain environment.
- Understand the history and environmental challenges of living in a high altitude/mountain environment.

[247] HELICOPTER OPERATIONS AND SPECIAL PROGRAMS IN A HIGH ALTITUDE ENVIRONMENT.

P.K. Werlin
Flight For Life Colorado, Georgetown, CO

Colorado was the birthplace of civilian, hospital based helicopter operations for medical purposes. Over the last 45 years, flight programs have been created and now cover nearly every area of the United States. Many programs have evolved over that period into highly specialized operations that take care of patients ranging from the smallest of premature newborns to the very complex medical patient up to and including patients on Extracorporeal Membrane Oxygenation. Mixed in with the day to day patient care challenges are the special operations missions. This presentation covers Flight For Life Colorado's package of programs designed to meet the special challenges faced in the Colorado Rockies.

Learning Objectives:

- Summarize the challenges of helicopter operations at high altitudes.
- Review the aspects of high risk, low frequency missions.
- Illustrate 4 types of mission profiles practiced by Flight For Life Colorado.

[248] MOUNTAIN RESCUE IN HIGH ALTITUDE ENVIRONMENTS

B. Taylor^{1,2}
¹*Wilderness EMS, Colorado Mountain College, Breckenridge, CO;*
²*Summit County Search & Rescue, Frisco, CO*

PROBLEM STATEMENT: The evacuation of a subject from a high altitude environment presents rescuers with a unique set of obstacles to overcome. It is critical that medical providers and rescuers understand some of the common challenges mountain rescuers face during long, austere evacuations at high altitude. Pre-planning how to deal with these common obstacles will provide a smoother, safer evacuation.

TOPIC: A highly trained mountain rescue team will have the combination of high situational awareness, technical training, and the right resources to provide an overall safe, timely evacuation of the injured subject. In this presentation, we will explore some solutions to common evacuation problems that are frequently encountered during high altitude evacuations. **APPLICATIONS:** All missions/expeditions should establish pre-plans, contingency plans, and evacuation plans before the start of the expedition. Training hard for the worst case scenario will help ensure a safe evacuation by having already rehearsed potential scenarios. Team members who can serve as rescue leaders should be identified prior to a missions start. These rescue leaders should brief all team members on the search and rescue plans prior to field work.

RESOURCES: Mountain Rescue Association, National Association of Search and Rescue

Learning Objectives:

- Participants will learn mountain rescue evacuation strategies utilized in high altitude environments.

[249] HIGH ALTITUDE MINES, HEALTH, AND CLEAN WATER: OLD PROBLEMS AND NEW CONSIDERATIONS

A.L. Parmet
Mine Emergency Response Team, Henderson Mine and Mill, Keystone, CO

PROBLEM STATEMENT: In order to understand the health hazard from high altitude mines, it is necessary to understand the

types of risks posed by mines and how to mitigate these risks. **TOPIC:** Mines at altitude, old and new can be a source of environmental hazard. The history of high altitude mines in Colorado stretches back to the discovery of gold in Idaho Springs in 1859. Non-industry workers usually do not have to worry about technical mine rescue and may easily avoid the risks of collapse, confined space, entrapment, and oxygen displacement asphyxiation. However, the health risk due to contamination of water requires deliberate consideration on all sides. It is important to understand the types and origins of these water born toxins that affect human health. Mitigation of these risks must include long term waste water treatment and mitigation at the source of contamination. There are also emergency measures that mitigate contamination of public water supplies caused by sudden or catastrophic releases such as in the 2015 Gold King mine spill.

APPLICATIONS: An understanding of the nature of mine hazards easily allows avoidance of unfamiliar situations in a unique environment that could rapidly turn deadly. Therefore, a greater focus is on understanding the management of water born pollution hazards which are important to high altitude travel medicine and public health.

Learning Objectives:

1. Identify basic risks of old and new mines and how to avoid them.
2. Understand the origins, types, and effects of water born toxins due to mining.
3. Describe the methods of immediate and longer mitigation of chronic and sudden releases of pollutants that threaten human health and drinking water.

[250] AVALANCHE RESCUE AND MEDICAL CONSIDERATIONS

A. Parmet^{1,2}

¹Rapid Avalanche Deployment, Summit County Rescue Group, Keystone, CO; ²CDIP/ICU/CI, St. Anthony Summit Medical Center, Frisco, CO

PROBLEM STATEMENT: In order to care for patients in avalanche accidents, it is necessary to understand the unique rescue requirements, pathophysiology, and treatment techniques. **TOPIC:** Avalanches kill and injure many at high altitude. Concerns focus heavily on time and technique because survival versus time drops precipitously in the case of full burials, from 92% at 10 minutes to 30% at 35 minutes. There is great difficulty in locating, accessing, stabilizing and transporting these patients expediently from high altitude winter environments to appropriate treatment centers. Many accidents are MCIs (Mass Casualty Incidents) further complicating the problem. Considerations differ between organized and companion rescue. The combined difficulties can only be overcome by proper approaches, training, and techniques utilizing specialized resources appropriately. Consideration includes aeromedical resources for insertion of specialized rescue teams, medical providers, equipment, and evacuation of patients. Rescue involves unique location tools such as radiolocation, harmonic radar, specialized search dogs, and massive probe lines. Medical management and transport decisions must consider a combination of high altitude, trauma, hypothermia, hypercapnia, and asphyxia. Combining all aspects of avalanche rescue can yield improved outcomes for these patients. **APPLICATIONS:** Expedient but practiced rescue and treatment of patients in avalanche accidents is key to their survival. The concerns vary during the phases spanning from involvement in the avalanche to arrival at hospital. These avalanche accidents cross the realms of travel medicine, aeromedical evacuation, and altitude medicine.

Learning Objectives:

1. Describe the phases of avalanche rescue and evacuation, the techniques available to organized and companion rescue, and the special equipment utilized for high altitude avalanche search and rescue.
2. Understand the pathophysiology involved with avalanche patients, descriptive statistics of morbidity and mortality, unique elements of triage, and special medical treatment considerations for the avalanche patient at altitude.
3. Identify the basic nature of avalanches and avalanche accidents, prevalence and distribution in the mountains during the year, and components of prevention.

Wednesday, May 03

8:30 AM

Plaza F

S-053: SLIDE: ADVANCES IN SPACE MEDICINE

Chair: Volker Damann

Cologne, Germany

Co-Chair: Judith Hayes

Friendswood, TX

[251] SCREENING AND MANAGEMENT OF ASYMPTOMATIC RENAL STONES IN ASTRONAUTS

D. Reyes^{1,2}, J. Locke¹, A. Sargsyan^{1,3}, K. Garcia^{1,3} and B. Tarver¹

¹NASA-JSC, Houston, TX, Houston, TX; ²Aerospace Medicine, UTMB, Galveston, TX; ³KBRwyle, Houston, TX

INTRODUCTION: A clinical practice guideline was created for the screening and management of asymptomatic renal stones in U.S. astronauts. The true risk for renal stone formation in astronauts due to the space flight environment is unknown. Proper management of this condition is crucial to mitigate health and mission risks. **METHODS:** The NASA Flight Medicine Clinic electronic medical record and the Lifetime Surveillance of Astronaut Health databases were reviewed. An extensive review of the literature and current aeromedical standards for the monitoring and management of renal stones was also done. This work was used to develop a screening and management protocol for renal stones in astronauts that is relevant to the spaceflight operational environment. **RESULTS:** In the proposed guidelines all astronauts receive a yearly screening and post-flight renal ultrasound using a novel ultrasound protocol. The ultrasound protocol uses a combination of factors, including: size, position, shadow, twinkle and dispersion properties to confirm the presence of a renal calcification. For mission-assigned astronauts, any positive ultrasound study is followed by a low-dose renal computed tomography scan and urologic consult. Other specific guidelines were also created. **DISCUSSION:** A small asymptomatic renal stone within the renal collecting system may become symptomatic at any time, and therefore affect launch and flight schedules, or cause incapacitation during a mission. Astronauts in need of definitive care can be evacuated from the International Space Station, but for deep space missions evacuation is impossible. The new screening and management algorithm has been implemented and the initial round of screening ultrasounds is under way. Data from these exams will better define the incidence of renal stones in U.S. astronauts, and will be used to inform risk mitigation for both short and long duration spaceflights.

Learning Objectives:

1. Understand the need for a robust clinical guideline to screen for renal stone and renal stone precursors in astronauts to reduce medical and mission risks.

[252] THE ROLE OF CSF IN SPACEFLIGHT-INDUCED OCULAR DEFORMATIONS AND VISUAL IMPAIRMENT

N. Alperin¹, A. Bagci¹, S. Lee¹, B.L. Lam¹ and C. Otto²

¹University of Miami, Miami, FL; ²NASA, Houston, TX

INTRODUCTION: Flattening of the posterior sclera and protrusion of the optic nerve are among the hallmark signs of the visual impairment intracranial pressure (VIIP) syndrome reported in many ISS astronauts. Although the mechanism causing the ocular structural changes in VIIP is unknown, it has been attributed to cephalad vascular fluid shift. This study utilizes advanced MR imaging to quantify changes in ocular morphology, orbital and cranial CSF volumes, and brain vascular tissue volumes in astronauts following short- and long-duration spaceflights to determine the underlying cause of the VIIP-related ocular deformations. **METHODS:** High resolution orbit and brain MRI scans obtained before and shortly after spaceflight from 7 long-duration ISS astronauts and 9 short-duration Space Shuttle astronauts were analyzed to identify the physiologic and morphologic changes associated with VIIP. Changes in globe deformations were quantified using automated algorithm that captures the 3D morphology of the posterior hemisphere of the globe to overcome the limited sensitivity of previously used subjective assessments by visual inspection. Postflight increases in globe flattening and nerve protrusion were tested for associations with changes in orbital and ventricular CSF volumes, and brain

tissue vascular fluid volumes. **RESULTS:** Compared to short-duration astronauts, long-duration astronauts had significantly greater post-flight increases in globe flattening ($p < 0.00001$) and optic nerve protrusion indices ($p < 0.00001$). Long-duration astronauts also had significantly greater increases in orbital ($p = 0.005$) and ventricular CSF volumes ($p < 0.05$). There were no significant post-flight changes in brain grey or white matter volumes in either group. The large post spaceflight ocular change observed in the ISS crewmembers were associated with greater increases in orbital and intracranial CSF volume but not with interstitial brain tissue fluid volume. **DISCUSSION:** The strong positive associations between globe deformations and CSF volume increases and the lack of increase in brain vascular tissue volumes imply that CSF has a greater role than the intracranial vascular fluid shift in spaceflight induced ocular changes. While association does not imply causality, it is reasonable to conclude that the increased orbital CSF space behind the eye compresses the posterior pole of the globe and causes the deformations observed in VIIP.

Learning Objectives:

1. Introduce a novel method for automated quantitation of the globe deformation occurring in astronauts who experience VIIP syndrome.
2. Learn about the relative contributions of the CSF and vascular systems to the ocular structural changes observed in VIIP.

[253] MODELING THE RISK OF SYMPTOMATIC RENAL STONE EVENT DURING SPACEFLIGHT

E. Kerstman^{1,2} and D. Reyes^{1,2}

¹Johnson Spaceflight Center, NASA, Houston, TX; ²Aerospace Medicine, University of Texas Medical Branch at Galveston, Galveston, TX

INTRODUCTION: Determining the probability of symptomatic renal stone events during spaceflight is crucial to mitigate health and mission risks. Quantitative modeling methods can be used to bound medical risks for the individual and for the mission. **METHODS:** The NASA Integrated Medical Evidence Database (iMED) was used to estimate the risk of symptomatic renal stone events in crews spending 21 days to 36 months in space. Renal stone incidence from the literature was combined with astronaut health data using a Bayesian analysis to give the incidence of renal stone events. This information was convolved with mission length to provide probability data for different length missions. **RESULTS:** The overall incidence of renal stone events from the iMED (IMM Data Request D-20150911-334) is 0.00365 events per person year, or about 3.6% over 10 years, which is comparable to the observed rate in U.S. astronauts and commercial aviation pilots. For a 21-day Lunar sortie the probability of renal stone event was 0.021% (95% CI, 0.017 – 0.026), for a six month ISS mission 0.182% (0.149 – 0.222), and for a 3 year Mars mission 1.090% (0.887 – 1.320). **DISCUSSION:** Modelling the incidence of medical events provides a quantitative base to inform decisions about screening, management and mission medical planning for renal stones and other medical events during spaceflight.

Learning Objectives:

1. Bayesian and other modeling methods can be used to help bound risks of potentially rare medical events during spaceflight.

[254] DEVELOPMENT OF ULTRASONIC TECHNOLOGIES FOR MANAGEMENT OF KIDNEY STONES IN SPACEFLIGHT

J.C. Simon¹, B. Dunmire¹, B.W. Cunitz¹, O.A. Sapozhnikov^{1,2}, A. Maxwell^{1,3}, W. Kreider¹, J. Thiel⁴, Y. Wang¹, H. Wessells³, K. Janssen⁵, J. Ahn³ and M.R. Bailey^{1,3}

¹Center for Industrial and Medical Ultrasound/Applied Physics Lab, University of Washington, Seattle, WA; ²Department of Acoustics, Moscow State University, Moscow, Russian Federation; ³Department of Urology, University of Washington, Seattle, WA; ⁴Department of Radiology, University of Washington, Seattle, WA; ⁵Department of Urology, Madigan Army Medical Center, Tacoma, WA

INTRODUCTION: Bone demineralization, dehydration, and stasis put astronauts at an increased risk of forming kidney stones, but current Earth-based technologies to detect and treat kidney stones are unsuitable for space. Our team is developing novel ultrasonic technologies for the management of kidney stones in flight. **METHODS:** Using a flexible ultrasound system, ultrasound imaging parameters were modified to enhance the appearance of kidney stones with S-mode™, including utilization of the color Doppler ultrasound twinkling artifact

which highlights the stone with rapidly changing color. Approved first-in-human clinical trials of ultrasonic propulsion (UP™) to reposition kidney stones were successfully completed with a commercial Philips/ATL C5-2 transducer. Since then, improvements have been made to the system including increasing the intensity of the commercial transducer and the use of a new, lower frequency transducer. In approved swine, burst wave lithotripsy (BWL™) is in development to safely fracture kidney stones into passable fragments using short, low frequency bursts of ultrasound. **RESULTS:** With the imaging modifications, stone size error between S-mode™ ultrasound and computed tomography (CT) in human subjects is <1 mm (95% confidence). Twinkling increases the specificity in stone detection with ultrasound and evidence supports a mechanism related to micron-sized crevice bubbles trapped on the stone surface. Preliminary approved studies in swine have shown that twinkling is significantly reduced by exposure to the elevated levels of carbon dioxide found on the International Space Station. In the first-in-human clinical trial, UP™ successfully moved 65% of stones and has since been implemented on NASA's flexible ultrasound system. Improvements to the technology, i.e., increased power and push duration and lower frequency transducer, has resulted in an 80% increase in stone repositioning in a phantom model. Finally, BWL™ has been shown to efficiently fractionate bladder stones in swine irrespective of exposure to elevated levels of carbon dioxide. **DISCUSSION:** These ultrasonic technologies form a single system for the complete management of kidney stones from diagnosis through treatment that is available for both spaceflight and the 3 million Americans who seek treatment for kidney stones annually. [Work supported by the National Space Biomedical Research Institute through NASA NCC 9-58 and NIH NIDDK grants DK043881 and DK104854].

Learning Objectives:

1. Develop an understanding of the role of ultrasound in the detection and treatment of urinary stones.

[255] VIIP 2017 CLINICAL UPDATE

B. Tarver

NASA-JSC, Houston, TX

INTRODUCTION: NASA's space medicine community knowledge regarding "Vision Impairment Intracranial Pressure", or VIIP, has been evolving over time. Various measures of occupational health related to this condition had to be determined and then plans/processes put into place in order to monitor this syndrome. The most robust of these processes were initiated in 2010. This presentation will provide a current clinical update of the astronaut occupational health data related to VIIP. **METHODS:** NASA and its international partners require their astronauts to undergo routine health measures which have been deemed important to monitoring VIIP. There is concern that the spaceflight environment aboard ISS could cause some astronauts to have physiologic changes detrimental to either ongoing mission operations or long-term health related to the ocular system and possibly the CNS. Specific medical tests include but are not limited to brain/orbit MRI (NASA unique protocol), OCT, fundoscopy and ocular ultrasound. Measures are taken prior to spaceflight, in-flight and post-flight. Measures to be reported include incidence of disc edema, globe flattening, choroidal folds, cotton wool spots, optic nerve sheath diameter (ONSD) and change in refractive error. **RESULTS:** 73 ISS astronauts have been evaluated at least partially for VIIP related measures. Of these individuals, approximately 1 in 7 have experienced disc edema. The prevalence of the other findings is more complicated as the medical testing has changed over time. Another confounding factor is most of the astronauts have prior spaceflight experience at the time of the "pre-flight" testing. Overall, 26 separate individuals (35% of total) have experienced at least one of the findings NASA has associated with VIIP. **DISCUSSION:** In 2010 NASA and its US operating segment (USOS) partners (CSA, ESA and JAXA) began routine occupational monitoring and data collection for most VIIP related changes. Interpretation of that data is extremely challenging for several reasons. Current clinical data will be presented along with some limitations of data interpretation. Historically, we've reported data per eye and not necessarily per person. This has led to difficulty in understanding how many individuals have experienced "VIIP" within the aerospace medicine community. The presenter will attempt to provide clear and concise communication of VIIP findings.

Learning Objectives:

1. Understand the changes within the astronaut visual system that are being monitored and how they change during and after an ISS mission.
2. Appreciate the novel nature of VIIP related changes and the challenges of "treating" the syndrome.
3. Recognize the current likely mechanisms at work within the human system that could result in a greater expression of VIIP related findings.

[256] TISSUE-ENGINEERING IN SPACE AND IMPLICATIONS FOR FUTURE SPACE SURGEONS

P. Lee

Surgery, The Ohio State University Wexner Medical Center, Columbus, OH

INTRODUCTION: Recent advances in tissue-engineering (TE) are allowing for the production of more *in vivo*-like tissues with greater applications to medicine and scientific research. These tissue-engineered constructs have applications to the space program as biological replacement tissue, a protein delivery platform, and an *in vitro* model for studying the effects of spaceflight on tissues. Additionally, it may be possible to take advantage of the microgravity environment of space to improve the TE process. The use of these constructs as potential replacement tissue also has clear implications for surgery in space. **METHODS:** A systematic and comprehensive search of the scientific literature was carried out to identify published studies and papers pertaining to TE topics that may have relevance to the space program. These studies were reviewed and organized to provide a current view of the state of the technology and their potential future applications to the space program. **RESULTS:** Many different tissue types are currently being tissue-engineered. However, there are still many limitations to current TE technologies, including smaller absolute and specific forces, lack of vascularization, limited scale-up and *in vitro* longevity, immature forms of the tissues, and a limited ability to create complex tissues. However, there are theoretical advantages to TE in a microgravity environment and the International Space Station now provides scientists with a unique opportunity to take advantage of this environment for research and manufacturing purposes. In addition to the advantages of TE in space, tissue-engineered constructs may have several applications for space missions as well. They can potentially serve as replacement tissues for astronauts. Especially with the advent of recent 3D bioprinting technologies, it may be possible create needed tissues on-demand. Such tissues may be invaluable for future space physicians and surgeons who may need them during a space mission. Additionally, tissue-engineered constructs can serve as an *in vitro* model to efficiently study the effects of spaceflight on various tissues. Finally, these tissues also have the potential to serve as an implantable platform for sustained systemic delivery of therapeutic proteins. **DISCUSSION:** Recent advances in the field of TE have emerging applications to the space program. Continued research and development in this area will undoubtedly lead to many new and exciting opportunities.

Learning Objectives:

1. To understand the applications of tissue-engineered constructs.
2. To understand current limitations of tissue-engineering and potential ways to overcome them.
3. To understand how tissue-engineering applies to the space program, including surgery in space.

Wednesday, May 03
Governor's Square 14

8:30 AM

S-054: SLIDE: HUMAN FACTORS IN AVIATION PROTECTION, SAFETY, & SURVIVABILITY

Chair: Jeffrey Jones
Houston, TX

Co-Chair: Philippe Souvestre
Vancouver, British Columbia, Canada

[257] FREQUENCY OF HELICOPTER UNDERWATER EGRESS REFRESHER TRAINING (HUET) BASED ON SELF-ASSESSED COMPETENCES

P. Valk¹, E. Oprins¹, C. Bottenheft¹, B. Koolen² and T. Meeuwse²
¹TNO, Soesterberg, Netherlands; ²RNLAF, Soesterberg, Netherlands

INTRODUCTION: RNLAF Helicopter aircrew get Helicopter Underwater Egress Training (HUET) in a water basin using a Modular Egress Training Simulator (METS™) in order to be prepared for escaping the aircraft when ditching involuntarily into the water. The frequency of this refresher course (yearly or every 3 years) depends on the type of flying population (e.g. pilots, load masters, aeromedical personnel, etc.), and the content is not evidence based since these type of accidents hardly occur. Ideally, training should be based on the amount of 'retention' of acquired competence. Self-confidence in being prepared for these emergencies also play an important role. HUET is experienced as quite stressful because skills have to be practiced underwater. This study investigates how often the refresher training should be provided according to helicopter aircrew, based on self-assessed retention of competence, and how stress affects these experiences.

METHODS: Helicopter aircrew (57 pilots, 37 others) filled out a questionnaire on how often refresher training should take place. They also assessed themselves on acquired competence, split up into HUET-specific knowledge and skills, and evaluated the set-up and content of the HUET courses. **RESULTS:** Most respondents indicated that the first refresher course should already take place after a year but the frequency should decrease over the next years (e.g. once in 2 or 3 years). This is different from current practice with equal time intervals. Participants that failed the course indicated that training should be significantly less frequent. This finding was negatively affected by feelings of stress.

CONCLUSION: According to helicopter aircrew, the frequency of HUET refresher courses should be reconsidered for the different populations (pilots, loadmasters, medics, etc.). Failing the course and feelings of stress are negatively correlated with the preferred training frequency. We did not demonstrate a relationship between training frequency and self-rated retention of acquired competence. We recommend to perform a longitudinal study to investigate competence assessed by HUET instructors as well as self-ratings by helicopter aircrew during repeated HUET courses. We recommend to pay attention to stress reduction during the course since this hampers performance and self-confidence.

Learning Objectives:

1. To explain the dynamics of retention of theoretical knowledge and skilled behavior.
2. To demonstrate the learning issues in an applied refresher training setting.
3. To show the impact of stress related factors in a training environment.

[258] IMPROVED RESTRAINT AND ESCAPE FOR REAR CREW: THE INTEGRATED TORSO HARNESS, A UK MILITARY PERSPECTIVE

B. Posselt and N. Simpson

Aircrew Equipment Integration Group, Royal Air Force, Centre of Aviation Medicine, RAF Henlow, Hitchin, United Kingdom

MOTIVATION: The military has suffered fatalities in the past as a result of personnel falling from aircraft. The use of body armour systems has altered the way in which the historical dispatcher's harness belt can be worn, forcing them lower down over the pelvis. This, combined with increased torso mass can result in inversion of the individual in the event of a fall from the aircraft. There is also the real risk of slipping from the harness. Therefore, an adapted, more effective and protective restraint system is sought by the Ministry of Defence (MOD). **OVERVIEW:** The torso harness is integrated into the fitted body armour, providing all over torso support and restraint. Three subjects representing the 5th, 50th and 95th percentile range of aircrew trialled the new equipment, using the current dispatchers harness for comparison. Each subject was assessed using the Defence Standard 05-134, to include objective assessment of ability to perform work station manoeuvres in a Lynx airframe, suspension from a hoist, simulating a fall from an aircraft, as well as emergency quick release. All subjects were able to conduct limited representative workstation manoeuvres, whilst restrained by a floor mounted anchor

point. When suspended by the hoist, subjects felt supported wearing the torso harness and remained in an upright position. Activation of the release handle allowed swift disconnection via the three ring circus and tail unit. In contrast, when suspended by the dispatchers harness, all subjects rotated to a head down position. This caused pain over the pelvis and lower abdomen and even difficulty in breathing. Release from the harness in this position was difficult, with some subjects unable to disconnect at all. Under tension, a large gap appeared between the belt and subject, allowing considerable movement, with significant risk of slipping from the harness completely. **SIGNIFICANCE:** The torso harness is due to be rolled out and integrated to specific military aircraft platforms. It will provide an improved supportive restraint system and maintain the individual in an upright position in the event of suspension, enabling an attempt at self-recovery. In addition the three ring circus release enables a swift disconnection in the event of an emergency.

Learning Objectives:

1. To consider the requirements for restraint in rear crew on a military platform; to understand how these can impact flight safety and how they can be met with improvements in restraint equipment.

[259] ASSESSING GENERAL AVIATION PILOTS' KNOWLEDGE OF AVIATION WEATHER

Y. Ortiz¹, B. Blickensderfer¹, J. Lanicci², J.M. King¹, T.A. Guinn², R. Thomas³, J.K. Cruitt¹ and A. Jennis¹

¹Human Factors and Systems, Embry-Riddle Aeronautical University, Daytona Beach, FL; ²Applied Aviation Science, Embry-Riddle Aeronautical University, Daytona Beach, FL; ³Aeronautical Science, Embry-Riddle Aeronautical University, Daytona Beach, FL

INTRODUCTION: FAA and NTSB analyses revealed two-thirds of weather-related General Aviation (GA) accidents resulted in at least one fatality. A possible risk factor may be insufficient weather knowledge among GA pilots. From weather phenomena and its impact on pilot and aircraft performance to aviation weather hazard products (e.g., forecasts) and weather information displays, GA pilots may lack sufficient knowledge in interpreting, predicting, and utilizing the weather data available. Therefore, the purpose of this study was to assess GA pilots' overall weather knowledge. **METHODS:** A team of meteorologists, human factors specialists, and a flight instructor developed 113 multiple choice questions covering topics in the FAA AC-0045G and related material. The topics included aviation weather phenomena (e.g., thunderstorms), weather hazard products, and weather hazard product sources (e.g., Aviation Weather Center). Seventy-nine pilots (ranging from Student to Commercial; $Mdn_{flight\ hours} = 120$; $M_{age} = 20.62$) from a southeastern university completed the assessment. **RESULTS:** A 3 x 3 mixed analysis of variance was conducted to assess the impact of pilot certificate/rating (Student, Private, Instrument) and category of knowledge (Weather Phenomena, Weather Hazard Products, Weather Product Sources) on percentage correct. A main effect of pilot rating occurred ($F(2, 76) = 9.79, p < .01$, partial $\eta^2 = .21$). Specifically, pilots with instrument ratings scored higher ($M = 75.11$) than non-instrument pilots ($M_{Student} = 62.33$; $M_{Private} = 67.17$). There was also a main effect for knowledge category (Wilks' $\Lambda = .63, F(2, 75) = 21.75, p < .01$, partial $\eta^2 = .37$). Pilots scored higher on product sources ($M = 78.21$) than they did on weather products ($M = 68.02$), and the lowest scores were on weather phenomena concepts ($M = 61.86$). Additional analyses indicated that pilots have lower scores when interpreting weather hazard products such as surface weather information, satellite data, and weather radar. In contrast, pilots had higher scores on knowledge of approved weather product sources. **DISCUSSION:** The moderate knowledge scores may indicate knowledge gaps, and may be a contributing factor to the GA weather-related accident rate. Further assessments are needed to identify all potential aviation weather knowledge gaps, as well as possible training gaps in these areas. To improve GA safety, the next step may be filling any gaps through pilot training and other methods.

Learning Objectives:

1. The audience will learn that general aviation pilots scored the lowest on Weather Phenomena and Weather Hazard products, and the highest on Weather Hazard Product Sources.
2. The audience will learn that Instrument rated pilots scored higher across all three categories of aviation weather knowledge than non-instrument pilots.

[260] INATTENTIONAL BLINDNESS A SIGNIFICANT FACTOR CONTRIBUTING TO AN AIRLINE CRASH, A CASE STUDY

W.V. DeHaan

Flying Physicians Assn., Boulder, CO

PROBLEM STATEMENT: This case report describes how both pilots of a flight crew failed to see multiple visual cues that were well within their field of view. **BACKGROUND:** During certain phases of a ground and flight operation, professional flight crews are required to abstain from non-pertinent conversation (the "sterile cockpit") in order to avoid being distracted from the tasks at hand. This requirement is not always complied with. This crash exemplifies the potential tragic consequences of normalization of deviation and how a deficiency of mental and visual-perceptual attention resulted in the loss of 49 lives. **CASE PRESENTATION:** In a condition of darkness, the captain and first officer of a commuter airliner were given taxi instructions to the only lighted, night-use runway. Transcripts of multiple communications with the local controller and with each other strongly support a belief that they understood the number-identification of the runway to which they were cleared to taxi for takeoff. Regardless, they taxied onto the only other runway at the airport, which had a different number-identification. They then attempted a takeoff even though the runway was a day-use-only, unlighted runway of insufficient length, and crashed off the far end. There was a long list of conspicuous visual cues which, if they had "seen" (visually perceived) even one or two of them, would have precluded them from making their mistake. **OPERATIONAL RELEVANCE:** This case highlights how complacency can develop due to normalization of deviations. It is no doubt tempting (and likely prevalent) to deviate from the sterile cockpit requirement and become involved in social conversation when performing routine (and boring?) checklists and procedures over and over. Such non-pertinent conversation can become the norm, since it rarely ever leads to unfortunate results. This case illustrates the need for a means to identify non-compliance, and to put in place a method that requires the flight crew to observe and identify visual cues that are essential for safe operation.

Learning Objectives:

1. A plethora of images fall on our retinas in rapid succession but our brain is not large enough to process all of that information. Therefore, we are selective as to what we consciously visually perceive. If our attention is distracted, we may miss important, conspicuous visual cues as if we were blind to them.

[261] A CASE OF POSSIBLE SPATIAL DISORIENTATION - ANALYSIS OF OPERATIONAL ASPECTS AND PREVENTIVE STRATEGIES

J. Sandvik¹, J.B. Stangnes¹, J. Mellem² and A. Wagstaff¹

¹Norwegian Armed Forces Medical Services, Institute of Aviation Medicine, Oslo, Norway; ²Advisory Staff, Accident Investigation Board Norway, Lillestrøm, Norway

PROBLEM STATEMENT: This case report describes possible spatial disorientation (SD) in a passenger airline incident during approach and the analysis of how the visual approach aids and operational procedures may be involved in creating spatial disorientation on one hand, and support preventive strategies on the other. **BACKGROUND/LITERATURE REVIEW:** Many aircraft accidents and incidents have been attributed, at least partially, to SD. Even though SD is more commonly reported in military operations and general aviation, SD has been involved in several passenger airline accidents. Training air crew in recovering from SD is important, however, preventing SD is key in order to reduce the number of accidents. **CASE PRESENTATION:** A DHC-8 was performing a visual circling approach to a short field airport in the North of Norway in the dark and gusty wind conditions with 38 people on board. The aircraft experienced a sudden loss of airspeed and altitude, and recovered only 83 ft above the sea. Although most likely not being the cause of the incident, an analysis showed that the pilot flying may have experienced a somatogravic illusion, and this may have complicated the situation and recovery. An analysis was performed to evaluate the safety of the airport approach and the operational procedures of the different phases of that approach, in terms of to what extent this could play a part in inducing

SD. OPERATIONAL RELEVANCE: The importance of spatial disorientation as a potential accident risk may be underestimated, especially in commercial airline operations. Typical situation where risk may arise include take-off, approach and go-around in visually challenging situations with little or no visible horizon. Passenger airline pilots should be taught more about SD, SD risk factors and participate in SD simulator training. An additional approach to reducing SD accidents may be evaluating and changing operational procedures, introducing other technology or visual or other approach aids.

Learning Objectives:

1. Give examples of possible methods of preventing spatial disorientation.

[262] IS THERE A RELATIONSHIP BETWEEN NECK RANGE OF MOVEMENT AND NECK PAIN IN FAST JET PILOTS?

J. Owen¹ and J. Sim²

¹RAF Valley, RAF, Holyhead, United Kingdom; ²SHAR, Keele University, Keele, United Kingdom

INTRODUCTION: Neck pain in fast jet pilots has been closely researched for many years, with most studies focussing on causative factors, prevention and possible management strategies. Whilst range of movement (ROM) is frequently used in this research and clinical practice, consensus is lacking on its prognostic importance. Accordingly, this study examined ROM as a predictor of neck pain. **METHODS:** Military aircrew, based on fast jet squadrons at RAF Valley were invited to join the study. Volunteers attended data collection sessions, where neck ROM was measured using the CROM device (Performance Attainment Associates, Minnesota). A questionnaire explored participant demographics, flying experience and current presence/absence of pain. This was a cross sectional study with no re-test or treatment intervention. Statistical analysis was by binary logistic regression analysis, with presence/absence of pain as the outcome variable. Ethical approval was granted from the Ministry of Defence Research Ethics Committee. **RESULTS:** 44 aircrew volunteered for the study. Eleven had pain at the time of testing and 33 were pain free. Seventeen (38.6%) reported flying up to 10 hours per week on average, with only three (6.8%) performing up to an average of 20 hours flying per week. Controlling for age, reduced movement in the sagittal plane (combined flexion/extension) was a significant predictor of pain (odds ratio = 0.870; $p=0.008$). Combined side flexion and combined rotation were non-significant predictors with $p=0.067$ and $p=0.839$ respectively. In a separate analysis, weekly flying hours (controlling for age) was also a non-significant predictor for pain ($p=0.619$). **DISCUSSION:** This study demonstrated a relationship between reduced neck ROM in the sagittal plane and the presence of pain. Other neck movements and weekly flying hours were not significantly associated with pain. It would be beneficial to replicate this study in a larger sample group (allowing more predictors to be examined), over a longer data collection period and across other flying stations. It is essential not only to treat and manage aircrew suffering with neck pain, but to gather information that will allow rehabilitation services to be more proactive in the prevention and early detection of potentially career limiting neck pain in fast jet aircrew.

Learning Objectives:

1. The participant will gain greater insight and understanding into the relationship between neck pain and neck ROM in fast jet pilots.

Wednesday, May 03
Governor's Square 15

8:30 AM

S-055: PANEL: COMPLEX PROBLEMS, NOVEL SOLUTIONS: JUNIOR AND FUTURE FLIGHT SURGEONS LEADING INNOVATION ACROSS THE UNITED STATES AIR FORCE

Chair: Kelly Laskoski
San Antonio, TX

Co-Chair: Paul Nelson
Maxwell AFB, AL

PANEL OVERVIEW: The diverse missions of aviators, special duty operators, and trainees across the United States Air Force present complex operational medicine problems. This panel features junior Flight Surgeons from various Air Force Bases (AFB) who will discuss how their flight medicine shop delivers innovative solutions to combat the diverse population of war fighters they care for. All solutions have one central theme: bringing medical services directly to their supported populations to increase the value of clinical services and to minimize lost performance and training. Our first presentation discusses a clinic wide standardized approach at Fairchild AFB in providing no-go pills to a flyer population with a high operations tempo, with the benefit of standardization not only seen by the clinic, but also by the patients themselves. Our second presentation focuses on the shortcomings of the Air Force's fitness-for-duty recommendations by providers across military treatment facilities, and proposes a novel automated tool that could screen medical encounters to cue generation of return to work recommendations in the Aeromedical Services Information Management System (ASIMS). Our third presentation offers a unique solution to treating the human weapons system being born out of Lackland AFB at the 350th Battlefield Airman Training Group. Termed the "Battle Clinic", an integrated fusion cell operates just steps away from their training grounds and gym with two athletic trainers, a physical therapist, two flight medicine physicians, and a sports medicine physician all working in concert to improve medical care and minimize lost training days. Our fourth presentation addresses heat stress and the effect it can have on pilots and air crew in a deployed environment, specifically at Al Udeid Air Base, and the recommendations to mitigate this risk to preserve cognitive performance. The fifth and final presentation features the methodical approach that Columbus AFB has taken to approach airsickness in its student pilot population as a means to not only improve performance, but to also to decrease attrition in this valuable training pipeline.

[263] A MODIFIED APPROACH TO FATIGUE COUNTERMEASURES AT FAIRCHILD AFB

J. Fisher

Unites States Air Force, Fairchild AFB, WA

MOTIVATION: Fatigue is a well-known risk in military aviation. Current operations tempo is very high, and pilots and boom operators at Fairchild AFB (FAFB) are deploying regularly across many time zones. Even routine local sorties are often at odds with normal circadian rhythms. No-go pills are often sought after by our aviators to combat fatigue—they can be a quick and easy solution. But are aviators truly exhausting all other countermeasures? This presentation will address new policies and procedures implemented by Fairchild AFB Flight Medicine aimed to better educate and equip our aviators to combat fatigue, including judicious use of no-go pills. **OVERVIEW:** Over the past few years the no-go process at FAFB has been variable and provider dependent. This creates the potential for 'doctor shopping.' While no-go pills can certainly be effective, there is also the risk of overuse and potential dependency in these controlled substances. There are certainly flying requirements where no-go pills would be effective and safe. On the other hand, there are also many instances when they are clearly not needed or even contraindicated. In considering no-go pills, the specifics of an aviator's mission may be unknown, overlooked, or perhaps even misrepresented. In an effort to clarify the process and accurately identify appropriate usage, we have implemented a new no-go request form starting October 2016 that is emailed to all flight surgeons and requires specific mission details (take-off time, crew rest, length of sortie, etc.). The 'on-call' flight surgeon for that day is then responsible for determining the validity of the request and prescribing the medication. This is sent back to the requestor and CC'd to all flight surgeons for transparency. Additionally, we are providing fatigue briefings to individual squadrons that focus on countermeasures other than no-go pills. **SIGNIFICANCE:** This new process aims to limit unnecessary use of no-go pills as well as improve clinic efficiency. The use of this electronic form eliminates previous accepted protocol of 'walk-in' and telephone requests which can be disruptive to scheduled patient care. By removing the need for face to face encounters it also keeps appointment slots open for other patients. Additionally, with better and frequent education from the base flight surgeons and physiologists we hope to reduce reliance on no-go pills.

Learning Objectives:

1. How to create a clinic-wide standardized approach to providing no-go pills to a flyer population with a high operations tempo.

[264] MEDICAL READINESS SURVEILLANCE: USING AN AUTOMATED TOOL TO ASSIST WITH PROFILE GENERATION AND SCREENING

C. Uptegraft and C. Witkop

Uniformed Services University of the Health Sciences, U.S. Air Force, Bethesda, MD

MOTIVATION: An audit across multiple medical treatment facilities in the Air Force Medical Service revealed significant shortcomings in how Air Force (AF) primary care managers (PCMs) apply fitness-for-duty standards. Only 47% of all clinical encounters were found to have complete, accurate occupational dispositions. Without accurate dispositions, the providers cannot reliably supply line commanders with medically ready Airmen.

OVERVIEW: After assigning a clinical diagnosis to patients in the electronic health record, PCMs determine whether this diagnosis affects the service member's (SM's) ability to perform her/his job duties, fully complete the AF fitness test, and/or deploy. These restrictions must be coded separately within the Aeromedical Services Information Management System (ASIMS) as an AF Form 469 or "profile". Failure to enter a correct profile within ASIMS results in inaccurate readiness statistics and inappropriate or missing performance limitations, increasing the potential for medically unsafe work conditions, fitness tests, and deployments. Multiple potential reasons for failure exist. Associating diagnoses with a patient's occupation is not a focus of primary care residencies, and non-flight-surgeon PCMs never receive any official occupational or preventive medicine training. Current information systems also offer minimal decision-support to assist with profile creation thereby allowing a significant contribution from human error. MDGuidelines, however, offers evidence-based return-to-work (RtW) recommendations by International Classification of Disease code, age, gender, and job class. Using clinical encounter data from the MHS Mart database and relating job-class categories from MDGuidelines to a patient's AF Specialty Code, a Medical Readiness Surveillance Tool (MRST) could identify SMs that may need a profile. This presentation will showcase a prototype MRST that uses MDGuidelines and clinical encounter data and discuss its potential benefit for Aerospace Medicine. **SIGNIFICANCE:** An automated tool that could screen medical encounters and ASIMS for missing or inaccurate occupational dispositions and give providers RtW recommendations at the end of clinical encounters would fill a much needed gap in AF Aerospace Medicine. Cues for profile generation with real-time recommendations would greatly improve the accuracy of medical readiness numbers and the overall job performance of SMs.

Learning Objectives:

1. To demonstrate the application of surveillance principles to medical readiness.

[265] MITIGATING OPERATIONAL RISK RELATED TO HEAT STRESS AT AL UDEID AIR BASE

M.J. Chiappone

U.S. Air Force, Andrews AFB, MD

MOTIVATION: Exposure to extreme heat is common at Al Udeid Air Base (AUAB) and most other installations within the U.S. Central Command (CENTCOM) Area of Responsibility (AOR). Furthermore, several USAF airframes currently in operation have poor or no built-in air conditioning system prior to engine start or takeoff, potentially leaving crews exposed to high temperatures for 60-90 minutes, or longer. Several studies, mostly in the fields of sports medicine and human physiology, have shown a decrease in cognitive performance with exposure to extreme environmental conditions, including heat. Our goals at AUAB were to identify whether similar performance degradations can be seen in aircrew working in extreme temperatures. **OVERVIEW:** In the first phase of the survey during June 2016, sixteen volunteers were recruited from the 340th Expeditionary Air Refueling Squadron and the 379th Expeditionary Medical Group to complete two simple cognitive tests, reaction time and Serial 7's, before and at 30 and 60 minutes of exposure to the high temperatures in a KC-135 or B-52. The aircraft were in configurations that crews could be expected to operate and ambient temperature readings were obtained while volunteers simulated a

typical preflight sequence. Both dry and Wet Bulb Globe Temperatures (WBGT) were measured. Temperature measurements up to 132.7°F (WBGT: 110.8°F) were obtained in the cargo compartment of the KC-135 and measurements of 130.3°F (WBGT: 102.1°F) were obtained in the cockpit of the B-52. With a small sample size, reaction time was not found to be significantly different after heat exposure, nor were the number of errors made on Serial 7 testing in the B-52. However, on the KC-135 (n=11), a total of 2 errors were made prior to heat exposure, compared to 4 errors at 30 minutes of exposure and 8 errors after 60 minutes. **SIGNIFICANCE:** While the sample size used in this heat survey was too small to demonstrate a significant degradation in cognitive performance, the WBGT measurement on each aircraft was significantly higher than the accepted level for Black Flag work conditions (>90°F). This is a concerning threat to operational safety and should be evaluated further with a larger sample population. We recommended that immediate steps be taken to minimize aircrew exposure to extreme heat. This presentation will discuss real-world strategies for mitigation of heat stress in a high ops-tempo environment.

Learning Objectives:

1. To understand the affect that heat stress can have on pilots and air crew in a deployed environment.

[266] APPROACH TO AIRSICKNESS AT AN UNDERGRADUATE PILOT TRAINING BASE

K.R. Taylor and Z. Powers

Flight Medicine, 14th Medical Group, USAF, Columbus, MS

MOTIVATION: In the last year, the Columbus Air Force Base (AFB) Flight Medicine clinic had over 250 medical encounters for airsickness. This represents a major cause of performance decrement in the student pilot population, and is either causal or a contributing factor in a large percentage of attrition in this population. For such a common complaint, we still do not have a standard Air Force approach to addressing airsickness in a student pilot population. **OVERVIEW:** This presentation will review the medical literature on airsickness, comparing approaches across military services and across student training bases. We will then present the standardized approach for student pilots at Columbus AFB with our rationale for using this approach. This model has evolved locally based upon Flight Surgeon preference over many generations of student pilots and flight surgeons, a situation likely similar to other pilot training populations. We will compare our practice to the literature and standard practices elsewhere, identifying gaps in our current evidence based knowledge. These gaps could be addressed through further research and study proposals to allow a systematic evidence based approach to airsickness applied to the military student pilot population.

SIGNIFICANCE: Airsickness is one of the most common causes of both performance degradation and attrition in the student pilot population. Our responsibility as base level Flight Surgeons supporting this flying population is to identify the best evidence based approaches to this problem, and seek to better fill gaps in our knowledge where they exist.

Learning Objectives:

1. To understand that the approach to airsickness in a student pilot population is important as a means to not only improve performance, but to also to decrease attrition.

[267] BATTLE CLINIC: AN INTEGRATED FUSION CELL DESIGNED TO OPTIMIZE CARE OF THE HUMAN WEAPONS SYSTEM

K. Laskoski

U.S. Air Force, San Antonio, TX

MOTIVATION: A unique elite human weapons system is carefully being crafted each day at Lackland Air Force Base (AFB) within the newly instituted Battle Clinic to support the 350th Battlefield Airmen Training Group. For the first time in U.S. military history, the Air Force activated a unit solely dedicated to train the service's ground component, encompassing the training for Pararescue, Tactical Air Control Party, Combat Control Team, and Special Operations Weather Team. These warriors in turn require careful coordinated care throughout this rigorous pipeline in order to return them quickly to training with minimal lost training days. **OVERVIEW:** Termed the "Battle Clinic", an integrated fusion cell operates just steps away from the main Battle Gym with two athletic trainers, a physical therapist, two flight medicine physicians, and a sports medicine physician all working in concert to improve medical care for

these unique Airman. This team not only aims to treat physical training injuries at the outset, but also to prevent injuries from occurring by instituting rehab early and as often as they need it. The Battle Clinic is a growing living entity that began in a small storage room adjacent to the Battle Gym, and has since moved to an area with greater capabilities and advance technology for ready use. This 'embedded' approach to care has grown to encompass much more than what was originally envisioned. **SIGNIFICANCE:** Comprehensive, synergistic medical care at the Battle Clinic is helping produce elite, combat-ready Airmen, all while striving to minimize lost training days. Much like in sports medicine and professional sports, when a player gets injured or needs care, the athlete is treated with a team approach and resources are leveraged to ensure a swift recovery. This has proven to be essential in this training pipeline wherein there is only a short 60-day window that is allowed for students to be out of training.

Learning Objectives:

1. To understand the need for multidisciplinary embedded medical care for combat Airman.

Wednesday, May 03
Governor's Square 12

8:30 AM

S-056: PANEL: HARMONIZATION IN AEROMEDICAL ASSESSMENT: PERSPECTIVES FROM THE EUROPEAN CMOS' FORUM

Chair: Sally Evans

Gatwick, West Sussex, United Kingdom

Co-Chair: Francisco Rios-Tejada

Madrid, Spain

PANEL OVERVIEW: Overview of European organization and framework under the umbrella of the European Aviation Safety Agency (EASA), including CMO Forum, NAAs of Member States, National structures, regulatory procedures and role of AME with responsibilities and oversight. Future Trends and challenges.

[268] EUROPE AEROMEDICAL ASSESSMENT: CMO FORUM PERSPECTIVE

F. Rios-Tejada¹ and S. Evans²

¹CMO, AESA, Madrid, Spain; ²Medical, UK Civil Aviation Authority, Gatwick, United Kingdom

PANEL OVERVIEW: This Panel is presenting a general and update view of the European Management of Aircrews, throughout the integration of National Bodies into a wider paneuropean organization (EASA), in order to understand the organizational framework of Aviation Medicine in Europe. First presentation, explain the European organization, role of National Aviation Authorities (NAAs) of member states, role of AMEs, national structures and general regulatory procedures. In the second presentation, it is presented how EASA propose implementing rules in the field of Aviation, including Aviation Medicine, certify & approve products and organizations, in fields where EASA has exclusive competence, provide oversight and support to Member States, promote the use of European and worldwide standards and cooperate with international actors in order to achieve the highest safety level for EU citizens. In the third presentation, we review the regulatory framework for aircrew and ATCOs, the Implementing Rules, Acceptable Means of Compliance (AMC), Alternative AMCs and Guidance Material. In the fourth presentation, it is described future trends, challenges and perspectives by reviewing the most relevant organizational, procedural, operational and medical issues raised, and the future impact over aircrews, EASA States and national authorities. Finally, the fifth presentation will discuss the most current issues under discussion among EASA States and provide knowledge of the way to implement different approaches in order to address such already identified aeromedical problems, related among others issues, to specific clinical evaluation, emerging air technologies, safety risk management and AME education and instruction.

Learning Objectives:

1. To introduce the audience to the European Organization and System responsible for the safe management of air operations and discuss the main aeromedical topics currently under discussion among EASA States.

[269] MEDICAL CERTIFICATORY REGULATION OF FLIGHT CREW AND ATCOS IN EUROPE

D. Maher¹ and R. Vermeiren²

¹Medical, Irish Aviation authority, Dublin, Ireland; ²Medical, Eurocontrol, Brussels, Belgium

INTRODUCTION: European medical certification has grown from individual national standards, through Joint Aviation Regulations to FCL Part-MED which is empowered by European Law and also for medical certification of ATCOS in Europe. From a wide variety of national rules we have gone to an obligatory pan-European medical certification system under EASA. A new paradigm in the medical certificatory regulation of Flight Crew and ATCOS has been rolled out in the member states of the European Aviation Safety Agency, from prescriptive to performance, or risk based regulation. **OUTLINE:** In Europe, the medical certification of flight crew is regulated by the FCL Part-MED regulation, empowered by European Law superseding National Law and adopted by member states, which is overseen by the European Aviation Safety Agency. The move from prescriptive to performance and risk based regulation has enabled regulators to respond to current medical and best aeromedical practice. This has generated both a steep learning curve and a threat of loss of harmonization. In 1999 a rulemaking group of EURONTRON was created to establish common medical standards for Europe, published in 2002, updated in 2006 and from then, on EASA took progressively over, first by enforcing the EUROCONTROL rules, then by setting up an own rulemaking task which embedded the EURONTRON content into a European Union legislative framework, including the rules for medical certification class 3 ATCO which follow the same structure as very similar medical criteria than commercial class 1 pilots. **SIGNIFICANCE:** The implementation of the Part-MED FCL and ATCO Regulation has created a dynamic evolving regulation. It has teetered on the cliff of disharmony but has moved towards a new level of standardization employing new and existing fora. It is expected that these measures will result in improved, appropriate and risk based regulation that will enhance safety in aviation across Europe and beyond, and also guarantee of an equal safety level and free movement to work all over Europe.

Learning Objectives:

1. Performance/risk based regulation, Regulatory evolution, International debate and resolution, Local Implementation.

[270] CURRENT ISSUES FOR THE NAAS OF EASA MEMBER STATES

F. Torchia¹ and A. Furia²

¹Medical, Italian Air Force, Rome, Italy; ²Medical, ENAC, CAA Italy, Rome, Italy

MOTIVATION: Different approaches in addressing some aeromedical topics are currently under discussion among EASA States, regarding aircrew clinical evaluation, emerging air and medical technologies, role of Occupational Medicine specialist (OHMP) in aviation medicine and safety management of future commercial space operations. **OVERVIEW AND SIGNIFICANCE:** Aircrew mental health assessment. EU 1178/2011 Aircrew Regulation will be soon updated and, among other issues, will include recommendations issued by the Germanwings accident Task Force, especially in the field of aircrews' Mental Health assessment, a new definition which will include both Psychiatry and Psychology, hopefully allowing a broader understanding and management of the mental status of the aircrew. New provisions for mental assessment of the airmen at initial selection and before entering the flight line will be drafted into the Regulation, together with new provisions regarding enhanced AMEs' competences in assessing the mental health status of an applicant. Emerging air technologies. RPAS operators' medical certification became recently an issue for the enormous increasing of the RPAS industry. Italian CAA, in harmonization with EASA rules, disciplined the different types of RPAS and the related medical certificates required, giving the AMEs full

autonomy for the certification of the applicants in case of a medical certificate limited to RPAS operations only (i.e. insulin dependent type 2 diabetes and RPAS ops). Cooperation between AME and Occupational Medicine specialist (OHMP). EASA Aircrew Regulation allows OHMP to certify Cabin Crew fitness under certain requirements and if experienced in aviation medicine. Not every EASA States enforced this possibility. In the future, it could be useful a closest cooperation between AMEs and OHMP, under NAA supervision, especially those enforcing medical surveillance in commercial airlines. Commercial space policy. Italian CAA has issued a Regulatory Policy for the prospective commercial space transportation certification and operations in Italy, following an MoC with FAA and with the support of the Italian Air Force. The aim is to set up EU and EASA legal and regulatory framework to operate future space commercial operations in a European environment.

Learning Objectives:

1. To introduce the audience to some aeromedical topics currently under discussion among EASA States and be aware of the way to implement different approaches in order to address such already identified aeromedical problems.

[271] EUROPE: HARMONISATION, CHALLENGES AND PERSPECTIVES

D. Lemming¹ and S. Mitchell²

¹Medical, Aviation & Maritime Transport, Norrköping, Sweden;

²Medical, UK CAA, London, United Kingdom

In the late 1990's the Aviation Authorities of Europe came together to agree a harmonized set of operational, licensing and medical rules to which each of the member states would adhere. These came to be known as the "JARs" comprising JAR-Ops, JAR-FCL-1 & -2 (Licensing for Airplanes and Helicopters) and JAR-FCL-3 (medical). States agreed to mutually recognize medical certificates without further enquiry. Medical standards were proposed and agreed by a panel of medical experts comprising representatives from National Authorities and Industry. In order to ensure harmonized implementation, an inspection/oversight scheme was set up to visit NAAs to check compliance. These Medical Standardization Teams were comprised of medical inspectors from the central JAA administration and NAA Medical Assessors. What were not harmonized by the JAA were systems of record keeping and oversight of AMEs. The EU regulations developed by an executive agency (European Aviation Safety Agency, EASA) were implemented in 2011/2012. The regulations go further towards harmonization of medical application and decision processes and how states are expected to perform oversight of license holders and AMEs. Compared to the situation under the JARs more responsibility is allocated to the AME and aeromedical guidelines are necessary. Use of paper and electronic medical records systems continue with some harmonization, principally due to a single supplier of suitable medical records systems. States still struggle with oversight of 'foreign' medicals and transfers of medical records between states. The 'informal' network of Chief Medical Officers of the European Authorities facilitates case and policy discussion. In the aftermath of the Germanwings crash, further harmonization measures have been proposed including a central medical data repository to assist with detection of non-declaration of medical issues, particularly when moving between states. Future challenges consist of ensuring transparency and an even quality in the assessment process, improving cooperation between participating countries and supplying adequate training for AMEs.

Learning Objectives:

1. Participants will have knowledge of the current state of procedural, operational and aeromedical integration of the medical requirements and oversight applied in EASA Member States.

[272] EASA - EUROPEAN AIRCREW AND ATCO STANDARDS

V. Valentukevicius, J. Vegers and C. Panait

Medical, EASA, Cologne, Germany

MOTIVATION: Over the last 30 years there has been a great evolution in the regulations for aero-medical certification in Europe: from ICAO, JAR-FCL and national rules, we have gone to a mandatory pan-European medical certification system in European Aviation Safety Agency (EASA) Member States. In this presentation we will give an idea

how EASA propose, harmonize, control and implement the content of the actual regulations and adapt them to current aviation problems.

OVERVIEW: Since 2003 EASA took progressively over JAR-FCL. EU Member states had to implement newly established Air Crew regulation including Part-Med in 2013. EASA propose EU implementing rules in the field of Aviation, including Aviation Medicine, certify & approve products and organizations, in fields where EASA has exclusive competence, provide oversight and support to Member States and third countries organizations. It also promotes European and worldwide standards and cooperates with international actors in order to achieve the highest safety level for EU citizens. **SIGNIFICANCE:** The standardization of Aircrew and ATCO's medical certification is ensuring an equal level of safety in aviation environment over Europe. The European Air Space is under the umbrella of a single European Organization.

Learning Objectives:

1. Understand organizational and regulatory procedures of EASA and describe ways and forms of top down management and performance.

Wednesday, May 03
Governor's Square 11

8:30 AM

S-057: PANEL: LESSONS FROM MOL: HOW THE MANNED ORBITING LABORATORY PROGRAM CONTRIBUTED TO AEROSPACE MEDICINE AND BEST PRACTICES

Sponsored by History and Archives Committee

Chair: John Charles
Houston, TX

Co-Chair: Mark Campbell
Paris, TX

PANEL OVERVIEW: The papers in this panel will provide a concise overview of the Manned Orbiting Laboratory (MOL) program, including its evolution from general purpose laboratory to single-purpose observatory, followed by in-depth presentations in the following biomedical areas: medical implications of radiation exposure due to its low-altitude polar orbit; selection of hypobaric oxygen-helium atmosphere; autonomous performance with demanding constraints; development of nutrition and associated technologies; and its candidate exercise capabilities.

[273] LESSONS FROM MOL: BACKGROUND AND CONTEXT

J.B. Charles¹ and M. Campbell²

¹NASA Human Research Program, Houston, TX; ²Private Practice, Paris, TX

PROBLEM STATEMENT: The Manned Orbiting Laboratory (MOL) program was conceived in 1963 to define and demonstrate the performance capabilities of humans in the novel environment of spaceflight and initially included a large number of technological, observational and biomedical investigations to establish appropriate benchmarks. However, this justification compared unfavorably with NASA's upcoming space station efforts. Therefore, before it was authorized in 1965, MOL was recast as a secret reconnaissance platform to place two military astronauts and an advanced camera system into low earth orbit for 30 days principally for high-resolution photography of America's Cold War adversaries. Only incidentally, it would have provided significant, reproducible and well-documented physiological and psychological stresses to its pilots permitting detailed evaluation of the effects of extended spaceflight on them. **TOPIC:** Although not a primary objective of this joint U.S. Air Force/National Reconnaissance Office program, space medicine and biomedical research would have benefitted immeasurably from this audacious effort. The persistence of the program's contributions to spaceflight even after its cancellation in 1969 testify to its central importance to the early Space Age. **APPLICATIONS:** MOL saw the initiation and development of novel approaches

and made lasting contributions in the areas of in-flight radiation assessment, nutritional and hygienic support, planning of workloads and rest periods with a minimum of real-time assistance from earth, and meaningful exercise to counter the effects of extended and uninterrupted weightlessness. These contributions improve the success of operations of NASA's Apollo, Skylab and Space Shuttle programs and continue to be felt today aboard the International Space Station.

RESOURCES: Charles, John and Dan Adamo, "Thirty Days in a MOL, Biomedically-relevant aspects of a reconnaissance mission inferred from orbital parameters," *Quest* vol. 22, No. 2 (2015): 3-14. Erickson, Mark, Lt. Col., USAF, *Into the Unknown Together: The DOD, NASA, and Early Spaceflight*, Air University Press (<http://www.maxwell.af.mil/au/aul/aupress>), Maxwell AFB, Alabama, 2005, page 463, available free from <http://handle.dtic.mil/100.2/ADA459973> (accessed Jan. 28, 2015). National Reconnaissance Office, *The DORIAN Files Revealed*, www.nro.gov/history/programs/docs/MOL_Compndium_August_2015.pdf (accessed Apr. 16, 2016).

Learning Objectives:

1. The attendee will understand the significance of the MOL program and its biomedical contributions to the future of human spaceflight in spite of being cancelled before a single flight in its program.

[274] LESSONS FROM MOL: SELECTION OF A SPACE CABIN HYPOBARIC OXYGEN-HELIUM ATMOSPHERE

J.T. Webb

SARC, LLC, Bandera, TX

PROBLEM STATEMENT: A unique oxygen-helium atmosphere was baselined for the USAF Manned Orbiting Laboratory (MOL) in the late 1960s. Why was this atmospheric content chosen, what was the research behind that decision, and why was there no follow-up relative to NASA's Moon-Mars exploration? The atmosphere must supply adequate oxygen for human activity but cannot contain any constituent detrimental to the health of the cabin/habitat crew. **TOPIC:** The use of helium, He, as an inert diluent in space cabin/habitat breathing mixtures could solve many problems while also creating some. Its consideration during development of the MOL may inform the balance of these issues and potential future use of He for Moon-Mars applications. **APPLICATIONS:** Spacecraft atmospheric oxygen at high concentrations is a fire hazard so inert gas is a major issue. Also, any ignition source in a space cabin/habitat may result in formation of detrimental atmospheric constituents involving combinations of oxygen and the available N_2 ; not so with inert He or Ne. Storage issues due to the small size of the He molecule would need to be addressed. The vocal communication issues inherent with breathing high concentrations of He are much reduced due to the relatively low percentage of He needed as the major diluent gas although it still may need more engineering. Moon and Mars exploration require habitats which provide healthy atmospheres. Since the moon has no atmosphere and Mars has virtually no oxygen or nitrogen, N_2 , in its atmosphere, the majority of the breathing gases for their habitats and pressure suits must be transported from earth. Oxygen may be recycled with plants and the off-gassed carbon dioxide of the occupants. The molecular weight of N_2 is 28 and of Neon, Ne, is 20, both much heavier than the 4 of He. The 5 to 7-fold higher weight of N_2 is good reason to transport the lighter He or Ne to Mars. **RESOURCES:** Cooke JP, Beard SE. Verbal Communication Intelligibility in Oxygen-Helium, and Other Breathing Gas Mixtures, at Low Atmospheric Pressures, *Aerospace Medicine*, 1965; 36(12): 1167-72. Welch BE, Robertson WG. Effect of inert gases in cabin atmospheres. *Bioastronautics and Exploration of Space*. NASA SP-7011. 1965:255-83. Zeff HJ, Krasnograd LJ, Motsay GJ, Glatte HV, Robertson WG, Welch BE. Study of man during a 56-day exposure to an oxygen-helium atmosphere at 258 mm. Hg total pressure - XII. Clinical observations. *Aerospace Med* 1966; 37(6):601-4.

Learning Objectives:

1. Oxygen toxicity can be avoided by including sufficient levels of other non-toxic gases in the breathing mixture such as nitrogen, neon, or helium.
2. Decompression sickness can result due to nitrogen gas emboli formation during decompression when nitrogen becomes sufficiently supersaturated to form a gas phase in tissues and/or blood.

3. Considerations for the Manned Orbiting Laboratory gas atmosphere included use of diluent gases such as nitrogen, helium, and neon with helium being generally favored.

[275] LESSONS FROM MOL: DEVELOPMENT OF NUTRITION AND ASSOCIATED TECHNOLOGIES

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PROBLEM STATEMENT: The Manned Orbiting Laboratory (MOL) program, authorized in 1965, was during a time when NASA was feeding astronauts for no more than 2 weeks. However, the MOL mission required feeding two crewmembers for 30 days which required more sophisticated food and waste management systems.

TOPIC: The MOL food system required a significant upgrade to the current Mercury/Gemini food system. It needed to provide the essentials of a diet for up to 30 days for two crewmembers. Due to the longer mission, there had to be more variety and acceptability as compared to the Gemini food system without increasing the time for food preparation and cleanup. An adequate number of acceptable food items were developed that would provide enough variety and nutrition in the foods to allow for a 6-day repeating cycle for 3 snacks and 1 meal per day. The daily time allotted for the snacks and meals preparation, consumption, and cleanup was less than 90 minutes. The waste management system also needed to be improved for this extended mission. The crewmembers had reported on earlier, shorter missions that they did not want to defecate due to the hand-held straddle trench provided. **APPLICATIONS:** Although the MOL program was ultimately cancelled, it fuelled the development of the entire food system from stowage to waste disposal for future Apollo missions. When the Apollo flights began to fly in 1968, there were a number of deficiencies in the baseline food system. Since NASA sponsored the ration development for Apollo at the US Army Natick Laboratories, the progress to improve the foods and food systems developed during the MOL program could be used in improving the Apollo food system. Both agencies continue to work together to develop an acceptable, safe, and nutritious food system for the astronauts and combat fighters. **RESOURCES:** Welbourn, Jerry L., Manned Orbiting Laboratory Feeding Systems Requirements, in *Aerospace Food Technology* (NASA SP-202), Washington, D.C.: NASA, 1970, pp. 15-20. Flentge, Robert L., Quantifying and Improving Manned Orbiting Laboratory Food, in *Aerospace Food Technology* (NASA SP-202), Washington, D.C.: NASA, 1970, pp. 21-30. Doppelt, Frederick F., Development Of New Concepts for the Feeding System for the USAF Manned Orbiting Laboratory, in *Aerospace Food Technology* (NASA SP-202), Washington, D.C.: NASA, 1970, pp. 37-42.

Learning Objectives:

1. To understand what the MOL menu consisted of.
2. To understand what the MOL food preparation and stowage consisted of.
3. To understand the constraints for the waste processing system.

[276] TITLE: LESSONS FROM MOL: 'CANNED'-IDATE EXERCISE CAPABILITIES

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PROBLEM STATEMENT: This case report describes the candidate exercise capabilities of the Manned Orbiting Laboratory (MOL) program, and explores parallels to the exercise systems of recent and future space programs. **BACKGROUND / LITERATURE REVIEW:** The Manned Orbiting Laboratory (MOL) was a classified joint US Air Force/National Reconnaissance Office program (1963-1969). While the program was shut down before the laboratory ever reached orbit, detailed design considerations for a vehicle to support two crew, 30-day mission were documented. The candidate exercise capabilities and related motivation, modality, and influence on

exercise programs throughout human spaceflight are explored here.

CASE PRESENTATION: Upon declassification of the MOL program, hundreds of files were released for public consumption. Included in these files were the Flight Test and Operations Plan, and a collection of photographs and artists renderings which collectively provided detailed insight to the habitable volume of the spacecraft and concepts of the support hardware. Even in this early era of human spaceflight, there was recognition that exercise would be a critical component of the 30-day outpost. Within the military, there was a growing experience base in high altitude and high speed flight which served as an evidence base for the physiological demands of launch and re-entry profiles, and was likely the driving consideration for provisions of an exercise system. Biomedical and human performance evaluations in microgravity were also driving objectives of the MOL program. Through conjecture, the exercise hardware appeared to be non-powered, provide primarily resistance exercise capability, had a low-profile depth yet extended to approx. seven feet in length, and was hard-mounted to the perimeter of the habitable volume. This device would be the first in a long line of iterations of exercise hardware designed for use during space missions. **OPERATIONAL / CLINICAL RELEVANCE:** The Orion capsule will have a habitable volume of approximately 300 ft³, and exploration class vehicles will be equally as volume limited. Factors such as environmental considerations (air, temp, and humidity), limited volume and power, behavioral health, and fitness for duty standards will be compared and contrasted between the conceptual MOL program and exploration missions currently in the design phase as we seek to apply lessons learned from our historical space programs.

Learning Objectives:

1. The attendee will understand the significance of the MOL program and its contributions to development of exercise capabilities for spaceflight, in spite of being cancelled before a single flight in its program.

[277] THE HISTORY OF BIOMEDICAL PLANNING FOR THE MANNED ORBITING LABORATORY

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PROBLEM STATEMENT: The Air Force Manned Orbiting Laboratory (MOL) Project initiated planning for long duration (30 days) spaceflight medical care, medical research, and medical countermeasures. These plans were initially ambitious but were streamlined as project constraints intervened. The planning initially ran parallel to Apollo Applications planning and after project cancellation were delivered to NASA. They laid the groundwork for the Skylab biomedical program. **TOPIC:** Some of the early ambitious, later to be deleted, MOL plans that had biomedical aspects included EVA, the Astronaut Maneuvering Unit, and in-flight centrifuge. Other plans incorporated into Skylab were mass measurement hardware, LBNP, the ergometer, cardiovascular research, and metabolic studies. Early planning conferences in 1963 gave insight into the depth of knowledge of long duration space medicine issues at that time. **APPLICATIONS:** The highly successful Skylab biomedical program and many features of the Shuttle and International Space Station biomedical programs have their basis in the planning and development of the Manned Orbiting Laboratory. **RESOURCES:** Declassified Manned Orbiting Laboratory (MOL) Records". National Reconnaissance Office. nro.gov/foia/declass/MOL

Learning Objectives:

1. To understand details of the biomedical planning that was carried out in the early MOL Program.
2. To understand how the biomedical planning for the MOL Program was transferred over to NASA and became part of the Skylab Program.
3. To understand what concepts of space medicine and physiology were held by early researchers in space medicine in the MOL Program.

Wednesday, May 03

Exhibit Hall

10:00 AM

S-058: POSTER: HYPOXIA & HYPO/HYPERBARIA, MUSCULOSKELETAL ISSUES, & ACCELERATION

Chair: Vivienne Lee

Farnborough, Hampshire, United Kingdom

Co-Chair: Ross Pollock

Farnborough, Hampshire, United Kingdom

[278] THE EFFECTS OF HYPOXIA ON THE DIRECT AND CONSENSUAL PUPILLARY LIGHT REFLEX

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INTRODUCTION: The present study evaluates whether normobaric hypoxia (NH) alters the eye's pupillary light reflex (PLR), a widely used clinical tool for assessing neurological status as well as the visual and autonomic nervous systems. The PLR is a reflex change in the pupil diameter (PD) in response to a brief flash of light. Normally, the light flashed in one eye causes a nearly instantaneous, rapid and simultaneous constriction of the pupil in both eyes, followed by a far slower dilation. The PLR in the flashed eye, the direct PLR (dPLR), is essentially indistinguishable from the PLR in the non-flashed eye, the consensual PLR (cPLR). We report here the first study of hypoxic effects on both the cPLR and dPLR. **METHODS:** Using the Reduced Oxygen Breathing Device with a hose and facemask, 26 Army aviator volunteers breathed tanked mean sea level (MSL) air and MSL air diluted with tanked nitrogen to produce a breathable air/nitrogen mix of about 12% oxygen. A commercial, off the shelf binocular pupillometer recorded each volunteer's cPLR and dPLR to a train of 10 flashes that alternated between the left and right eye. The flashes were of 100 ms duration, presented with a duty cycle of 1/s, with each flash about 1-lux luminance. The maximum and minimum PD, response latency and contraction velocity were recorded for each flash. Additionally, pulse oximetry provided pulse rate and peripheral oxygen saturation measures. Subjects acclimated for about 15 minutes before recording the PLRs. **RESULTS:** (a) Maximum and minimum cPLR and dPLR diameter were about 5% smaller when hypoxic compared to MSL, a statistically significant difference. (b) Over the train of 10 flashes, the effect on maximum and minimum PD was cumulative and parallel, offset by about 5% between the MSL and the 12% oxygen conditions. (c) Hypoxia did not differentially affect either the response latency or the constriction velocity. **DISCUSSION:** These results are consistent with previous findings showing a decrease in PD with hypoxia. The magnitude of the decrease in PD is too small to impact retinal image but is consistent with a hypoxia-associated change in the autonomic nervous system.

Learning Objectives:

1. To describe the pupillary light reflex and its measurement in humans.
2. To describe normobaric hypoxia.
3. To describe the impact of normobaric hypoxia on the pupillary light reflex.

[279] US ARMY HYPOBARIC CHAMBER EXPOSURE: DESCRIPTIVE EPIDEMIOLOGY OF ADVERSE EVENTS, 2014-2016

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¹Hyperbarics, US Army, Ft. Rucker, AL; ²US Army School of Aviation Medicine, Fort Rucker, AL

INTRODUCTION: The United States Army School of Aviation Medicine (USASAM) has conducted altitude physiology training for military air crew for several decades. While there are inherent physiologic risks with this training, including Decompression Sickness (DCS), to date there is no comprehensive medical model to determine with certainty whether an individual will develop an adverse event during high altitude exposure. Despite service-wide standardization of training and high USASAM training throughput, an extensive review of historical data for adverse events has not been conducted. Such a review would be helpful to guide hypobaric training methods and risk management. **METHODS:** Historical training records were retrieved through an IRB exemption for

FY 2014-2016. De-identified data were reviewed for inclusive training iterations for incidence of DCS (Types 1 or 2), any adverse physiologic sequela, and off-nominal events (a deviation in flight profile including leveling chamber, 'bounce' to higher altitude, or early abort following the initial pressure check). **RESULTS:** From FY14-16, 2395 personnel were trained in the USASAM hypobaric chamber in four different flight profiles: I (23), IV (1185), IV + rapid decompression (768), and V (419). Of all individuals trained, there were zero cases of DCS. There were 52 adverse physiologic events (2.17%), and 47 off-nominal events (1.96%) with large imbrication. Of adverse physiologic events, all were minor and otolaryngological; the most common being failure to equalize pressure or Eustachian tube dysfunction. **DISCUSSION:** This quantitative review provides summary observational data and descriptive epidemiology of hypobaric chamber training-related adverse events. The absence of DCS events in the setting of the rare occurrence of a minor physiologic insult is reassuring with regards to the safety of altitude training. Future studies are recommended that evaluate independent variables including gender, age, seasonality of training, chamber profile, or other variables that may serve to further delineate the safety of hypobaric exposure. This may also help validate a future predictive model for adverse events within these training profiles.

Learning Objectives:

1. Review historical incidence of decompression sickness, adverse physiologic sequelae, or off-nominal events for multiple years of hypobaric training exposure.

[280] SCENARIO-BASED QUANTIFICATION OF SLOW ONSET HYPOXIA-INDUCED PILOT VISUAL BEHAVIOR

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INTRODUCTION: The purpose of this study was to measure the flight-related visual behavior in hypoxic pilot participants as a percentage of their normoxic baseline at different SpO₂ levels. It was of particular interest to investigate the effect of hypoxia on visual behavior as measured using eye-tracking. It was hypothesized that as SpO₂ levels decreased, time to acquire visual targets would increase. **METHODS:** The study used a within-subjects design; SpO₂ level was the independent variable. Participants ($n = 14$; 13 males and 1 female) were commercial instrument rated pilots with 40 hours of G-1000 time. Approval from the researchers' institutional review board was obtained. Each participant wore a head-mounted eye-tracker and sat at the console of a G-1000 located inside a hypobaric chamber. A simulated ATC dictated a series of heading, altitude, and frequency changes as well as transponder codes to input. Video recordings of participants' pupil movements were made. Visual target acquisition time was calculated as the time interval between the end of each stimulus word (e.g., "turn," "descend") and pupil fixation on the relevant instrument on the flight console. Each participant's baseline visual target acquisition time was determined by task performance at an SpO₂ of 100%. Chamber altitude was then increased until SpO₂ rates declined at approximately 5% intervals. The ATC instructions were again relayed to the pilot using different numbers and in a different order at each SpO₂ level, and task performance was again measured. **RESULTS:** Preliminary results indicated a trend for mean visual target acquisition times to increase under hypoxic conditions when compared to the 100% SpO₂ condition. The 85% SpO₂ condition demonstrated a slight decrease in acquisition time compared to the 90% and 80% hypoxic conditions. **DISCUSSION:** The slight and transient increase in performance at 85% SpO₂ may be due to the early stages of fixation, a compensatory reaction in the slow onset hypoxia model in which pilots experienced an increased need to focus on the task upon realizing their decremented performance. The declining trend in performance resumed at 80% SpO₂ and continued until participants were required to don their oxygen masks. Additional planned research can evaluate visual behavior as a function of mild hypoxia and fatigue; prolonged cabin altitude exposures on long haul flights may in part contribute to impaired scanning in descent preparation and landings.

Learning Objectives:

1. The participant will understand that the relationship between SpO₂ and visual target acquisition time may be nonlinear and inverse.

[281] THE RELATIONSHIPS AMONG PHYSICAL FITNESS, PHYSICAL ACTIVITY, AND TIME OF USEFUL CONSCIOUSNESS

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¹Aerospace Medical Institute, National Defense Medical Center, Taipei, Taiwan; ²School of Medicine, National Defense Medical Center, Taipei, Taiwan

INTRODUCTION: Pilots have to face the challenge of hypobaric hypoxia during flight mission. Hypoxia tolerance has been evaluated by the time of useful consciousness (TUC), which is the amount of time for an individual to perform flying duties during hypoxic exposure. However, factors to affect TUC remain unclear. The aim of study is to identify the relationships between physical fitness and physical activity on the TUC during hypobaric chamber exposure. **METHODS:** 81 military pilots attending hypobaric chamber training at Aerospace Physiology Training Center were recruited in the present study. Physical examination score (3k running, push-up, and sit-up), Baecke physical activity questionnaire index, stress saliva markers, and TUC of 25000 ft were then measured. **RESULTS:** We found no significant relationships among TUC, desaturation oxygen rate, physical examination score (3k running, push-up, and sit-up), and Baecke physical activity score. However, 3k running score is positively related to TUC in over-30 years old pilots ($n = 10$, $r^2 = 0.3741$, $p = 0.06$).

Learning Objectives:

1. These findings suggest that aerobic physical training might be a beneficial effect to TUC in senior military pilots (over 30 years old).

[282] CARDIAC ARREST DURING HYPOBARIC CHAMBER TRAINING

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PROBLEM STATEMENT: This case report describes an aircrew member who developed cardiac arrest in a hypobaric chamber. He experienced symptoms of hypoxia at an altitude of 25,000 ft and lost consciousness during the following descent to ground level. Medical monitoring showed a flat-line ECG lasting 30 seconds. A cardiac asystole under normoxic conditions is very unusual. **BACKGROUND / LITERATURE REVIEW:** Syncope during high-altitude training, even if the subject is provided with oxygen, may have a number of causes. In some cases, subjects may lose consciousness after breathing in 100% oxygen (oxygen paradox) due to vasodilatation. Valsalva maneuvers to equalize the pressure in the middle ear could lead to unconsciousness. Expanding gas in the gastrointestinal tract may result in collapse. A cardiac arrest (asystole for 30 seconds) under these conditions is unusual. **CASE PRESENTATION:** A 52-year old aircrew member underwent his refresher hypoxia training in a hypobaric chamber. He experienced symptoms of hypoxia at an altitude of 25,000 ft and reconnected to the 100% oxygen supply. At a descent altitude of 3,000 ft he complained about dizziness. Shortly afterwards he lost consciousness. The ECG showed bradycardia followed by asystole. The inside observer started resuscitation and after 30 seconds a normal sinus rhythm was restored. The patient regained consciousness and was transferred to the local hospital. He reported four syncope episodes in his lifetime, one of which suffered in flight. Further examinations resulted in the diagnosis of neurocardiogenic syncope. He finally ended his aviation career at his own request. **OPERATIONAL / CLINICAL RELEVANCE:** Neurocardiogenic syncope is a common phenomenon and triggered by a variety of circumstances. The triggering mechanisms are imperfectly understood. The aviation environment carries the risk of provocative factors. Certification of aircrews with neurocardiogenic syncope is problematic due to the risk of sudden incapacitation. In this case, the syncope happened twice in a hypobaric environment. Normally subjects with hypoxic syncope and cardiac asystole fully recover in Trendelenburg's position when supplied with supplemental oxygen. In this case, the oxygen saturation was 95% and the asystole lasted 30 seconds. Chamber personnel should be aware of the risk of asystole in aircrew members undergoing hypobaric chamber training. Medical monitoring (ECG, pulse oximetry) has proven to be very helpful.

Learning Objectives:

1. Understand the emergency cases and procedures during hypobaric chamber training.

[283] LONG TERM EVALUATION OF RETINAL ARTERY OCCLUSION PATIENTS THAT WERE APPLIED HYPERBARIC OXYGEN TREATMENT

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INTRODUCTION: Retinal artery occlusion (RAO) represents an ophthalmologic emergency. Painless loss of monocular vision is the usual presenting symptom of RAO. Ocular stroke is commonly caused by embolism of the retinal artery, although emboli may travel to distal branches of the retinal artery, causing loss of only a section of the visual field. Immediate intervention improves chances of visual recovery. Hyperbaric oxygen treatment (HBOT) is one of the treatment modalities for RAO. HBOT may be beneficial if initiated within 2-12 hours of onset of symptoms. Objective of this study was to evaluate the usefulness of HBOT on the patients who had applied to our center for HBOT with a RAO diagnose. **METHODS:** 16 patients were included in this study for a 3 years' period those were applied HBOT with RAO diagnosis. HBOT sessions of these patients had been started as quick as possible soon after they have arrived. Also all patients had been started medication by ophthalmologists who sent them. To evaluate the outcome of the treatment the patients were called with telephone and ophthalmology clinic control examinations were obtained. Patients were asked survey questions about their visual ameliorations before and after HBOT. **RESULTS:** Mean initiation duration of patients to get HBOT was about 28 hours. Only one patient was initiated treatment after 13 days from the event and no visual amelioration was recorded. Within this patient, no visual amelioration was recorded for 2 more patients. Among the other 13 patients, 3 had 80% and more, 3 had 50-79% and 7 had below 50% visual amelioration. 11 of 13 patients had peripheral visual field amelioration. **DISCUSSION:** With the medical treatment, immediate intervention of HBOT was considered a useful treatment modality for RAO. The visual amelioration of the visual fields was considered especially in the peripheral vision rather than central vision.

Learning Objectives:

1. Define the management of retinal artery occlusion patients to evaluate for Hyperbaric Oxygen Treatment.

[284] NEUROPROTEOMICS OF BRAINSTEM AND HIPPOCAMPUS IN A RAT EXPOSURE MODEL OF EXTREME HYPOBARIA AND HYPEROXIA

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INTRODUCTION: High altitude U-2 pilots and altitude chamber technicians show increased incidence of white matter hyperintensities (WMH) in T2 weighted magnetic resonance imaging. Although exposed professions show no clinical deficits, subtle changes on neurocognitive function including reasoning/calculation, memory, information processing accuracy, and general cognitive functioning have been described. The purpose of this study was to explore molecular mechanisms in the brain that are affected by exposure to extreme hypobaria, excess oxygen, or a combination of both stressors. **METHODS:** We tested three experimental groups (n=6/group): (1) 1K ft and 21% O₂ (CTL); (2) 1K ft and 100% O₂ (HYP); and (3) 30,000 ft and 100% O₂ (ALT). Rats were placed in an altitude chamber and exposed to the pressure/oxygen stress conditions for 4h/day for three consecutive days. Immediately after the third exposure, brainstem, cerebellum, hippocampus, and cortex were dissected and frozen. For quantitative proteomics, proteins were extracted from brainstem, cerebellum, cortex and hippocampus followed by trypsin digestion. Peptides were labeled using Tandem Mass Tags and fractionated by strong cation exchange. Fractions were analyzed with a nanoUPLC coupled to an Orbitrap MS. Following data acquisition and analysis, modulated pathways were identified with Cytoscape Functional Interaction analysis software. **RESULTS:** Rats in the HYP and ALT groups showed distinctly modulated pathways for proteins primarily involved with cellular maintenance and energy metabolism, axon

guidance/gene expression, signal transduction, protein folding, adhesion, synaptic transmission, and cell growth across all brain regions. There were significantly more changes in the HYP group as compared with ALT.

DISCUSSION: Results suggest that WMH may be caused by differentially modulated molecular mechanisms that may serve as markers of hypobaric exposure and oxygen toxicity in high altitude pilots and altitude chamber technicians. (In compliance with DODI 3216.01).

Learning Objectives:

1. Understand molecular causes for WMH in the brain of high altitude pilots and altitude chamber technicians.

[285] HYPERBARIC MEDICINE UPDATE

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PROBLEM STATEMENT: Undersea Hyperbaric Medicine (UHM) is an American Board of Medical Specialties subspecialty that is supported by the American Board of Emergency Medicine and the American Board of Preventive Medicine. In the United States, from 1994 to 2014, the number of hyperbaric chamber sites expanded from approximately 200 to over 1,200, a growth rate during that time period of over 500%. In carefully selected patients with certain diagnoses, hyperbaric oxygen (HBO2) treatment can save life, limb, and eyesight. Unlike most other specialties, exposure to the basics in UHM is not offered at many medical schools or in many residencies.

TOPIC: The Undersea & Hyperbaric Medical Society maintains a list of diagnoses, which has grown over the decades. To be placed on the list, data from research and experience are carefully assessed by panels of experts in multiple specialties, not just UHM. In recent years the list has grown; currently it contains 14 diagnostic categories. Carefully selected patients with diagnoses on this list, who have failed to improve in a timely manner with other indicated interventions, may be considered for HBO2 treatment consultation (bearing in mind that not all HBO2 consultations will necessarily be determined to be appropriate for HBO2 treatment). **APPLICATIONS:** In carefully selected patients, HBO2 treatment can be lifesaving. An aspect of this update poster is looking at some of the parameters used in this careful patient selection process. Since UHM fundamentals are not offered at all medical schools or in many residencies, the medical knowledge presented here can assist physicians, nurses, or other professionals in determining whether their patient could benefit from an HBO2 consultation.

Learning Objectives:

1. List the current diagnoses that are commonly accepted indications for hyperbaric medicine consultation in carefully selected patients in the United States.
2. Name the location of the current list of diagnoses that are indications in the United States.
3. State the resources that are manned 24/7 for hyperbaric medicine guidance.

[286] UNDESERVED DECOMPRESSION ILLNESS: CASE REPORTS FROM LOUISIANA STATE UNIVERSITY UNDERSEA AND HYPERBARIC MEDICINE FELLOWSHIP PROGRAM

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PROBLEM STATEMENT: The authors present a series of five case reports outlining recent, significant, "undeserved" decompression injury experiences treated at the Louisiana State University post-graduate medical training program in Undersea and Hyperbaric Medicine. **BACKGROUND / LITERATURE REVIEW:** Decompression illness (DCI) is an omnipresent concern for those subjected to significant changes in ambient pressure as in underwater diving, aviation, tunneling and those receiving hyperbaric oxygen therapy (HBOT). In the United States, the number of outpatient hyperbaric medicine clinics has grown steadily. However, a precipitous decline has been noted in both the number of hyperbaric facilities able to provide 24 hour DCI coverage and fellowship programs producing physicians trained in undersea and hyperbaric medicine. It has been argued that such a decline is an unconcerning product of technological advances in diving safety such as improved diving computers. However, even under the umbrella of improved safety measures, "undeserved" hyperbaric injuries

continue to manifest themselves. **CASE PRESENTATIONS:** Each of the five cases serves as an overview of the complexity of coordinating the treatment of severe DCI patients. These cases also have the distinction of being "undeserved" or developed under "unprovocative" circumstances while undersea or dry chamber diving. The neurologic sequelae of the injuries to include hemiplegia, sensory deficit and cortical blindness as well as their treatment and outcome are presented. In addition, significant laboratory findings, imaging results and patient transport factors are discussed.

OPERATIONAL / CLINICAL RELEVANCE: These cases highlight the key findings of DCI through a variety of DCI experiences. These cases provide an introduction/review of signs and symptoms of DCI and relevant treatment protocols. It also illustrates the need for specialized training received by undersea and hyperbaric medicine fellows and further research in DCI.

Learning Objectives:

1. The audience will appreciate that "undeserved" decompression illness is common among divers despite following robust published diving procedures and will recognize the neurologic sequelae that can be associated with a decompression insult.
2. The audience will be able to briefly summarize common treatment protocols for decompression illness.
3. The audience will appreciate the variety of severe DCI cases that are treated as part of fellowship level medical training in Undersea and Hyperbaric Medicine.

[287] EFFECTS OF SHORT TERM HYPOBARIC AND NORMOBARIC HYPOXIC PRECONDITIONING ON ACUTE HYPOXIA EXPOSURE IN MICE

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INTRODUCTION: Hypoxic preconditioning (HPC) has been shown to be protective against injuries induced by hypoxia exposure and effective in improving tolerance or performance at high altitude. Previous studies have adopted different methods to achieve HPC, including hypobaric and normobaric HPC. However, whether hypobaric or normobaric HPC exerts similar preconditioning effects is still controversial. The purpose of this study is to compare effects of these two different HPC protocols on acute hypoxia tolerance in mice. **METHODS:** Male Kunming (KM) mice were randomly divided into the following 7 groups (n=10 in each group): hypobaric HPC in a hypobaric chamber (405 mmHg, 5 000 m of altitude), 1 h/d (H1) or 2 h/d (H2) or 4 h/d (H4) for 7 d; normobaric HPC in a normobaric chamber (10.6 % nitrogen oxygen gas mixture), 1 h/d (N1) or 2 h/d (N2) or 4 h/d (N4) for 7 d; the control group (CON). After HPC period, survival time of the mice (9 600 m altitude) from different groups was recorded upon exposure to acute hypoxia. The blood was collected after the mice in each group was sacrificed immediately. The hemoglobin concentration was examined by Radiometer ABL90 Flex. **RESULTS:** After HPC training, survival time of H2, N2, H4 and N4 group was significantly ($P<0.01$) prolonged when exposed to 5 % nitrogen oxygen gas mixture. There was no significant difference neither in H1 nor N1 group compared to CON. The hemoglobin concentration was also significantly ($P<0.01$) increased in response to 7 days HPC training (H1, N1, H2, N2, H4 and N4) compared to CON. Related to hypobaric /normobaric HPC protocols, the differences of survival time and hemoglobin concentration were significantly ($P<0.01$) increased in N2 and N4 group compared to H2 and H4, respectively, but no significant difference was found between H1 and N1 group. **DISCUSSION:** HPC prolongs the survival time of KM mice when exposed to acute hypoxia and increases hemoglobin concentration in order to carry more oxygen. NHPC might results in better protective effects than HHPC against acute hypoxia exposure.

Learning Objectives:

1. To compare physiological effects on hypobaric and normobaric hypoxic preconditioning.
2. Attendees will identify factors associated with aforementioned differential effects.

[288] NEUROIMAGING SURVEILLANCE OF HYPERBARIC OXYGEN CHAMBER TECHNICIANS

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INTRODUCTION: In recent years, high-altitude U2 pilots, astronauts, and scuba divers have been found to have an increased number of T2 hyperintense lesions within the cerebral white matter. One of the proposed etiologies of these white matter hyperintensities is neurologic decompression. At the present time, it is unknown whether hyperbaric oxygen chamber technicians who are also exposed to repeated neurologic decompression also have increased number of white matter T2 hyperintensities in the cerebral white matter. This knowledge is important for two reasons. First, neuroimaging surveillance will help identify and characterize potential occupational health hazard of neurologic decompression manifesting as cerebral white matter hyperintensities to hyperbaric oxygen chamber technicians. Second, if white matter T2 hyperintensities are present in hyperbaric oxygen chamber technicians who are also exposed to repeated neurologic decompression events, then the proposed theory that the white matter T2 hyperintensities are due to neurologic decompression will be strengthened. **METHODS:** An IRB-approved, HIPAA-compliant neuroimaging study on volunteer experienced hyperbaric oxygen chamber technicians will be performed at our institution. Each subject will be interviewed for demographic information as well as hyperbaric oxygen chamber experience and risk factors for white matter hyperintensities. Each subject will receive a non-contrast MRI of the brain and spinal cord on a 3 Tesla MRI scanner. The neuroimaging protocol will include T1, T2, FLAIR, gradient recall echo (GRE), susceptibility weighted imaging (SWI), and diffusion weighted imaging (DWI). If white matter lesions are present, then characterization of lesion pattern and number will be performed by a board-certified neuroradiologist. In addition, linear regression will be performed to assess for a possible correlation between experience and number of cerebral white matter lesions adjusting for age, gender, and risk factors for white matter lesions. **RESULTS:** The neuroimaging scans have not yet been acquired at this time; however, the MRI scans and analysis will be completed prior to the 2017 AsMA conference. **DISCUSSION:** The clinical meaning of the results and their application to aerospace medicine will be interpreted upon completion of the neuroimaging scans. Future research will be suggested based on the results.

Learning Objectives:

1. To determine whether hyperbaric oxygen chamber technicians have an increased number of white matter T2 hyperintense lesions in the brain and spinal cord for their age.
2. If white matter hyperintense lesions are present, then characterization of lesion pattern will be performed. Also, a correlation between the number of lesions and cumulative hyperbaric oxygen chamber exposure will be performed.

[289] A COMPARISON OF PULSE OXIMETRY AND NEAR INFRARED SPECTROSCOPY FOR HYPOXIA DETECTION IN FIGHTER PILOTS

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INTRODUCTION: Hypoxia is a recognized medical emergency for pilots, representing a large portion of otherwise preventable aircraft mishap fatalities. Single-pilot aircraft are especially susceptible because there is no redundancy in the human system flying the plane. While some pilots chose to wear finger-mounted pulse oximetry units, this is an unacceptable solution for pilots who need the full, unencumbered use of their fingers. Whereas previous solutions have been investigated, none have satisfactorily monitored pulse oximetry without needing major alterations to existing flight equipment or causing undue discomfort. This study was conducted to determine if near-infrared spectroscopy (NIRS) of the sternocleidomastoid muscle is an acceptable surrogate for pulse oximetry. **METHODS:** All test subjects (3 male, 1 female) were USAF trained aerospace physiologists, one was also a current and qualified F-16 pilot. A Medtronic® NIRS probe was superficially adhered to the left and right sternocleidomastoid muscles of each subject before donning an HGU-55/P flight helmet. For baseline comparison, pulse oximetry was monitored using a finger-mounted probe. Test subjects were then "flown" on an altitude chamber requalification profile using a Reduced Oxygen Breathing Device (ROBD). Subjects were initially taken to 8K feet MSL for 3 minutes before "climbing" to 25K feet MSL. Upon recognition of hypoxic symptoms, test subjects initiated "gang-load" procedures. NIRS and pulse oximetry data were recorded in ten second intervals throughout the profile. **RESULTS:** All test subjects reported no pain or discomfort when

wearing the NIRS probes, nor did they report any reduced range of motion or operating limitations. On a normalized scale, NIRS was just as accurate as finger-mounted pulse oximetry in detecting decreases in blood oxygen saturation. Furthermore, decreases in blood oxygenation were just as sensitive for NIRS probes when compared to pulse oximetry. Finally, NIRS probes were faster to show recovery to normal oxygenation levels after initiation gang-loading procedures. **DISCUSSION:** The data suggest that NIRS probes monitoring tissue saturation of the sternocleidomastoid muscles is indeed a viable surrogate for real-time blood oxygenation monitoring. Furthermore, the more rapid response of NIRS is likely due to the proximity of the sternocleidomastoid to central arterial supply vessels, versus the peripheral nature of the fingertip oximetry probe.

Learning Objectives:

1. Near infrared spectroscopy of the sternocleidomastoid muscle is a viable surrogate for finger-mounted pulse oximetry.

[290] DIFFERENCES IN CERVICAL AND TRUNK NEUROMUSCULAR CHARACTERISTICS BETWEEN BLACKHAWK PILOTS AND CREW CHIEFS

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INTRODUCTION: Military helicopter pilots and crew chiefs have a high prevalence of neck pain and low back pain, due to the physical stress of flight missions/training (prolonged sitting, whole-body vibration, and/or heavy gear). However, pilots and crew chiefs perform occupationally specific tasks, potentially causing cervical and trunk neuromuscular characteristics to deteriorate through different mechanisms. The purpose of this study was to compare cervical and trunk strength and flexibility as well as forward neck/shoulder posture and cervical proprioception between Blackhawk pilots and crew chiefs. **METHODS:** A total of 34 U.S. Army Blackhawk helicopter pilots (N=17, Age: 30.1±5.3 years, Height: 175.9±9.1 cm, Mass: 80.1±11.6 kg, total flight hours: 993.5±680.4 hours) and crew chiefs (N=17, Age: 28.8±5.5 years, Height: 174.2±9.1 cm, Mass: 79.4±11.2 kg, total flight hours: 847.1±422.3 hours) were recruited and matched based on gender, age, and total flight-hours. Subjects participated in laboratory testing including cervical muscular strength measurement with a hand-held dynamometer, trunk muscular strength measurement with an isokinetic dynamometer, cervical and trunk active range-of-motion (ROM) measurement with an inclinometer, posture assessments (forward head, forward shoulder, and pectoralis minor length) with a double square, and cervical proprioception assessments (active joint position sense) with a 3D video motion capture system. Paired t-tests or Wilcoxon tests were used to compare differences between matched groups (p<0.05). **RESULTS:** Compared to the pilots (PLT), the crew chiefs (CC) had significantly less ROM on trunk rotation (PLT: 155.3±11.3°, CC: 146.5±11.7°, p=0.029) and extension (PLT: 49.3±7.2°, CC: 44.0±6.8°, p=0.009) and increased forward head posture (PLT: 21.0±1.4 cm, CC: 21.8±1.1 cm, p=0.041). No differences were found on other variables (p>0.05). **DISCUSSION:** The current findings may be explained by the fact that crew chiefs frequently lean forward to scan the area underneath the helicopter. When treating neck pain and low back pain, it is important for clinicians to recognize specific occupation-related differences and develop strategies to counterbalance those needs. Supported by USAMRMC #W81XWH-11-2-0097.

Learning Objectives:

1. Recognize the needs for developing different injury prevention strategies for helicopter pilots and crew chiefs.

[291] ANALYSIS OF THE G ENVIRONMENT DURING A RED BULL AIR RACE

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INTRODUCTION: The Red Bull Air Race is an elite competition involving high speed, low-level aerobatic maneuvers over a set course. During aerobatic competition, pilots are exposed to high levels of applied +Gz. A full understanding of the Gz environment of the modern high performance aerobatic competition aircraft remains to be developed. The purpose of this study was to document the nature and characteristics of the Gz environment to which aerobatic pilots are exposed during the Red Bull Air Race competition. **METHODS:** Gz data were downloaded from an aircraft competing in the Red Bull Air Race competition at a race during the 2015 season. The Gz data were acquired via the aircraft's onboard data acquisition system. **RESULTS:** The race run was around 1 minute in duration. The Gz environment during this run consisted of extremely frequent and repetitive excursions to very high peak +Gz levels; 39% of the duration of the race was spent at +Gz levels greater than +4 Gz. There were eight separate exposures to +8 Gz. Maximum and minimum levels of Gz recorded were +10.76 Gz and -0.12 Gz, respectively. **DISCUSSION:** This study confirms the physiologically challenging nature of modern aerobatic competition. The G exposures appear to be very high, repetitive, but limited in duration. Rapid fluctuation in recorded Gz levels point to rapid onset and offset of Gz, which is most likely a result of race-specific aerobatic maneuvers. The aerobatic competition Gz environment is different from that of the modern fighter aircraft, with higher peaks but very limited duration. The potential for flight safety to be compromised by G-related symptoms in this dynamic and competitive environment is very real and warrants further attention.

Learning Objectives:

1. Participants will learn about the nature and characteristics of the +Gz environment during competitive aerobatic flight.

[292] NECK INJURY CRITERIA DEVELOPMENT FOR SYSTEM LEVEL EJECTION TESTING; COMPARISON OF ATD AND HUMAN RESPONSE TO GY ACCELERATIVE INPUT

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INTRODUCTION: Modern Helmet Mounted Displays (HMD) provide pilots with night vision, weapons cuing, onboard systems management, and many other enhancements to operational capability. These additional HMD capabilities are essential in today's advanced military operating environment, but come at the cost of higher head supported mass. Increasing HMD mass combined with expanding pilot mass ranges increases the risk for neck injuries during ejection. **METHODS:** Existing neck load data from military and university experiments with anthropomorphic test devices (ATDs), post mortem human subjects (PMHS), and human subjects subjected to Gy acceleration were used to compute a peak multi-axial neck injury criteria (MANIC) Gy. Linear regression models of the MANIC-Gy to peak acceleration relationship were developed for the both the combined human/PMHS data and the ATD data. **RESULTS:** Comparison of the linear regression models of the Human/PMHS and ATD responses indicates that the Human predicted response is consistently higher than the ATD. The peak expected value of the MANIC (Gy) at 16Gs for ATD response was 0.6 and for Human/PMHS response was 1.05. 16Gs is approximately the highest predicted Gy acceleration a pilot could experience in a typical ejection environment. **DISCUSSION:** The transfer function developed in the research and associated MANIC (Gy) risk functions provide a foundation for evaluating military escape system testing in the Gy plane of motion. Additionally, stochastic analysis in this work served to validated research by Zinck et al. (2015) who developed a transfer function in the Gx plane. Together the Zinck et al. (2015) and the current work has set the foundation for a final analysis of the Gz plane in future research. These transfer functions make previously developed human-centric neck injury criterion (Parr, 2014) directly applicable to dynamic testing with ATDs as part of the developmental and operational testing of escape systems. Collectively, this research is expected contribute to a complete set of multi-axial neck injury criteria that can be applied to ATD testing to predict human neck injury risk in any domain where head supported mass is required in high acceleration environments.

Learning Objectives:

1. The participant will be able to understand the difference in neck response between humans and anthropomorphic test devices (ATDs) over a range of accelerative input in the Gy plane (side impact).

[293] NECK PAIN PREVALENCE ON FRENCH FIGHTER AIRCRAFT CREW: OBSERVATIONAL STUDY AMONG 311 FLYING CREW MEMBERS

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INTRODUCTION: the increasing performances of modern fighter aircrafts imposed more physical constraints on pilots. The main musculo-skeletal constraints concern the cervical spine and is responsible for neck pain whose prevention still remains difficult. We propose a neck pain survey on French fighter crewmembers in order to determine its prevalence and its potential contributing factors. **METHODS:** An anonymous questionnaire was distributed in the military aeromedical centers and in the fighter squadrons from May to July 2016. Every fighter aircraft personnel (pilots and navigators) from the French Air Force and Navy was invited to complete the survey. Besides the anthropometrics and the aeronautical path, the onset, frequency, intensity, and impact of neck pain were studied as well as its modes of occurrence. **RESULTS:** 311 fighter aircraft personnel completed the survey; their mean age was 36.09 ± 6.88 years. 82.3% of respondents were French air force fighter pilots. 60.4% (n = 188) of fighter aircraft personnel reported having experienced neck pain. 63% of the air force pilots reported having had neck pain vs. 40.5% of the navy pilots. The history of neck trauma was identified as neck pain provider (23.2% vs. 5%). Only 58.8% of respondents claimed to know the postural preventive measures but 65.6% of them reported not having sufficient knowledge of these measures. No relation was found between neck pain and age or total flight hours of the personnel. 71.7% (n = 134) of the fighter aircraft personnel suffering neck pain had experienced it in flight. The major factors in flight triggering neck pain were G-load exposure (59.6%), air combat maneuvers (53.7%), rotation (39.3%), checking six (32.4%) and wearing night vision goggles (NVG) (31.9%). 7.1% of neck pain suffering fighters flying personnel reported having pain at every flight. The average duration of flight incapacity was estimated to be 2.94 ± 7.49 days. 46.8% of fighter aircraft personnel with neck pain reported having consulted an osteopath. **DISCUSSION:** On modern fighter aircrafts, more than half of the personnel experienced neck pain and for the majority of them, the pain occurred during a flight particularly with G-load and air combat maneuvers. More information, practice of cervical muscle strengthening exercises and warm-up must be taught during the career of fighter aircrew members. A longitudinal follow-up of fighter aircraft personnel during their career must be suggested.

Learning Objectives:

1. Our study indicates a continuing high incidence of neck pain in the French aircrew members of modern fighter aircraft.
2. More information on the prevention of neck pain must be given to fighter pilots whatever their age and experience.

[294] INFLUENCE OF CHANGING GRAVITY AND EXERTED EXHALATION - LINKAGE BETWEEN OXYGEN UPTAKE AND CARDIAC OUTPUT

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PURPOSE: The study was designed to show that gravity changes comparing human centrifuge (HCF) runs to parabolic flight (PFC) maneuvers induce similar changes in pulmonary oxygen uptake in the resting and exercise condition, without metabolic processes. **METHODS:** 12 subjects having flight medical certificate and signed written inform

consent (age: 30 ± 4 y, weight: 79 ± 8 kg, height: 179 ± 8 cm, BMI: 24 ± 2 kgxm⁻²) were tested on a long-arm human centrifuge applying a postGz-protocol. The cycle of a real parabola was transcribed as follows: 1.7 g for baseline (equiv. 0 g), 25 s with 2.1 g (hyper-g, pull up), 22 s of 1.2 g (transition, µg), and 25 s of 2.1 g (hyper-g, pull down); this sequence was repeated 16 times. The 1.2 g intervals of the protocol were performed in relaxed rest or with exhalation on exertion (forced pressure ventilation, lower extremity muscle contraction, and a combination). Cardiac output (\dot{Q}) was measured beat to beat and oxygen uptake ($\dot{V}O_{2,pulm}$) as well as carbon dioxide output ($\dot{V}CO_{2,pulm}$) were analyzed breath by breath. The same setting was flown in two parabolic flight campaigns. **RESULTS:** At rest, after gravity change '2.1 g – 1.2 g', an increase in \dot{Q} from 7.2 L/min (± 1.8 L/min) up to 9.1 (± 2.3 L/min) with transients for $\dot{V}O_{2,pulm}$ from 0.50 L/min (± 0.15 L/min) to 0.72 L/min to (± 0.15 L/min) were found and for $\dot{V}CO_{2,pulm}$ from 0.42 L/min to (± 0.33 L/min) to 0.60 L/min (± 0.28 L/min), respectively. Six seconds after onset of 1.2 g both, $\dot{V}O_{2,pulm}$ and $\dot{V}CO_{2,pulm}$ were decreased until the change '1.2 g – 2.1 g'. In contrast, with exhalation on exertion only a slight, unsystematic \dot{Q} ' increase was observed. $\dot{V}O_{2,pulm}$ and $\dot{V}CO_{2,pulm}$ were not increased above resting baseline. After exhalation on exertion $\dot{V}O_{2,pulm}$ and $\dot{V}CO_{2,pulm}$ showed a low significant ($P < .05$) increase of approximately 0.4 L/min. The characteristic of the curve progression comparing HCF and PFC are comparable. **CONCLUSION:** The results clearly show a dependency between \dot{Q} and pulmonary $\dot{V}O_2$ as well as $\dot{V}CO_2$. Exhaling on exertion seem to empty the lung tissue and leads to a significant increase in gas exchange which only partially is a companion by \dot{Q} changes in recovery. These data allow further refining of modelling of cardiovascular influences on pulmonary $\dot{V}O_2$ to estimate muscular $\dot{V}O_2$ kinetics. We assume based on these findings that it could be possible to have a model of cardiovascular and pulmonic research using a long-arm human centrifuge.

Learning Objectives:

1. Finding a method to compare hyper-gravity and micro gravity conditions to have a physiological model of cardiovascular and pulmonary research.

[295] A PORTABLE TIME RESOLVED NEAR INFRARED SPECTROSCOPY (NIRS): COMPARISON OF CEREBRAL OXYGENATION CHANGES WITH CONVENTIONAL AND WEARABLE NIRS DEVICE

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INTRODUCTION: Conventional cerebral near infrared spectroscopy (NIRS), typically performed by the continuous wave (CW) technique, has been successively used to monitor cerebral oxygenation changes in various aviation environment including high acceleration (Gz) and hypoxia exposures. However, it has been reported that the confounding effects of extracranial tissue to CW NIRS measurements could not be completely eliminated. Differently from CW method, time resolved (TRS) or time domain NIRS, with picosecond pulsed light sources and time-resolved detectors, can measure the distribution of photon time-of-flights and get rid of photons back-scattered by superficial layers such as skin and skull. Recent advanced technologies helped to build a clinically adapted TRS setup. In this study, the commercially available portable TRS-NIRS was compared with conventional and wearable NIRS device to measure cerebral oxygenation changes during passive head up tilt (HUT). **METHODS:** There were 3 healthy male subjects participated in this study. Sensors of TRS-NIRS and wearable NIRS were attached to right and left forehead, respectively. During this test, we monitored blood pressure continuously. Subjects were placed in a supine position (0°) for 2 minutes, and then were tilted to an 80° head up position for 6 minutes. **RESULTS:** Cerebral oxygenation parameters of both devices were consistently decreased during HUT. Maximum changes of oxy-hemoglobin and cerebral oxygen saturation were 6.1 µmol/L and 7.3 %, respectively in TRS recordings, while 0.1 arbitrary unit of oxy-hemoglobin in the wearable NIRS. The recoveries of oxygenation parameters were observed in TRS about 3min after HUT, but not in wearable NIRS. **DISCUSSION:** TRS-NIRS may be more sensitive than CW method to detect subtle changes in oxygenation

and blood volume. The consistent changes in both TRS and CW NIRS showed the wearable NIRS could be useful to in-flight cerebral oxygenation monitoring for high +Gz and hypoxia exposures.

Learning Objectives:

1. To understand state-of-the-art NIRS technologies for cerebral oxygen status monitoring in aviation environment.

[296] EPIDEMIOLOGIC STUDY OF U.S. AIR FORCE MUSCULOSKELETAL INJURY DETECTION AND PREVENTION (RECORDS REVIEW & SURVEY): PHASE I LITERATURE REVIEW

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MOTIVATION: Injuries among U.S. Air Force (USAF) active duty personnel negatively impact duty availability, decrease resilience, reduce unit cohesion, and can degrade missions. Musculoskeletal injuries (MSIs) occur for a variety of reasons; however, many of the MSI conditions that hospitalized active duty personnel in 2003 resulted from the cumulative effect of micro-trauma, as opposed to an acute trauma. Overuse injuries were 82% of all non-battlefield injuries that required medical evacuation from Operation Iraqi Freedom, Operation Enduring Freedom, or Operation New Dawn. Existing research has focused on basic training, Army units, and elite athletes or was over 10 years old. Recently there have been two USAF research studies focused on injuries suffered by Battlefield Airmen and Security Forces. **OVERVIEW:** The purpose of this study is to critically examine literature on incidence, prevalence, and risk factors to guide future MSI research within the USAF and support the goal of improving human performance. The breadth and depth of MSIs from 2005 – 2015 were assessed using the following search engines—Google Scholar, PubMed, OVID, and the Franzello Aeromedical Library at the USAF School of Aerospace Medicine—to examine peer-reviewed published literature using key words. A total of 200 articles met the inclusion criteria for the study. Using pre-defined criteria, the articles were evaluated and scored by eight reviewers. After scoring, the reviewers consolidated the information, creating a synopsis of the literature to move the project forward into the next phase. **SIGNIFICANCE:** Although there has been a large body of research on MSI, presently there is a lack of knowledge on injuries among active duty USAF. The literature review will provide in-depth understanding of existing literature on injuries in samples of populations. The literature review is creating a foundation for the next research phase, which will investigate MSI and human performance on all active duty USAF personnel.

Learning Objectives:

1. Overuse injuries were 82% of all non-battlefield injuries that required medical evacuation from Operation Iraqi Freedom, Operation Enduring Freedom, or Operation New Dawn.

[297] NEUROMUSCULAR CHARACTERISTICS OF ARMY HELICOPTER PILOTS: IMPLICATIONS FOR AIRCRAFT-SPECIFIC NECK AND LOW BACK PAIN

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INTRODUCTION: The Army utilizes varying helicopter types based on their mission and task requirements. In particular, smaller helicopters are known for limited cockpit space and uncomfortable seating, potentially leading to a higher prevalence of neck/low back pain (NP/LBP). Pilots' cervical/trunk neuromuscular characteristics such as strength, flexibility, posture, and proprioception have shown to be risk factors of NP/LBP and play an important role elucidating aircraft-specific differences for intervention strategies. Therefore, the purpose of this study was to evaluate and compare neuromuscular characteristics of pilots of four different aircraft types. **METHODS:** A total of 115 active-duty male helicopter pilots were recruited and reported for laboratory testing (AH64 Apache (n=32: 34.3yr, 177.7cm, 86.0kg, 1578.1 total flight-hrs), UH60 Black Hawk (n=38: 31.4yr, 178.6cm, 85.2kg, 1064.7 total flight-hrs), CH47

Chinook (n=10: 35.6yr, 178.4cm, 84.4kg, 1534.2 total flight-hrs), and OH58 Kiowa (n=35: 31.0yr, 177.1cm, 80.6kg, 1381.5 total flight-hrs)). Laboratory testing consisted of cervical/hip/trunk range-of-motion (ROM) and strength, head and shoulder posture, and cervical rotation joint position sense. Based on the normality of the data, one-way analysis of variance or Kruskal-Wallis with post-hoc analyses were used to compare the dependent variables among the groups. **RESULTS:** The OH58 pilots had decreased ROM in cervical flexion/extension, cervical rotation, and hip rotation ROM and decreased strength in cervical rotation and trapezius muscles than the UH60 pilots (p<0.05). Post hoc analyses are, respectively, from left to right:

Name: AH64, UH60, CH47, OH58, post hoc

Cervical Flex-Ext ROM: 125.6°, 133.6°, 126.6°, 119.9°, Sig: UH>OH.

Cervical Rotation ROM: 144.1°, 148.7°, 148.4°, 137.3°, Sig: UH>OH.

Hip Rotation ROM: 105.7°, 109.6°, 103.6°, 99.8°, UH>OH.

Lumbar Flex-Ext ROM: 67.9°, 62.6°, 61.0°, 74.2°, OH>UH/CH.

Cervical Rotation Strength: 20.8%BM, 22.4%BM, 24.6%BM, 19.9%BM,

CH>AH/UH/OH; UH>OH. Upp Trapezius Strength: 496.9%BM, 593.1%BM,

645.9%BM, 491.5%BM, UH/CH>AH; UH>OH. Mid Trapezius Strength:

12.6%BM, 15.2%BM, 19.2%BM, 12.1%BM, UH/CH>AH/OH; CH>UH.

Lower Trapezius Strength: 13.4%BM, 16.0%BM, 20.9%BM, 12.5%BM,

UH/CH>AH/OH; CH>UH. **DISCUSSION:** Decreased cervical/hip ROM and

trapezius muscular strength may predispose OH58 pilots to NP/LBP. Early detection of suboptimal neuromuscular characteristics could help developing aircraft-specific intervention strategies. Supported by USAMRMC #W81XWH-11-2-0097

Wednesday, May 03
Plaza A/B

10:30 AM

S-059: PANEL: RESIDENT GRAND ROUNDS II

Sponsored by The American Society of Aerospace Medicine Specialists

Chair: Mark Coakwell
Dayton, OH

PANEL OVERVIEW: This panel will consist of pairs of Aerospace Medicine residents presenting clinical cases of aeromedical interest or significance. During their residency practicum years, residents conduct evaluations of patients with diverse medical problems. Residents prepare and present a case report based on a patient encounter undertaken during their practicum experience. One resident from each pair presents the history of the presented problem. The other resident presents the physical findings and a discussion of the aeromedical policies associated with the condition. Learning Aerospace Medicine at the specialist level involves understanding the impact of medical conditions on aircrew health and mission accomplishment. The cases presented will not only be of academic interest but will also illustrate aeromedical decision making in the operational environment.

Wednesday, May 03
Plaza D/E

10:30 AM

S-060: PANEL: OPERATIONAL BASED VISION ASSESSMENT RESEARCH PANEL

Co-Chair: James Gaska
Wright-Patterson AFB, OH

Co-Chair: Steven Hadley
Wright-Patterson AFB, OH

Co-Chair: Marc Winterbottom
Wright-Patterson AFB, OH

PANEL OVERVIEW: The objectives of the USAFSAM Operational Based Vision Assessment (OBVA) Laboratory, and similar programs of

research across multiple laboratories, are to 1) provide quantitative data defining the visual performance capability that will contribute to success of the mission; 2) provide operational based vision standards and waiver criteria and evaluate human performance with the use of vision correction, enhancement, protective technologies; 3) uncover strategies (training, engineering) to improve vision performance and possibly counter innate or acquired deficiencies; 4) establish platform-specific vision standards; and 5) modernize aircrew vision screening. This panel presents the results from several different research laboratories concerning OBVA research. The first presentation, from USAFSAM, provides an overview of OBVA research objectives and discusses the importance of the development of automated vision testing and vision standards and screening modernization. The second presentation from USAFSAM presents research concerning the effect of color deficiency on the identification of color-coded precision approach path indicator (PAPI) landing lights. A third presentation from USAFSAM describes the effect of a veiling luminance, or "green glow", on the detection of external aircraft lights, as well as the recovery period after the veiling luminance is turned off. This has been an issue not only for the F-35, but for other vision enhancement devices such as NVGs and previously fielded HMDs. A presentation by DSO National Laboratories (Singapore) describes research evaluating a new computer-based functional field of view vision test and the relationship between test results and the detection of peripherally located air-to-air targets. Finally, a fifth presentation from Defence Research and Development Canada (DRDC), in collaboration with York University Center for Vision Research, will discuss the importance of stereopsis for distance estimation in the context of a simulated rotary wing landing task.

[298] THE EFFECT OF VISIBILITY AND COLOR DEFICIENCY ON PRECISION APPROACH PATH INDICATOR IDENTIFICATION IN A SIMULATED NIGHT LANDING SCENARIO

J.P. Gaska, M. Winterbottom, C.T. Bullock and S.C. Hadley
OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

INTRODUCTION: Precision approach path indicator (PAPI) lights assist pilots in maintaining the proper glideslope while landing. Because PAPI lights use a four-light array of red and/or white lights to convey glideslope information, it is important to quantify how color vision deficiency affects performance when using these devices. **METHODS:** Forty-two observers participated in this Institutional Review Board-approved study and were classified as color-normal (15), protan (11), or deutan (16) using the Operational Based Vision Assessment cone contrast test. The high spatial resolution (0.5 arcmin/pixel) Operational Based Vision Assessment dome was used to simulate a night landing at Sheppard AFB. The individual PAPI lights were effectively point sources that matched the chromaticity values of aviation white and aviation red and, importantly, the luminance of the white lights was fixed at twice that of the red lights. Observers were positioned at a simulated distance of 3 mi from the runway and were required to identify if the PAPI lights were all-red (too low), all-white (too high), or absent. Psychometric functions relating the proportion of correct responses to atmospheric visibility level were estimated for both detection (PAPI present or absent) and discrimination (red vs. white) performance. **RESULTS:** For detection, the group mean performance of color normal and color deficient observers was not different at any visibility level. For discrimination, mean protan performance also did not differ significantly from normal. For deutans, discrimination performance was significantly lower than color normal observers, although the differences were small and there was a large overlap between members of the two groups. **DISCUSSION:** The performance losses due to color vision deficiency documented in this research are much smaller than in previous research. This is likely due to the fact that previous studies randomized luminance between trials to minimize luminance difference cues, whereas the current study used a fixed white/red luminance ratio. Because the current experiment better replicates the operational visual environment, it is likely that previous studies have overestimated the expected performance loss of color vision deficient individuals when using PAPI lights.

Learning Objectives:

1. Understand how precision approach path indicator (PAPI) lights assist pilots in maintaining the proper glideslope while landing.

2. Understand why it is important to quantify how color vision deficiency affects performance when using these PAPI lights.
3. Understand how the OBVA lab uses simulated operational task to investigate the relationship between visual capabilities and operational performance.

[299] AN OBJECTIVE ASSESSMENT OF FUNCTIONAL-FIELD-OF-VIEW USING PHYSIOLOGICAL SIGNALS

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INTRODUCTION: The functional-field-of-vision (FFOV) describes the visual area around the eye fixation where information is attended to. Current FFOV assessments are largely based on subjective responses. Objective assessments of relevant physiological markers should also be investigated to support the validity of subjective results. In the current literature, two physiological signals, Steady State Visual Evoked Potential (SSVEP) and Pupillary Oscillation (OP) have shown to be potential markers of vision attention. In this study, we investigated the relationship between FFOV and physiological signals (SSVEP and OP). **METHODS:** Fifty-seven healthy human participants with best-corrected visual acuity of 6/6 or better in both eyes and no visual field defects were recruited. All participants underwent two computer-based tasks. The first task was a FFOV task where participants were instructed to respond to both the central aircraft target changes and the placement of the 4 peripheral aircraft targets which were briefly presented. The percentage correct responses to both the central and peripheral targets defined the FFOV performance scores. The second task was an extremely difficult task aimed to stretch the vision attentional limit around the eye fixation. It consisted of trials presenting a single randomly orientated letter 'C' target surrounded by an annulus-ring stimulus filled with checker-patterns and distractors. Participants were instructed to make the best effort to identify both the central 'C' target's orientation and the position of the peripheral target correctly. The checker-patterned annulus ring was pattern-reversed to produce SSVEP signals, from the scalp around occipital region. The onset frequency of the peripheral distractors was set to elicit OP signals that were recorded as pupil size changes. **RESULTS:** Multiple linear regression revealed a statistical significant equation with an R^2 of 0.632 ($F(26,30)=1.986$, $p=0.036$). Further analysis on the sizes of annulus ring suggested that ring radius of 6.5° , 9° , and 11.5° have the strongest impact on the predictability of FFOV from the physiological signals. **DISCUSSION:** The results suggested the possibility of an objective test using physiological signals recorded from the occipital region of the brain and pupil behavior from the eye to support the findings on FFOV subjective performance.

Learning Objectives:

1. The use of physiological signals as the method to objectively assess visual performance.

[300] THE IMPACT OF STEREOSCOPIC 3D DEPTH CUES ON DISTANCE ESTIMATION IN A SIMULATED LOW HOVER SCENARIO

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INTRODUCTION: Stereopsis is the ability to perceive depth based on binocular disparity and is believed to be important for certain aircrew tasks. For example, functional stereoscopic vision has been shown to provide an advantage for boom operators during certain aerial refueling scenarios. We propose that stereopsis will aid depth estimation in rotary-wing hover maneuvers. To test this hypothesis, we assessed performance on a distance estimation task under stereoscopic (S3D) and monocular (2D) viewing conditions. **METHODS:** Four types of S3D still images (3 terrains, one control pattern without 2D cues) were simulated from the point of view of a Flight Engineer looking downward (45deg) out a helicopter door. The end of a helicopter skid was visible and provided a consistent

reference point in all images. Test altitudes from the skid to the ground ranged from 0-5ft with a 2" step size. Observers (n=14, 7 female) estimated the distance between the skid and the ground. To do this, they assigned a value to represent the distance between their head position and the skid, and judged the distance from the skid to the ground relative to that value. All observers participated in S3D and 2D viewing conditions. Normalized data was analyzed using a linear mixed-effects model with full maximum-likelihood estimation methods. **RESULTS:** Estimates of relative distance were significantly affected by the viewing mode: performance was significantly more accurate in the S3D than in the 2D conditions. When terrains were viewed monocularly, observers did scale their estimates with distance, but were well below expected values. **DISCUSSION:** These results support the hypothesis that stereopsis facilitates judgements of relative distance in simulated low hover scenarios. Future experiments will determine if the advantage afforded by stereopsis remains at larger distances (high hover), and if it is maintained when additional 2D information (e.g. relative size) is available.

Learning Objectives:

1. The participant will learn about operational requirements for stereoscopic depth perception in the context of rotary wing operations.

[301] OPERATIONAL BASED VISION ASSESSMENT RESEARCH PANEL OVERVIEW, RESEARCH OBJECTIVES AND IMPORTANCE OF DEVELOPMENT OF AN AUTOMATED VISION TESTER (AVT)

S.C. Hadley⁴, M. Winterbottom³, J.P. Gaska¹ and L. Williams²
¹FECO, 711/HPW/USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; ²USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; ³OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; ⁴Ophthalmology, USAF School of Aerospace Medicine, Niceville, FL

MOTIVATION: The USAFSAM Operational Based Vision Assessment Laboratory is conducting collaborative vision research with the U.S. Army, U.S. Navy, Canadian Defence Research and Development Canada (DRDC)-Toronto/York University; the Canadian Forces Environmental Establishment (CFEME); Singapore Defence Science Organisation (DSO) National Laboratories and Australia Defence Science and Technology Group and Israel Air Force (IAF). Collaborative research will be introduced and the USAF Automated Vision Tester (AVT) development will be discussed. **OVERVIEW:** The objectives of the USAFSAM Operational Based Vision Assessment (OBVA) Laboratory, and similar programs of research across multiple laboratories, are to 1) provide quantitative data defining the visual performance capability that will contribute to success of the mission; 2) provide operational based vision standards and waiver criteria and evaluate human performance with the use of vision correction, enhancement, protective technologies; 3) uncover strategies (training, engineering) to improve vision performance and possibly counter innate or acquired deficiencies; 4) establish platform-specific vision standards; and 5) modernize aircrew vision screening. This panel presents the results from several different research laboratories concerning OBVA research. The first presentation, from USAFSAM, provides an overview of OBVA research objectives and discusses the importance of the development of automated vision testing and vision standards and screening modernization. **SIGNIFICANCE:** The Operational Based Vision Assessment collaborative group individual research projects will be presented in this panel. In addition, the development of the AVT and its potential impact will be discussed in detail.

[302] THE EFFECT OF HMD GREEN GLOW ON AIRCRAFT DETECTION IN A SIMULATED NIGHT REFUELING SCENARIO

L. Williams, J.P. Gaska, M. Winterbottom and S.C. Hadley
 OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

INTRODUCTION: During nighttime missions, the visor illumination in the F-35 HMDS, even at the minimum brightness setting, can obscure out-the-window visual features that may be important for piloting the aircraft. In order to quantify the relationship between visor illumination or "green glow"

intensity and operational performance we simulated a nighttime refueling scenario and measured detection thresholds for aircraft in the airspace near the refueling aircraft. **METHODS:** Seven well trained observers participated in this IRB approved experiment. They sat in a darkened room and viewed a projected image through an HMD and were instructed to fixate on a KC-135 tanker with wing lights turned on against a (low mesopic) sky luminance of 0.02 candelas per square meter. In a given trial, an F-35 fighter, also with wing lights turned on, appeared to either the right or left of the tanker and the observer was required to push a button corresponding to the fighter location. An adaptive threshold estimation (PSI) method was used to estimate the F-35 distance or wing-light luminance required to reliably detect the fighter location. In the steady state experiments, the green glow luminance was held constant and thresholds were measured at seven intensity levels ranging from green glow off to approximately 80 times the nighttime sky luminance. In the dynamic condition, green glow was repetitively turned on at the maximum luminance level for 15 seconds and then turned off for 15 seconds. Thresholds were estimated every 3 seconds during this alternating cycle, for a total duration of 18 minutes. **RESULTS:** There was approximately a 4-fold increase in luminance thresholds measured at the highest green glow level relative to the green glow off condition. The dynamic measurements demonstrated that the observers adapted to the change in green glow within 3 seconds of the transition. **DISCUSSION:** Efforts are currently underway to reduce the green glow levels in the next generation of the F-35 HMD. This research provides a quantitative description of the performance gains expected from reducing green glow in missions that require detecting outside light references.

Learning Objectives:

1. The objective is to understand the degree to which green glow in a helmet mounted display effects operational performance by reducing contrast of the out-the-window visual scene.

Wednesday, May 03
 Plaza F

10:30 AM

S-061: SLIDE: PHYSIOLOGY OF SPACEFLIGHT

Co-Chair: Judith Hayes
 Friendswood, TX

Co-Chair: Alan Moore
 Houston, TX

[303] HEMOGLOBIN O₂ SATURATION WITH MILD HYPOXIA AND MICROGRAVITY

J. Conkin², J.H. Wessel³, J.R. Norcross¹, O. Bekdash¹, A.F. Abercromby⁴, M.D. Koslovsky¹ and M.L. Gernhardt⁵
¹KBRwyle, Houston, TX; ²KBRwyle, Houston, TX; ³KBRwyle, Houston, TX; ⁴NASA, Houston, TX; ⁵NASA, Houston, TX

INTRODUCTION: The increase in the alveolar-arterial oxygen (O₂) partial pressure gradient during increasing hypoxia may further increase in microgravity (μ G). **METHODS:** Four male astronauts on STS-69 (1995) and four on STS-72 (1996) submitted to an acute sequential hypoxic challenge by breathing for 4 minutes at 18.0%, 14.9%, 13.5%, 12.9%, and 12.2% O₂ – balance nitrogen at sea level. The 18.0% O₂ mixture was equivalent to an inspired O₂ partial pressure (P_iO₂) of 127 mm Hg when exposed to 527 mm Hg while breathing 26.5% O₂ for several days in μ G. A Novamatrix CO₂SMO Model 7100 recorded heart rate (HR, beats \times min⁻¹) and hemoglobin (Hb) O₂ saturation through finger pulse oximetry (S_pO₂, %), end-tidal carbon dioxide partial pressure (P_{ET}CO₂, mm Hg), and respiration rate (RR, breaths \times min⁻¹) through an infrared capnograph positioned in a mouthpiece. Measurements were also taken the day of return to Earth (R+0) and at R+2. Linear mixed effects models assessed changes in S_pO₂ after exposure to μ G. Interactions between measurement condition and available physiologic measurements were also explored. **RESULTS:** Astronaut S_pO₂ levels at baseline, R+0, and R+2 were not significantly different from in flight, about 97% given a P_iO₂ of 127 mm Hg. There was no difference in astronaut S_pO₂ levels between baseline and R+0 or R+2 over the hypoxic challenge. Additionally, no significant interactions were identified. **CONCLUSIONS:** While μ G did not affect astronaut Hb O₂ saturation in this study, large

within- and between-subject variability in S_pO_2 at increasingly hypoxic doses require a deeper understanding of subject-specific factors that influence O_2 transfer onto Hb.

Learning Objectives:

1. To better understand the transport of O_2 from a mildly hypoxic environment onto hemoglobin when transition to and from μG are considerations.
2. Application of appropriate statistics to minimize within- and between-subject variability in S_pO_2 response to sequential hypoxic challenge.

[304] INCREASED CEREBRAL BLOOD PULSATILITY DURING HEAD-DOWN TILT AND CO_2 EXPOSURE: SPACE-COT STUDY

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INTRODUCTION: Some astronauts have exhibited visual symptoms during and post-flight, including hyperoptic shifts, posterior eye globe flattening, dilated optic nerve sheaths, and even papilledema. The symptoms do not reliably disappear upon return to earth, and globe flattening combined with elevated lumbar puncture pressures in some astronauts implicates cephalad fluid shifts. Elevated CO_2 levels could exacerbate such fluid shifts. We investigated the hypothesis that cerebral blood volume (CBV) pulsatility is increased during head-down tilt (HDT) and also with exposure to elevated carbon dioxide (CO_2). **METHODS:** This investigation was part of the SPACE-COT study conducted at the German Aerospace Center's envihab facility, Cologne, Germany in collaboration with the National Space Biomedical Research Institute. Six healthy subjects were recruited to participate in two 30-hour -12° HDT sessions: one in ambient air (0.04% CO_2) and one in elevated CO_2 (0.5% CO_2). Near-infrared spectroscopy was used to monitor regional cerebral blood volume changes over time in prefrontal cortex at baseline and at 0.5, 5.5, and 21.5 hours into the HDT protocol. Total hemoglobin (HbT) pulsatility was quantified at both cardiac (~1 Hz) and Mayer wave frequencies (~0.1 Hz). **RESULTS:** Mixed-effects linear regression was conducted with factors of: (i) hours in HDT, (ii) environment (0.04% vs. 0.5% CO_2), and (iii) time by environment interaction. Cardiac pulsatility (CP) exhibited a significant linear increase over time (0.031 ± 0.009 mM/hour, $p=0.001$). A marginal interaction ($p=0.07$) suggested that CP may be more pronounced in CO_2 than in ambient air. The Mayer pulsatility (MP) amplitude exhibited a significant interaction ($p=0.049$). This was caused by a strong linear increase in MP over time during HDT with elevated CO_2 but a small, static increase in MP during HDT in ambient air. **DISCUSSION:** CBV pulsatility increased with time in HDT, and Mayer pulsatility is further enhanced in the elevated CO_2 environment. Since NIRS pulsatility reflects arterial vessel "distension", we speculate that chronic, long-duration changes in pulsatility serves as a mechanical stimulus that could initiate vascular (or even nerve sheath or ocular) remodeling, thus helping explain astronauts' symptoms. It remains to be determined if these changes are associated with significant alterations in static ICP, and whether cerebrospinal fluid pressure-buffering is fully compensatory.

Learning Objectives:

1. Better understand NASA's visual impairment and intracranial pressure risk.
2. Learn about a novel application approach for near-infrared spectroscopy.
3. Learn about potential physiological interactions between the head-down tilt analog for spaceflight and elevated CO_2 .

[305] RELATIONSHIP BETWEEN CARBON DIOXIDE LEVELS AND REPORTED CONGESTION AND HEADACHES ON THE INTERNATIONAL SPACE STATION

R. Cole^{2,1}, J. Bowman⁶, C. Coble⁴, M. Young³, S. Mason⁵ and M.L. Wear²
¹University of Texas, League City, TX; ²KBRwyle, Houston, TX; ³NASA, Houston, TX; ⁴MEIT, Houston, TX; ⁵MEIT, Houston, TX; ⁶Harvard Affiliated Emergency Medicine Residency, Boston, MA

INTRODUCTION: Congestion is common during spaceflight, and congestion medications have been used on the International Space Station (ISS). While congestion has been attributed to fluid shifts, fluid equilibrium is reached during the first week of flight but congestion still continues to be reported. Congestion has anecdotally been reported in relation to ISS CO_2 levels; this evaluation was undertaken to determine if an association exists. **METHODS:** Reported headaches (HA), congestion symptoms, and CO_2 levels were obtained for ISS expeditions 2-31, and time-weighted means and single-point maxima were determined for 24-hour (24hr) and 7-day (7d) periods prior to each weekly private medical conference. Multiple imputation addressed missing data, and logistic regression modeled the relationship between probability of reported event of congestion or HA and CO_2 levels, adjusted for possible confounding covariates. The first seven days of flight were not included to control for fluid shifts. Data were evaluated to determine the CO_2 concentration required to maintain the risk of congestion below 1% to allow for direct comparison with a previously published evaluation of CO_2 concentrations and HA. **RESULTS:** This study confirmed a previously identified association between CO_2 and HA and also found a significant association between CO_2 and congestion. Each 1-mmHg increase in CO_2 doubles the odds of a crewmember reporting congestion. The average 7d CO_2 would need to be maintained below 1.5 mmHg to keep the risk of congestion below 1%. The predicted probability curves of HA and congestion curves appear parallel when plotted against pp CO_2 levels with congestion occurring at approximately 1 mmHg lower than HA would be reported. **DISCUSSION:** While there are multiple causes of congestion, congestion is associated with ISS CO_2 levels. CO_2 levels are also associated with reported HA. While it may be expected for crew with congestion to also complain of HA, these two symptoms are commonly mutually exclusive. Furthermore, it is unknown if a temporal CO_2 relationship exists between congestion and HA. CO_2 levels were time-weighted for 24hr and 7d, and thus the time course of congestion leading to HA was not assessed; however, congestion could be an early CO_2 -related symptom when compared to HA. Future studies evaluating if CO_2 -related congestion leads to HA would be difficult due to the relatively stable daily ISS CO_2 levels, but a systematic study could be implemented if desired.

Learning Objectives:

1. Understand there is a relationship between CO_2 and congestion on the International Space Station.
2. Understand there is a relationship between CO_2 and headache on the International Space Station.

[306] ACCOUNTING FOR GRAVITY IN OCULAR HEMODYNAMICS AND INTRAOCULAR PRESSURE MODELING

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INTRODUCTION: Head down tilt bed rest is often used as an analog for physiological changes in space, but ocular changes observed in bed rest differ from changes seen in microgravity. Microgravity exposure eliminates both hydrostatic gradients and compressive forces due to tissue weight. These effects are impossible to eliminate in any long-term study on Earth. Because of this, ocular system models should incorporate these variables to predict how the eye adapts to gravitational changes. **METHODS:** Using a Georgia Institute of Technology developed model we predicted IOP changes over the course of 25 minutes in the supine and prone positions by setting G_x (gravity in the head-to-toe direction) to 1 upright, and to 0 supine/prone. We compared model results to corresponding IOP data from a previous study using human subjects. We modified the model to account for gravitational changes in the G_x (chest-to-back direction) in addition to the G_z direction. The model included a feature to use either literature-derived supine episcleral venous pressure data to compute ocular venous pressure (OVP), or to calculate OVP from central venous pressure and hydrostatic factors. For supine results, we used literature-derived EVP values which improved model accuracy. Literature values for prone EVP were not available in the model. **RESULTS:** After 15 minutes supine, human subjects had an average IOP of 12.7 mmHg. Without accounting for G_x the

model predicted an IOP value of 13.0 mmHg. With G_x included, the prediction improved slightly to 12.9 mmHg. In the prone position, after 15 minutes, human subjects had an average IOP value of 18.0 mmHg. Without accounting for G_x , the model predicted an IOP value of 10.7 mmHg. With G_x included, the prediction improved to 18.8 mmHg. **DISCUSSION:** The model initially predicted IOP changes in the supine but not prone conditions. Adding a G_x term increased the accuracy of predictions for both the supine and prone positions. The corneal surface where IOP is measured is above heart level supine and below it prone. The hydrostatic gradient changes due to gravity in the G_x direction must be incorporated in addition to the G_z change to predict ocular changes better. Work is in progress to expand these results to the microgravity condition. Incorporating all these gravitational effects will help to understand and predict ocular changes when the gravity vector is removed in microgravity.

Learning Objectives:

1. To understand the factors that may contribute to visual changes in microgravity and how they can be modeled.

[307] OCULAR COHERENCE TOMOGRAPHY IN THE EVALUATION OF ANTERIOR EYE INJURIES IN SPACEFLIGHT

D.M. Fer², J. Law¹ and J. Wells¹

¹NASA Johnson Space Center, Houston, TX; ²Surgery, University of California San Francisco East Bay, Oakland, CA

PROBLEM STATEMENT: While Ocular Coherence Tomography (OCT) is not a first-line modality to evaluate anterior eye structures terrestrially, it is a resource already available on the International Space Station (ISS) that can be used in medical contingencies that involve the anterior eye. With remote guidance and subject matter expert (SME) support from the ground, a minimally trained crewmember can now use OCT to evaluate anterior eye pathologies on orbit. **TOPIC:** OCT utilizes low-coherence interferometry to produce detailed cross-sectional and 3D images of the eye in real time. Terrestrially, it has been used to evaluate macular pathologies and glaucoma. Since 2013, OCT has been used onboard the ISS as one part of a suite of hardware to evaluate the Visual Impairment/Intracranial Pressure risk faced by astronauts, specifically assessing changes in the retina and choroid during spaceflight. The Anterior Segment Module (ASM), an add-on lens, was also flown for research studies, providing an opportunity to evaluate the anterior eye in real time if clinically indicated. Anterior eye pathologies that could be evaluated using OCT were identified. These included corneal abrasions and ulcers, scleritis, and acute angle closure glaucoma. A remote guider script was written to provide ground specialists with step-by-step instructions to guide ISS crewmembers, who do not get trained on the ASM, to evaluate the anterior eye. The instructions were tested on novice subjects and/or operators, whose feedback was incorporated iteratively. The final remote guider script was reviewed by SME optometrists and NASA flight surgeons. **APPLICATIONS:** The novel application of OCT technology to spaceflight allows for the acquisition of objective data to diagnose anterior eye pathologies when other modalities are not available. This demonstrates the versatility of OCT and highlights the advantages of using existing hardware and remote guidance skills to expand clinical capabilities in spaceflight. **RESOURCES:** Doors M, Berendschot TT, de Brabander J, Webers CA, Nuijts RM. Value of optical coherence tomography for anterior segment surgery. J Cataract Refract Surg. 2010 Jul; 36(7):1213-29.

Learning Objectives:

1. Discuss how Ocular Coherence Tomography can be used to evaluate anterior eye pathologies on the International Space Station.

[308] SOMATIC MOSAICISM AND HUMAN SPACEFLIGHT: A NEW CHAPTER IN HUMAN GENETICS RESEARCH

C.T. Haas^{2,1}, C. Shaw^{1,5}, V.E. Wotring^{1,3}, T. Johnson¹, C. Moreno¹, J.P. Sutton¹ and G.B. Scott^{1,4}

¹Center for Space Medicine, Baylor College of Medicine, Houston, TX; ²Internal Medicine, Baylor College of Medicine, Bellaire, TX; ³Pharmacology, Baylor College of Medicine, Houston, TX; ⁴Molecular and Cellular Biology, Baylor College of Medicine, Houston, TX; ⁵Molecular and Human Genetics, Baylor College of Medicine, Houston, TX

INTRODUCTION: The astronaut genomic analysis project (AGAP) has sequenced DNA of retired astronauts to detect possible mutational signatures of human spaceflight. Our study is focusing on characterizing long-term accumulation of somatic mutations - those mutations arising in a subset of cells during an individual's lifetime. **METHODS:** Peripheral blood was collected from 11 retired astronauts, 7 males and 4 females, and 4 terrestrial controls. DNA was extracted by standard methods. Each astronaut DNA sample was used to produce 4 technical replicate libraries using an 8-mer 96 x 96 molecular indexing method (NextFlex, Bioo Scientific). These libraries were pooled and subjected to custom capture enrichment (Nimblegen) prior to amplification and sequencing. Targeted regions (n=8772) included all exons from the Catalogue of Somatic Mutations in Cancer (COSMIC) gene census list, encompassing 1.6 megabases (MB). Molecular indexing was used to ensure mosaic variation was not the result of experimental artifacts. A subset of candidate somatic variants identified will be validated using quantitative allele-specific PCR assays. DNA variants seen in astronaut samples will be compared to DNA variants observed in four healthy adult terrestrial control samples and a reference genome, NA12878. **RESULTS:** All research subjects' DNA samples passed quality control. Aligned sequencing depth averaged approximately 450 reads per nucleotide, covering over 90% of the 1.6 MB targeted. Analysis revealed candidate mosaic sites in all astronauts and controls. Repeated mosaic sites were observed across independent library preparations, indicating the likely true-positive nature of mosaic findings. Bioinformatics comparisons demonstrate that most candidate mosaic sites are C>T (G>A) transition events. Analyses comparing astronauts with control samples is ongoing. **DISCUSSION:** This is a pilot study for sequencing DNA of astronauts who have flown in space, and the intent of the study is to identify parameters necessary for the design of well-powered models with a larger cohort. We have identified likely true-positive somatic mosaicism with a preponderance of C>T transition events. Comparison of these mutations with control samples may reveal how somatic mosaic events are affected by the space environment and specifically by space radiation. In the future, prospective studies might inform effective interventions for radiation induced somatic mutations in astronauts.

Learning Objectives:

1. Describe the key differences between inherited mutations and somatic mutations.
2. Describe how environmental exposures such as space radiation could increase the prevalence of somatic mutations within an individual over time.
3. Describe the potential clinical consequences of somatic mutations.

Wednesday, May 03
Governor's Square 14

10:30 AM

S-062: PANEL: AEROSPACE SAFETY CENTERS YEAR-IN-REVIEW: 2016

Sponsored by AsMA Aerospace Safety Committee

Co-Chair: Tyler Brooks

Ottawa, Ontario, Canada

Co-Chair: Dana Windhorst

Kirtland AFB, NM

PANEL OVERVIEW: This panel presents the results of a review of 2016 aerospace safety data. Representatives from military and civil aerospace organizations will present summaries and analyses of their safety data collected in 2016. Cause factors, including mechanical and human factors, will be explored, identifiable trends will be highlighted, and updates on risk mitigation strategies will be discussed. With certain types of accidents increasingly becoming rare events, the panel discussion is a unique opportunity to review the collective experiences of multiple safety programs and consider a variety of risk mitigation solutions.

[309] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: 2016 YEAR IN REVIEW

T. Brooks

Director of Flight Safety, Canadian Armed Forces, Ottawa, Ontario, Canada

INTRODUCTION: The Royal Canadian Air Force (RCAF) operates all Army, Navy and Air Force aircraft in the Canadian Armed Forces. The Director of Flight Safety (DFS) investigates aviation occurrences with the goal of preventing accidental loss of aircraft and personnel. Contributory or causal human factors are identified using the Canadian Forces Human Factors Analysis and Classification System (CF-HFACS). Statistics and analysis from fiscal year (FY) 16 are discussed. **METHODS:** Class A and B accidents in FY16 were reviewed to identify human factors which may have caused or contributed to these occurrences. These factors were reviewed in the context of previously identified hazards which have been prioritized by DFS and include: fatigue, culture, and substances hazardous to aviation. **RESULTS:** Fatigue, culture and substances hazardous to aviation continue to be relevant hazards in the RCAF. **DISCUSSION:** DFS has undertaken several initiatives specifically aimed at mitigating these factors.

Learning Objectives:

1. The participant will be able to describe recent initiatives undertaken by DFS to address hazards to aviation in the RCAF.

[310] U.S. CIVIL AVIATION SAFETY IN 2016

C.A. DeJohn and W.D. Mills

AAM-600 Aerospace Medical Research Division, FAA Civil Aerospace Medical Institute, Oklahoma City, OK

INTRODUCTION: The National Transportation Safety Board investigates all civil aviation accidents and reports current and historical accident data. Trends in accident rates and performance data were analyzed for all types of civil aviation operations with emphasis on 2016 data. **METHODS:** U.S. civil aviation accident data was analyzed to determine trends from 1990 to 2016, whereas safety performance measures were analyzed for various time periods depending on available data. **RESULTS:** Fatal accident rates for all types of operations significantly decreased for the period 1990 to 2016 ($p < 0.05$). Air taxi and general aviation accident rates decreased more rapidly than their respective fatal accident rates ($p < 0.01$). Safety performance measures for commercial air fatalities, runway incursions and general aviation fatal accidents all showed that actual rates were significantly below the target rates ($p < 0.01$) for 2008 to 2016. **DISCUSSION:** An analysis of accident rates between 1990 and 2016 and safety performance measures trends from 2008 through 2016 for all types of operations indicated steady improvements in civil aviation safety.

Learning Objectives:

1. To become familiar with the three most important FAA Safety Performance Measures.
2. To become familiar with the three most important initiatives to reduce the general aviation fatal accident rate.
3. To become familiar with the accident rates for air carrier, commuter, air taxi and general aviation.

[311] U.S. ARMY AVIATION SAFETY: YEAR IN REVIEW FY2016M. McPherson¹ and R.J. Dickinson²*¹U.S. Army School of Aviation Medicine, Enterprise, AL; ²U.S. Army Combat Readiness Center, Fort Rucker, AL*

INTRODUCTION: Discuss (FY)2016 accident statistics and analysis for USA Class A-C aviation mishaps including human factors analysis. **METHODS:** FY2016 data was obtained from U.S. Army Combat Readiness Center database (RMIS) for Class A-C aviation mishaps and reviewed for human factors analysis as determined by Centralized Accident Investigation boards. **RESULTS:** In the manned aviation category Army Aviation experienced 61 Class A-C mishaps in FY2016. This is a 27% decrease from the 81 Aviation mishaps in FY2015. The U.S. Army experienced seven Class A Mishaps in FY16 from the 13 Class A mishaps in FY15. The Class A accident rate dropped from 1.52/100k flight hour to 0.87/100k flight hour. There were eight mishap fatalities in FY16. **DISCUSSION:** Overall the Class

A accident rate decreased 43% from FY15 to FY16. Human error accounted for all of the Class A mishaps and 86% of the Class A-C mishaps.

Learning Objectives:

1. Review the overall trend in U.S. Army manned aviation accidents.
2. Discuss human error in aviation mishaps.

[312] NAVAL AVIATION SAFETY: 2016 YEAR IN REVIEW

M. Penny, L.A. Vitatue and K. Littel

U.S. Navy, Code 10, Naval Safety Center, Norfolk, VA

INTRODUCTION: The Naval Safety Center analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors. **METHODS:** All Class A flight mishaps involving U.S. Navy and Marine Corps aircraft during fiscal year 2016 (FY16) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 16 there were 7 Class A mishaps in the U.S. Navy (0.81 per 100,000 flight hours) and 8 Class A mishaps in the U.S. Marine Corps (3.31 per 100,000 flight hours). A review of Class A flight mishaps over the past 10 years demonstrated that human factors were the predominant causal factors. Current emerging topics of discussion related to Naval Aviation Safety will also be presented. **DISCUSSION:** HFACS is a useful tool in safety investigation analysis and assists in identifying causal factors to focus mitigation strategies to prevent future mishaps. Its standardization across the Department of Defense facilitates cross-analysis and shared efforts to prevent future mishaps. On-going challenges include human systems integration in new and legacy platform upgrades.

Learning Objectives:

1. Review the overall trend in U.S. Navy and Marine Corps flight mishaps and the most common human factors identified as causal factors.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for Naval Aviation mishaps.
3. Review the trends in Naval Aviation mishap HFACS causal factors over the last decade.

[313] U.S. AIR FORCE AVIATION SAFETY: FY 2016 YEAR IN REVIEW

D. Windhorst, D. Porter, B.T. Musselman, T.S. Strongin and T.E. Mayfield

Human Factors Division, USAF Safety Center, Kirtland AFB, NM

INTRODUCTION: Review of fiscal year (FY) 2016 statistics and analysis for USAF Class A, Aviation mishaps including classification with DoD Human Factors Analysis and Classification System (DoD HFACS). **METHODS:** FY16 data was obtained from the USAF Safety Center database for Aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards (SIB). The human factors present were categorized for the present year and the preceding 8 years. **RESULTS:** The U.S. Air Force experienced 12 Class A aviation mishaps during FY16 (a rate of 0.88 per 100,000 flight hours) with 9 destroyed aircraft and 16 fatalities. The review of Class A aviation mishaps over the past year demonstrated that most are attributed to human factors. The use and analysis of DoD HFACS will be discussed. **DISCUSSION:** Although the total number of Class A aviation mishaps and the overall Class A mishap rate decreased significantly from FY15, the number of fatalities increased due to the types of aircraft involved. Human factors analysis reveals patterns of contributory factors that appear to be amenable to organizational influence.

Learning Objectives:

1. The audience will know the overall trend in USAF mishaps and human factors contributing to current year mishaps in comparison with data from previous years.
2. The audience will know how human factors appear to have influenced the occurrence of these mishaps.

[314] NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) 2016 YEAR IN REVIEW

T.G. Dillinger

Office of Safety and Mission Assurance, NASA Headquarters, Washington, DC

INTRODUCTION: This presentation provides information regarding NASA reportable mishaps, close calls, and hi-visibility events during the year 2016. In addition to occurrence data, Human factors and mishap prevention information is also provided. The focus will be on current data, analysis, and trends based on 2016 data. **METHODS:** NASA collects Class A, B, C, and D mishap information as well as close calls and hi-visibility events in an investigation database called NMIS – NASA Mishap Investigation System. NMIS data, along with human factors (HF) data from the NASA Safety Center (NSC) database is annually analyzed and reported. This includes analysis and trending by year, aircraft, and other various factors. These results are compared within and across a variety of factors for trending. Data from 2016 will be used to show current events and trending. **RESULTS:** NASA continues to show a decline in reportable events. Aviation mishap rates show a clear decline. While safety rates show improvement, efforts to maintain vigilance and efforts to instill a strong prevention-focused safety culture are an important part of NASA Safety program. **DISCUSSION:** Analysis of NMIS data and safety prevention efforts indicates steady improvements in all safety – including aviation. Efforts to delve further in human factors seek to maintain advancements, continually improve future mishap reduction efforts, and see further decline in preventable mishaps.

Learning Objectives:

1. Review the overall trend in NASA reportable events and common factors associated with those events.

Wednesday, May 03
Governor's Square 15

10:30 AM

S-063: SLIDE: BRAINS, BLOOD, BREATHING, AND WORMS

Co-Chair: Robert Orford
Scottsdale, AZ

Co-Chair: Ryan Peirson
Wright-Patterson AFB, OH

[315] NO NEUROCOGNITIVE IMPAIRMENT FOUND IN U.S. NAVY AIRCREW INFECTED WITH HIV

M. Ajao, R. Carpenter
NAMI, Pensacola, FL

INTRODUCTION: HIV-associated neurocognitive disorders (HAND) can be attributed to either the viral infection or the side effect of suppressive combination antiretroviral therapy (ART). Although studies to date have reported neurocognitive deficits to be more common in HIV-infected individuals—including those taking or not taking ART—than those without the infection, no studies of U.S. Navy (USN) HIV-infected aviation personnel who are optimally medically managed exist in the medical literature. **METHODS:** An IRB-approved retrospective chart review was performed. We reviewed all cases of USN aviation duty HIV waiver requests since 2000. CogScreen-AE, Minnesota Multiphasic Personality Inventory (MMPI), and demographic data were collected. Descriptive statistics were used to describe the data and mean CogScreen-AET scores were calculated. **RESULTS:** Three individuals completed the waiver application process. Ages at time of waiver request ranged from 25-34 years, all were male, and all were treated with antiretroviral therapy. Two individuals were officers and one was enlisted rank. No pathology was detected by the MMPI. T scores on CogScreen-AE ranged from average to above average; case 1 mean T score - 55, case 2 mean T score - 51, case 3 mean T score - 63. **DISCUSSION:** The CogScreen-AE assesses five areas of neurocognitive function: attribute identification, motor coordination, visual association memory, speed/working memory, and tracking. T scores are based on normative data established by major airlines pilots with ranges: <30 associated with significant neurocognitive impairment, 40-60 average, >60 above average. Overall, our cases scored in the average to above average range, suggesting no significant neurocognitive impairment. Although small, this is the first neurocognitive dataset of USN HIV-infected aviation personnel to be published and suggests that further studies should be done to support special military duty waivers for HIV infection.

Disclaimer: The views expressed in this abstract are those of the authors and do not necessarily reflect the official position of the Department of the Navy, Department of Defense, or the U.S. government.

Learning Objectives:

1. Discuss aeromedical implications of HIV infection with respect to neurocognitive function.

[316] PRIMARY SPONTANEOUS UPPER EXTREMITY DVT AND PE IN A MILITARY HELICOPTER PILOT: A CASE REPORT

S. Knight

U.S. Navy, Pensacola, FL

PROBLEM STATEMENT: Upper extremity DVT and PE cause significant complications to the younger pilot population due to medication use and potential complications. **BACKGROUND/LIT REVIEW:** Primary upper extremity DVT is rare but “represents 1 to 4 percent of all cases of deep venous thrombosis. The average age at presentation is in the early thirties and the male to female ratio is 2:1, and involves active individuals, in particular those that participate in over the head activities, i.e. weight lifting, swimming, throwing sports, etc. **CASE PRESENTATION:** The subject pilot was a 35-yr old MH-60 pilot with over 2500 flying hours. The incident occurred while serving in a non-active flying billet. He presented to the flight medicine clinic for his annual flight physical with complaint of mild right deltoid pain 1 day following administration of flu vaccine. Nine days later, he presented to civilian ER with increasing thoracic/flank pain and whole right upper extremity swelling and pain. He did not have any pulmonary or respiratory complaints/complications throughout the course. He was subsequently diagnosed with pulmonary embolism from right upper extremity DVT. Thrombophilia workup was negative and cardiothoracic angiogram revealed compression of basilic and subclavian veins. Medical history was insignificant. Patient was diagnosed with Paget-Schroetter syndrome and was discharged on anticoagulation therapy and referred for infraclavicular thoracic outlet decompression surgery. **OPERATIONAL/CLINICAL RELEVANCE:** This case outlines the evaluation of upper extremity pain and swelling. Primary upper extremity DVT is a rare condition that is a subset of all cases of upper extremity DVT. As primary upper extremity DVT is more common in the younger, more active individuals, which can cause significant morbidity and affect flight status due to treatments necessary. It is important to keep this condition as a possibility in the assessment of upper extremity pain and swelling in the population.

Learning Objectives:

1. Evaluate upper extremity pain/swelling
2. Understand risk factors associated with upper extremity primary DVT
3. Understand treatment options associated with the condition and how they affect aviation.

[317] VENOUS THROMBOEMBOLISM IN PILOTS

J. Siedenbarg

Medical Dept., Lufthansa, Uetersen, Germany

PROBLEM STATEMENT: Two cases of pilots with a venous thromboembolism (VTE) are discussed. **BACKGROUND/LITERATURE REVIEW:** Deep vein thrombosis (DVT) and pulmonary embolism (PE) are manifestations of venous thromboembolism (VTE) and occur frequently together. In the U.S., it is the third most cause for fatalities after myocardial infarct and ischemic stroke. The incidence for DVT is less than 1:1000, for PE 1:1700, the mortality for VTE 1:1300 in Europe and all depend on the age. Albeit the fact that many cases of DVT may not be diagnosed properly, the low incidence in the general population results in the assumption that VTE happens in pilots only infrequently. However, pain and dyspnea may distract the pilot from his duties, reduce the physical abilities in a mild hypoxic atmosphere, and result in an incapacitation. Whereas a VTE may be difficult to predict, pilots may come to the attention of flight surgeons after a diagnosis of previous DVT for assessment of their aeromedical fitness. **CASE PRESENTATION:** The presentation discusses the pathophysiology of VTE, two cases of pilots with previous DVT, and VTE respectively, their history, previous aeromedical assessment, disposition and risk as well as regulatory deliberations. In both pilots, dyspnea raised the suspicion for a pulmonary embolism, which was proven by CT later on. A previously unnoticed DVT was

causative in both cases. After proper treatment with intermittent anticoagulation, both pilots applied for recertification and a waiver. Arterial or venous thrombosis and pulmonary embolism require a referral to the licensing authority in Europe according to regulation (EU) 1178/2011. After 6 months of stable anticoagulation, a fit assessment may be considered, even if anticoagulation is continued. A stable anticoagulation has to be documented by frequent INR controls. Cessation of anticoagulation requires another review. An OML limitation, stipulating the affected pilot to operate only in multi-pilot operations is required. **OPERATIONAL/CLINICAL RELEVANCE:** A waiver for pilots after previous VTE has to consider functional sequelae of the previous disorder, the risk of recurrence and – if anticoagulation has not been discontinued – the risk of bleeding. These deliberations are important in the light of a predominantly sedentary occupation at the controls.

Learning Objectives:

1. VTE is a rare coagulation disorder with an age dependent incidence.
2. VTE may result in an incapacitation.
3. VTE requires meticulous risk assessment before recertification, considering functional sequelae, risk of recurrence and bleeding.

[318] LAM - FIT TO FLY? A CASE REPORT

U.L. Diestel

Private Practice, Hamburg, Germany

A 48-year-old female pilot / captain came to my practice in April 2016 the first time after her former AME retired. **CASE HISTORY:** October 2012 she had undergone surgery for partial removal of her left kidney. During a routine ultrasound testing a tumor at the left kidney was found. A histological examination showed an angiolipoma, which tested positive for Vimentin and HMB45. Secretion of these substances lead to reasonable suspicion of Leiomyangiomatosis (LAM). The preoperative X-ray of the lung showed multiple cysts, indicating a high risk of pneumothorax. This suspicion was confirmed: November 2012 at the right lung. Two surgeries followed. First treated with pneumokath, thereafter, pleurodesis with talc. January 2013, the elective pleurodesis followed on the left. March 2013, the pilot started work again. There has been no further occurrence of pneumothorax. According to EASA regulations, this case must be referred to the authority. MED.A50 - (EU) 1178/2011. That procedure took some four months. During that period, the results of O₂-diffusion had decreased slowly. So her pulmonology specialist began treatment with Sildenafil, which she tolerated well. Her results stabilized. Additional exams were required: MRI of the head to exclude meningiomas, pulmonary function test (body plethysmographia), diffusion test, 1-hour testing in a training center, under simulated higher altitude conditions up to 3500 m and continuous measurement of SpO₂. The results were satisfactory. **CONCLUSION:** The pilot got her medical again with following restrictions: TML, OML, SIC. Her Obligations: She is to submit all regular medical exam results. Should be there any change of health status or results the medical will be revoked.

Learning Objectives:

1. A single individual case takes a long time for editing. It needs empathy, phantasy and close collaboration with the authority to come to a satisfactory solution for the pilot.

[319] LUNG FUNCTION IN F-18 PILOTS USING OVER PRESSURE BREATHING SYSTEM

M.J. Mäntysaari², V.J. Mattila³ and T. Leino¹

¹Air Force Command Finland, Tikkakoski, Finland; ²Aeromedical Centre, Centre for Military Medicine, Helsinki, Finland; ³National Defence University, Helsinki, Finland

INTRODUCTION: In Finnish Air Force the positive pressure breathing system of F-18 is used during high G maneuvers. The effect of positive pressure breathing on pilots' lung function in a group of 40 pilots with more than 1000 F-18 flight hours was compared to that in an age-matched group of pilots not flying F-18 (control group). **METHODS:** Lung function was measured using flow-volume spirometry with test of bronchodilator response. Data are given as mean \pm SD and T-test was used in statistical analysis. **RESULTS:** The total flight hours were not significantly different in the F-18 group (1978 \pm 418 hrs) and the control group (1947 \pm 792 hrs, $p=0.816$). The F-18 group had greater height (180 \pm 5 cm) than the control group (178 \pm 5 cm, $p=0.039$). Age and

weight were comparable in the F-18 group and the control group: age 39 \pm 4 and 37 \pm 4 years ($p=0.057$), weight 82 \pm 9 and 83 \pm 12 kg ($p=0.851$), respectively. Use of tobacco products was not significantly different in the two groups. Forced vital capacity (FVC) was 5.80 \pm 0.64 l in F-18 group and 5.59 \pm 0.63 l in the control group ($p=0.128$). Forced expiratory volume in one second (FEV1) was 4.43 \pm 0.48 l and 4.34 \pm 0.47, respectively ($p=0.399$). Maximal instantaneous forced expiratory flow at 50% of FVC (MEF_{50%}) was 4.59 \pm 1.07 l/s and 4.69 \pm 1.15 l/s, respectively ($p=0.768$). Peak expiratory flow (PEF) was 10.51 \pm 1.35 l/s and 10.16 \pm 1.43 l/s, respectively ($p=0.308$). There were no significant differences in the lung function between the two groups. The bronchodilator response was comparable in F-18 and control groups: FVC changed -0.09 \pm 2.15 % and -0.45 \pm 2.57 %, respectively ($p=0.512$). FEV1 increased 4.41 \pm 3.49 % and 3.26 \pm 3.44 %, respectively ($p=0.281$). MEF_{50%} increased 18.08 \pm 13.73 % and 17.40 \pm 13.89 %, respectively ($p=0.979$). PEF increased 2.55 \pm 4.44 % and 1.42 \pm 4.23 %, respectively ($p=0.309$). **DISCUSSION:** The lung function was not significantly different in F-18 pilots with more than 1000 flight hours as compared to an age matched control group without F-18 experience. Our findings suggest that the over pressure breathing system used in F-18 operations does not affect negatively pilots' lung function.

Learning Objectives:

1. Learn the effects of using positive pressure breathing system on pilots' lung function in flow-volume spirometry.
2. Learn the effects of using positive pressure breathing system on pilots' bronchodilator response.

[320] F-22 PILOT WITH DIPHYLLOBOOTHRIASIS: FIRST CASE REPORT IN A U.S. MILITARY AVIATOR

S.D. Kasteler

U.S. Air Force, Langley AFB, VA

PROBLEM STATEMENT: This case report describes an F-22 pilot with diphyllobothriasis, necessitating grounding for physical and psychological distress during a multinational military exercise. **BACKGROUND/LITERATURE REVIEW:** Diphyllobothriasis is estimated to afflict 10-20 million people worldwide. Among the largest parasites of humans, the "fish tapeworm" grows from 2-15 m in length and can live >20 yrs in the intestines. While seven phylogenetically unique species have been implicated in human infections in North America, differentiation is usually clinically irrelevant, as initial treatment with praziquantel is the same. **CASE PRESENTATION:** 32-yr-old male F-22 pilot presented with mild stomach cramping and bloating, with associated nausea and intermittent loose stools for two days. He was treated with bismuth subsalicylate, which relieved his symptoms; however, the morning of the third day, during his usual bowel movement, he pulled out a 100 cm segment of worm which included the tail end but not the scolex. Although physically asymptomatic, he was psychologically distressed. Later that same day, he expelled another 288 cm broken segment. Examination of his stool revealed a large number of ova. Based on the ovoid appearance, size, color, and operculum of the ova, coupled with the characteristic flattened body, yellowish coloration, and rectangular proglottids with centrally located "rosette" uteri, he was diagnosed with diphyllobothriasis (likely *D. latum* or *D. nihonkaiense*). He was successfully treated with a single oral dose of praziquantel (>10mg/kg), confirmed by negative stool examination over 60 days post-treatment. Regarding his diet, he was stationed at Kadena AFB, Japan for three years, with an additional 3-month temporary duty assignment. During that time, he reported frequently eating sushi and occasionally sashimi, some of which was likely salmon. He also recalls a single episode of eating undercooked tilapia in Virginia. **OPERATIONAL/CLINICAL RELEVANCE:** This is the first reported case of diphyllobothriasis in a U.S. military aviator. Despite mild physical symptoms, the psychological distress and distraction of knowing he had a meters-long tapeworm was significant. Prompt treatment was paramount to resumption of operations. Aviators should be educated and encouraged to eat only well-cooked or previously frozen fish, especially when indulging in cultural cuisine such as sushi or sashimi from freshwater or anadromous species.

Learning Objectives:

1. Recognize and diagnose diphyllobothriasis.
2. Know how to treat and prevent diphyllobothriasis.
3. Understand and mitigate the unique operational impact of diphyllobothriasis.

Wednesday, May 03
Governor's Square 12

10:30 AM

S-064: PANEL: STATE OF EVIDENCE IN EN ROUTE CARE SIMULATION AND TRAINING RESEARCH

Chair: Tiffany Losekamp
Wright-Paterson AFB, OH

PANEL OVERVIEW: There has been a drastic increase of simulation use in training of the U.S. Air Forces' en route care (ERC) medical teams due to the downsizing of inpatient facilities, high acuity of wounded warriors, decreased deployments, and a need for skill sustainment and readiness. The majority of current simulation and training research is coming from pre-licensure academic institutions. It is difficult to translate this student-focused research into the specialized, professional, post-licensure, military environment. A 2014 integrated review of simulation use in aeromedical evacuation training identified minimal research to support training and simulation decisions for U.S. Air Force ERC. In an effort to address the lack of evidence the U.S. Air Force School of Aerospace Medicine has established a program of research focused on simulation and training specifically for ERC. The purpose of this panel is to deliver an overview of the current simulation research projects for ERC. Completed studies represented include research on simulation training techniques and research using simulation as a way to test clinical questions. Results and discussion on existing efforts will be provided from the following research projects: 1) Identifying Education Needs: Training Gap Analysis of Active Duty Aeromedical Evacuation Technicians and Nurses; 2) Student Characteristics in Advanced Critical Care Air Transport Team Training Success; 3) Mitigating Task Saturation in Critical Care Air Transport Team Red Flag Checklist; and 4) Hyperventilation During Manual Ventilation can be Reduced Using a Novel Respirator and Simulation-Based Training. The first two studies are fundamental in establishing training gaps and provide a focus area for interventional research in the ERC training/simulation research trajectory. These recognized gaps offer a baseline for simulation research. The last two studies are using simulation as a way to address and research clinical issues and problems identified by stakeholders. Simulation allows for a safe and controllable environment for providers to test new techniques and identify issues in processes and offers individuals a safe place to acquire valuable experience. Cleared, 88PA, Case # 2016-5156, 17 Oct 2016.

[321] IDENTIFYING EDUCATION NEEDS: TRAINING GAP ANALYSIS OF ACTIVE DUTY AEROMEDICAL TECHNICIANS AND NURSES

J. Roseboro and **T.A. Losekamp**
Aeromedical Research Department, USAF School of Aerospace Medicine, Wright-Paterson AFB, OH

INTRODUCTION: The Air Force is curtailing its medical treatment facilities, thus reducing the number of opportunities for skill attainment and proficiency for flight nurses (FNs) and aeromedical evacuation technicians (AETs). Identification of these training gaps allows a focused intervention when using simulation training techniques. The aims of this study were to (1) describe the clinical experience of active duty (AD) FNs and AETs and (2) identify the clinical education needs of the AD FNs and AETs. **METHODS:** The aims of the study were accomplished concurrently through the use of a single paper survey. Survey questions identified clinical experience and level of comfort performing clinical tasks. A convenience sample of AD FNs and AETs assigned to the AD AE squadrons was invited to participate; 105 AE clinicians participated in the study. Descriptive statistics were used to analyze results. **RESULTS:** Analysis of clinician comfort with various healthcare tasks revealed key areas where FNs and AETs were less comfortable providing care (on a 5-point scale): managing neonatal patients (Mean=2.82), using a ventilator (2.87), treating labor and delivery patients (2.94), and managing obstetric (3.19) and pediatric patients (3.48). By comparing collected data to subject-matter experts' ranking of important skills to AE, several tasks were distinguished as more comfortable to AE clinicians than

important to subject-matter experts; thus, these tasks were well grasped by clinicians, and the training regimens for them do not need to be changed. These skills include monitoring vitals and pulse oximetry, using restraints, and managing nasogastric tubes. The data from this study revealed the typical clinical experience of FNs and AETs in the tasks they were most comfortable with and shed light on the tasks that must be emphasized in future training regimens to ensure comfort and competency before clinicians take to the air. **DISCUSSION:** The findings from this study will continue to build a foundation for education initiatives and allow for targeted interventions to meet sustainment needs of AD FNs and AETs. Given fiscal constraints, leadership has identified a need to provide an evidence base for educational initiatives; this study begins to build that evidence base and provide direction and focus.

Learning Objectives:

1. Discuss the clinical experience of active duty flight nurses and aeromedical technicians.
2. Discuss the clinical education needs of active duty flight nurses and aeromedical technicians.
3. Discuss the impact of evidence based training on en route care.

[322] MITIGATING TASK SATURATION IN CRITICAL CARE AIR TRANSPORT TEAM: A RED FLAG CHECKLIST

T.A. Losekamp² and **D. Bevington^{1,2}**

¹CSTARS Cincinnati, USAF, Cincinnati, OH; ²Aeromedical Research Department, USAF School of Aerospace Medicine, Wright-Paterson AFB, OH

INTRODUCTION: The complexity of patient care and the nature of Critical Care Air Transport Team (CCATT) missions require competency in both medical care and technical and non-technical skills (NOTECHS). The current study was conducted to evaluate predictors of competence in NOTECHS. The aim was to clarify team susceptibility to task saturation, which has been demonstrated to result in poor outcomes in simulation missions. **METHODS:** Sixteen CCATTs were studied over a 6-m period. Teams were videotaped during a simulated mission in the 2-wk CCAT Advanced Course. Team and individual performances were scored using a validated assessment tool for NOTECHS. A commercially available salivary cortisol collection and measurement system was utilized. Three samples were collected: (1) baseline, (2) a pre-simulation, and (3) a post-simulation. A panel of experts in critical care and medical education reviewed the videotaped missions and evaluated team and individual performance during each crisis event utilizing an adapted rating tool. **RESULTS:** During the simulated missions, 69 crisis events were identified. Evidence of task saturation was present in 29/69 (42%) crisis events. Each team member was assigned a non-technical skill score or red flag score. The teams average red flag score correlated with task saturation during the simulated missions (odds ratio 0.5, 95% confidence interval 0.32-0.80, $p=0.01$). In the univariate analysis, daily intensive care unit (ICU) experience ($p=0.04$), previous attendance at the CCAT Advanced Course ($p=0.04$), previous experience in simulated CCATT missions ($p=0.04$), and previous deployment experience ($p=0.001$) correlated with the red flag score. In the multivariate analysis, daily ICU experience ($p=0.03$) and previous deployment experience ($p=0.04$) continued to be significant. Salivary cortisol levels increased by 0.124 g/dl over baseline as the result of the simulation ($p=0.0002$), but did not correlate with red flag scores or biographical data. **DISCUSSION:** Task saturation is frequently observed in simulated CCATT missions. The fact that the students experienced stress as a result of the simulation is significant in confirming their "suspension of disbelief" as it relates to the realistic nature of the training. NOTECHS correlate with the development of task saturation. Previous real-world CCATT experience and daily ICU care correlated with improved NOTECHS.

Learning Objectives:

1. Describe the incidence of non-technical skills and task saturation in Critical Care Air Transport Teams.
2. Describe the impact of non-technical skills and task saturation for Critical Care Air Transport Teams.
3. Discuss experiences that can improve non-technical skills and task saturation.

[323] HYPERVENTILATION DURING MANUAL VENTILATION CAN BE REDUCED USING A NOVEL RESPIRATOR AND SIMULATION-BASED TRAINING

R. Fang¹, B. McKinley¹, S. Wade¹, N. Roux¹, C. Copland¹, A. Ramsey¹ and T. Grissom²

¹U.S. Air Force, Baltimore, MD; ²Anesthesiology, University of Maryland School of Medicine, Baltimore, MD

INTRODUCTION: It is difficult to achieve therapeutic targets for manual ventilation during prehospital transport. Published and anecdotal evidence suggest that many patients with traumatic brain injury (TBI) and no evidence of pending herniation arrive unintentionally hyperventilated. **METHODS:** Enlisted Air Force personnel with prior emergency medical technician training completing a 3-wk trauma skills course in a civilian trauma center were evaluated on their ability to provide manual ventilation. All trainees were evaluated using a standardized simulated patient on the first and last days of training for ventilation using standard manual respirator and a novel manual respirator limiting tidal volume (TV) and respiratory rate (RR). In addition, on the third day of training, all students attended training didactics, hands-on instructional training manual ventilation including novel respirator. All students provided 2 min of manual ventilation with each respirator during each testing cycle. Breath-to-breath RR, TV, and peak airway pressures were recorded for all sessions and averaged per testing cycle. **RESULTS:** Initial 24 students completed the course with additional 120 students to be enrolled. At baseline, evaluated personnel were more likely to hyperventilate a simulated TBI patient. Use of the novel compared to the standard respirator was associated with a lower RR in both pre- (10.0 ± 2.9 vs. 12.6 ± 4.8 BPM) and post-course (10.8 ± 2.9 vs. 13.0 ± 4.4 BPM) testing and TVs closer to the 6- to 8-mL/kg target. Initial minute ventilation rates for novel and standard respirator were 6.1 and 8.4 LPM, respectively. Post-course testing showed significant reduction in minute ventilation with the use of both respirators, but still tending toward mild hyperventilation with the standard device. **DISCUSSION:** According to current guidelines manual ventilation in the intubated TBI patient should focus on maintaining norm- to slight hypo- carbia (partial pressure of CO₂ 35-40%) when herniation or pending herniation is not suspected. For them, use of both a technical (novel respirator limiting TV and RR) and educational (simulation-based training) solutions may improve achievement of therapeutic target. Ongoing work will assess the impact of manual ventilation delivered with bag-mask-valve ventilation using both one- and two-person techniques in this trainee population.

Learning Objectives:

1. The learning objective of this presentation is to explain the importance of appropriate manual ventilation.

[324] STUDENT CHARACTERISTICS IN ADVANCED CRITICAL CARE AIR TRANSPORT TEAM TRAINING SUCCESS

T.A. Losekamp

Aeromedical Research Department, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

INTRODUCTION: Critical Care Air Transport Team (CCATT) instructors employ a standardized 10-d training experience using lecture, hands-on experience, demonstration, and simulation that culminates in a final mission exercise and individual validation. For individuals to deploy they must have successfully completed (validated) the CCAT Advanced Course. Non-validation of the CCATT students is expensive, requiring time away from their home units, man-hours wasted, and inability of individuals to deploy. Identifying characteristics associated with successful or unsuccessful validation allows for targeted training and simulation interventions. The study aim was to identify and describe characteristics associated with the incidents of successful or unsuccessful completion of the CCAT Advanced Course. **METHODS:** A retrospective student record review from 2010-2014 was used for this study. After inclusion criteria were applied, 772 student records were included in analysis. Descriptive and inferential statistics were used to analyze results. **RESULTS:** The validation rate for the course over the 5-yr period was 85%. There is no evidence that the non-validation rate differs significantly in the three professional groups: 25% physicians, 42% nurses, and 33% respiratory therapists. In regard to hospital bed size from home unit, coming from a small hospital of less than

20 beds has the highest non-validation rate (17.14%). A negative association for success was identified with years of experience (odds ratio (OR): 0.92, 95% confidence interval (CI) 0.88-0.95, $p < 0.01$). There was a positive association for success related to CCATT deployment (OR: 1.97, 95% CI 1.43-4.73, $p < 0.01$) and caring for the critically injured in their current job setting (OR: 1.97, 95% CI 1.12-3.47, $p < 0.02$). **DISCUSSION:** Looking at successful validation characteristics allows for recommendations on how to best prepare for the CCAT Advanced Course. Multiple findings demonstrate unique challenges for students participating in the course; these include limited experience with critical care, individuals who are newer to their profession, and limited hospital size. The findings from this study may be used to provide targeted simulation experiences for students prior to or during the CCAT Advanced Course to address the identified gaps. These focused simulation experiences could lead to more successful validation rates and utilization of Air Force resources.

Learning Objectives:

1. Discuss the demographics of attendees to the CCATT Advanced Course.
2. Discuss the challenges for CCATT in skill acquisition and sustainment.
3. Discuss the indicators for CCATT Advanced Course success.

Wednesday, May 03
Governor's Square 11

10:30 AM

S-065: PANEL: APOLLO 1 MISHAP: ITS CAUSES AND ITS CONSEQUENCES FROM THE AEROMEDICAL PERSPECTIVE

Co-Chair: Mark Campbell
Paris, TX

Co-Chair: John Charles
Houston, TX

PANEL OVERVIEW: The in-cabin fire that killed the three prime crewmen for the first Apollo mission cleaved the American race to the moon into two halves: "before the fire" and "after the fire." While the fatal fire was not initiated by crewman actions, it revealed the accumulation of human weaknesses in spacecraft design, manufacturing quality control, space human factors and program management and oversight. This panel will address the biomedically-significant aspects of the fatal day in January 1967 in the context of the plans and scheduling of Apollo missions before the fire, the events on the day of the fire, the medical findings, and NASA's recovery from the loss to succeed in its moonlanding goal and its subsequent Apollo-based space efforts.

[325] CHRONOLOGY OF THE APOLLO 1 INCIDENT

M. Campbell¹ and J.B. Charles¹

¹NASA Human Research Program, Houston, TX; ²Private Practice, Paris, TX

PROBLEM STATEMENT: The Apollo 1 incident on January 27, 1967 was a tragic event that had both negative and positive consequences for both the rest of the Apollo Program and future space-flight. The events leading up to the tragedy, the timeline of the event itself, and the immediate aftermath are revealing to life support design issues, in-flight medical issues, and emergency launch pad emergency medical care issues. **TOPIC:** The chronology of the Apollo 1 mishap will be detailed including past experiences and research that was known before the incident, the timeline of the actual incident itself and future consequences. **APPLICATIONS:** Many lessons were learned through the analysis of the mishap and directly applied to spaceflight medical operations which are still present to this day. **RESOURCES:** 1. Brooks, Courtney G.; Grimwood, James M.; Swenson, Loyd S., Jr. (1979). "The Investigation". Chariots for Apollo: A History of Manned Lunar Spacecraft. NASA History Series. Washington, D.C.: Scientific and Technical Information Branch, NASA.. 2. Ertel, Ivan D.; Newkirk, Roland W.; et al. (1969–1978). "Part 1 (H): Preparation for Flight, the Accident, and Investigation: March 25 through April 24, 1967". The Apollo Spacecraft: A Chronology. IV. Washington, D.C.: NASA.. NASA SP-4009. 3. Apollo 204 Review Board Final Report, NASA's final report on its

investigation, April 5, 1967 <http://www.hq.nasa.gov/office/pao/History/Apollo204>.

Learning Objectives:

1. To understand the events that led up to the Apollo 1 fire including past studies on the safety of high pressure oxygen atmospheres.
2. To understand the events on the day of the Apollo 1 incident including activities related to emergency medical procedures.
3. To understand the consequences and lessons learned from the Apollo 1 incident and how they were applied to the rest of the Apollo Program and to space flight activities today.

[326] HISTORICAL REVIEW OF ENCLOSED CHAMBER FIRES AND RESEARCH ARTICLES CONCERNING HIGH OXYGEN CONCENTRATION ATMOSPHERES PREVIOUS TO THE APOLLO 1 FIRE

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The risks and benefits of a high oxygen concentration atmosphere in an enclosed chamber was known prior to the Apollo 1 fire. This is a review of enclosed chamber fires that had occurred prior to the Apollo 1 fire and a survey of articles written in the Journal of Aerospace Medicine concerning high oxygen concentration atmospheres. This provides a snapshot of the state of knowledge among aerospace medicine professionals and design engineers at the time of the Apollo 1 tragedy.

Learning Objectives:

1. What was the previous experience with fires in enclosed chambers prior to Apollo 1.
2. What was known in the scientific aerospace medicine literature concerning the risks and benefits of high oxygen concentration atmospheres.
3. What was the general state of knowledge concerning high oxygen concentration enclosed chambers at the time of the Apollo 1 fire.

[327] BIOMEDICAL RESEARCH DEFERRED IN THE AFTERMATH OF THE APOLLO FIRE: IMPACT ON PROGRESS IN HUMAN SPACEFLIGHT

J.B. Charles¹ and W.R. Carpentier²

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PROBLEM STATEMENT: Confidence in human space exploration requires an understanding of the physiological, psychological and clinical impacts of exposure to the novel spaceflight environment. This understanding is best achieved through a rigorous research program of in-flight assessments at rest and in response to quantifiable provocations, with comparison data acquired before flight to determine the specific effect of the flight, and again postflight to document the return to preflight baseline values. **TOPIC:** Before the Apollo fire, the early Apollo missions were expected to continue the pattern established in the Gemini program of accommodating significant scientific and biological experimentation, including human biomedical studies, during the flights. Apollo 1 and Apollo 2, both 2-week engineering test flights, were to carry almost as many biomedical studies as Gemini 7, a 2-week medical test mission. As a result of the Apollo fire, the early Apollo missions were scrubbed of all in-flight biomedical experiments and other non-operational evaluations. They were devoted to checkouts of the spacecraft components required to accomplish the national goal of a manned lunar landing and safe return to Earth. After that goal was attained and sufficient confidence had been established in spacecraft functionality, a small number of human and biological experiments were accommodated. However, even the earliest Apollo missions flown saw extensive pre- and postflight biomedical studies in support of the operational medical certification of astronaut capacity for the substantial workloads of lunar surface activities. These data are arguably the beginnings of modern space medicine and biomedical research. **APPLICATIONS:** The Apollo lunar surface crewmembers were sparsely instrumented but creatively monitored using data provided by their life support systems. Biomedical and biological research deferred from Apollo were largely acquired in the Skylab program of 1-, 2- and 3-month missions under well-controlled circumstances and with a larger number of participating crewmen. These data formed the basis for more intensive studies on Space Shuttle missions, which in turn established the foundation for the continuing

investigations on the International Space Station. **RESOURCES:** Charles JB. The First Apollo 2: Science and Operations Planned for the "Leaping Green Frog." *Quest* 9:2, 26-42.

Learning Objectives:

1. Attendees will understand the priority of biomedical and biological research early in the U.S. space program in the context of the operational constraints dictated by overarching programmatic goals.

[328] APOLLO 1 MISHAP: ITS CAUSES AND ITS CONSEQUENCES FROM THE AEROMEDICAL PERSPECTIVE

B. Tarver

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PROBLEM STATEMENT: NASA is currently working on a new space vehicle environment for its future exploration class missions. Space vehicle environments must support human life yet not significantly add to a variety of risks to the human. It is important to not forget lessons learned, particularly lessons learned the hard way. **TOPIC:** This presentation will be a historical review of the Apollo 1 fire incident. **APPLICATIONS:** NASA's mishap report and follow-on corrective actions (with attention to aerospace medicine inputs) will be reported. The atmosphere inside the capsule was both above ambient pressure and oxygen enriched. NASA had been warned about the dangers of this situation yet they felt risks were "controlled". A prescient photo of the crew was taken prior to the accident. Grissom, Chafee and White struck a prayerful pose behind a model of the Apollo. Were they saying "oh God get us thru this" or was this simply them being thankful for the opportunity before them? **RESOURCES:** NASA Final Report of Apollo 204 Review Board.

Learning Objectives:

1. Understand the multiple factors that contributed to the death of the crew which could have been altered prior to the test and which would have significantly reduced risks to the crew in the event of a capsule fire.

Wednesday, May 03

2:00 PM

Plaza A/B

S-066: PANEL: AEROSPACE MEDICINE RESIDENT GRAND ROUNDS: PART 3

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Mark Coakwell

Dayton, OH

PANEL OVERVIEW: This panel will consist of pairs of Aerospace Medicine residents presenting clinical cases of aeromedical interest or significance. During their residency practicum years, residents conduct evaluations of patients with diverse medical problems. Residents prepare and present a case report based on a patient encounter undertaken during their practicum experience. One resident from each pair presents the history of the presented problem. The other resident presents the physical findings and a discussion of the aeromedical policies associated with the condition. Learning Aerospace Medicine at the specialist level involves understanding the impact of medical conditions on aircrew health and mission accomplishment. The cases presented will not only be of academic interest but will also illustrate aeromedical decision making in the operational environment.

Wednesday, May 03

2:00 PM

Plaza D/E

S-067: SLIDE: COGNITION AND PERFORMANCE

Co-Chair: Dwight Holland

Roanoke, VA

Co-Chair: Patrick McGinnis

Friendswood, TX

[329] COGNITIVE SCREENING FOR MATURE PILOTS: THE RELATIONSHIP OF THE MONTREAL COGNITIVE ASSESSMENT TO PILOT PERFORMANCE

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ACE Lab, Carleton University, Ottawa, ON, Canada

INTRODUCTION: Identifying older pilots at risk due to cognitive decline is an important element of the aviation medical examination. The Montreal Cognitive Assessment (MoCA, Nasreddine et al, 2005) is one of two screening tools recommended for assessing older pilot cognitive health (FAA, 2011). However, there are no published studies examining the association of the MoCA with aviator performance. This research reports on the relationship of individual pilot differences, the MoCA, and CogScreen-AE (Kay, 1995), the second cognitive test recommended for older pilots, to landing performance. **METHODS:** The 44 licensed pilots (aged 40 to 74, female = 3) were volunteers from local flying clubs and schools. Ethics was obtained by the university ethics review board, and all participants provided written informed consent. Pilots flew cross-country and patterns in a Cessna 172 flight simulator. All participants were administered the CogScreen-AE and a peripheral motion contrast test (Henderson et al., 2013). The pilots aged 60+ (n=15, female = 0) were also administered the MoCA. Landing performance scores were derived from deviations from ideal location, speed, and heading at touchdown. Factor scores from CogScreen-AE measures were used as proxy MoCA scores for the full sample. Best subsets linear regression modeling (adjusted r-squared criterion) was undertaken to identify predictors of landing performance. **RESULTS:** For pilots aged 60+, the MoCA was the best predictor of landing performance, followed by mental flexibility and frequency of flying, total adjusted r-squared = 0.55. In the full sample, landing performance was predicted by working memory and a dual task factor (the strongest proxy for the MoCA, $r=0.71$, $p=.001$), and, to a lesser degree, by peripheral motion contrast sensitivity, mental flexibility, and symbol comparison reaction time, total adjusted r-squared = 0.42.

DISCUSSION: Results for the subset of pilots aged 60+ found that the MoCA could be used to predict landing performance. This finding was confirmed in the larger sample, where close proxy scores for the MoCA were also predictors of landing performance. These findings offer initial evidence that the MoCA is sensitive to pilot performance for a high-risk phase of flight: namely, visual approach landings. Our results inform the search for a reliable and valid cognitive health screening tool to identify at-risk pilots.

Learning Objectives:

1. Become familiar with two different cognitive health screening tools for mature pilots (the MoCA and the CogScreen-AE).
2. Learn about the particular challenges faced by mature general aviation pilots, such as multi-task cognitive performance.
3. Become familiar with emerging evidence regarding the utility of the Montreal Cognitive Assessment in predicting pilot performance for visual approach landings.

[330] THE EYEFLIGHT PROJECT: IDENTIFYING MARKERS OF COGNITIVE WORKLOAD NON-INVASIVELY

C.A. Scholl¹, E. Pohlmeier¹, M. Rich¹, M. Fifer¹, M.S. Jessee¹, B. Wester¹, M. Chevillet¹, J.M. Moran², G. Hwang¹ and F. Tenore¹

¹Research and Exploratory Development Department, Johns Hopkins University Applied Physics Laboratory, Laurel, MD; ²U.S. Army Natick Soldier Research, Development, and Engineering Center, Natick, MA

INTRODUCTION: This study evaluated whether physiological biomarkers can be used to assess cognitive workload non-invasively. Signals of mental processes such as pupil dilation or electrical signals emitted by the brain can be monitored on-line using non-intrusive measurement devices. To quantify cognitive workload, we developed a mission-relevant flight simulator task incorporating both eye tracking glasses and electroencephalography (EEG) to assess neurophysiological and ocular signals during a dual-paradigm working memory task.

METHODS: Experimental protocol was approved by the Johns Hopkins Medical Institutes' IRB and by the HRPO of the U.S. Navy. Written informed consent was obtained from each participant. We enrolled 10 participants to conduct experiments involving a flight simulator task to

assess the feasibility of using basic EEG and eye-tracking measures to classify workload. We then implemented a forward model analysis to identify the neuronal frequencies most responsible for the workload classifier performance. An auditory n-back task simulated monitoring communications during a basic flight task, which also manipulated task difficulty (i.e. workload). **RESULTS:** We were able to effectively classify different workloads using EEG data, resulting in a mean Area Under Curve (AUC) score of 0.87 for the easiest vs. hardest conditions, and a mean AUC score of 0.82 across all comparisons. Forward model analysis of the EEG data showed that the delta and theta frequency bands were most responsible for classifier performance. Finally, eye-tracking analysis revealed that pupil diameter increased as workload conditions became more difficult. **DISCUSSION:** Our results suggest that viable signals for measuring cognitive workload may be found in electrical signals measured with EEG. We also found that pupils dilate as a function of cognitive load in the dual task experiment, which is consistent with reports in the literature on pupil dilation under conditions of increased mental load and arousal. Next steps include investigating the cognitive underpinnings of the recorded data to explore its relationship to workload, and testing the robustness of such signals across different types of workload and environmental conditions.

Learning Objectives:

1. Physiological biomarkers such as EEG and eye-tracking can be used to assess cognitive workload non-invasively.

[331] OPTIMIZING SCHEDULES USING HEURISTICS IN THE HUMAN PERFORMANCE DOMAIN

B. Clapp

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INTRODUCTION: Established fatigue scheduling tools allow an assessment of the impact of work schedules on human performance. However, these tools rely upon humans to create the schedule, and operational realities often require scheduling incompatible with peak human performance. To reconcile this disparity, heuristics can help optimize schedules by balancing operational requirements with human performance insight gained from models like FAST. In complex environments like the Distributed Common Ground System (DCGS), heuristics provide powerful applications of human performance knowledge to better achieve command objectives when operational realities dictate compromise. **METHODS:** Simulations of the DCGS environment were developed using subject matter expert input. These simulations are mathematically similar to operational reality, but were randomly generated. Two heuristics were developed, one using the simplifications and approximations applied in the current DCGS environment to make the problem human-solvable and the other without these simplifications. The second heuristic was run both with and without considering human performance decrement due to fatigue. Finally, schedules generated in each of the three runs were put through a simulation of the operating environment, including fatigue impact, to assess relative mission performance and completion.

RESULTS: Because the first heuristic uses guaranteed level of effort for fixed lines to determine mission assignments, it does not consider actual staffing levels, fatigue, or individual skill in the mission assignment process. This inaccurate picture of the operational milieu results in over-assignment during low-performance periods, under-assignment during high-performance periods, and assigning missions to sites that lack the personnel to perform tasks to standard. Because the second heuristic considers staffing levels, skill, and fatigue, it does not over-assign missions, and disruptions/failures only occur due to last-minute rescheduling issues. Field tests of the heuristic are expected following presentation of the results to DCGS personnel. **DISCUSSION:** Heuristics provide the ability to take human performance knowledge and create a program that applies that knowledge in a consistent way to complex systems. Heuristics take human performance application from rule-of-thumb or guideline to concrete, universal system, ensuring that everything we know about how to get the most out of our people gets applied.

Learning Objectives:

1. Scheduling heuristics provide a powerful tool for applying human performance knowledge to get the most out of personnel.

[332] A BROAD OVERVIEW OF OPERATIONAL EPIDEMIOLOGY APPLICATION TO VARIOUS INQUIRIES FROM THE INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE COMMUNITY

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¹School of Aerospace Medicine, USAF, Beavercreek, OH; ²Force Health Protection, USAF School of Aerospace Medicine, Centerville, OH; ³AFIT, Wright-Patterson AFB, OH

INTRODUCTION: The intelligence, surveillance, and reconnaissance (ISR) community provides a unique set of challenges in the fields of epidemiology and aerospace medicine. Over the past 2 yr, the Operations Consult Service (OCS) at the U.S. Air Force School of Aerospace Medicine has been working with the ISR community to better understand and address many of these challenges. This presentation consists of a series of unique or semi-unique ISR problems, the methods applied to them, as well as any recommendations resulting from OCS work. **METHODS:** This presentation will provide highlights of the consultative work spearheaded by the OCS for the distributed common ground system community. It will include an overview of the literature on ambient lighting for the stations. Additionally, it will provide an overview of the ongoing process for improvement of workplace technology, resulting in continuing process improvements that, in turn, improve human performance. There will also be a discussion on the psychological impact of being in this community with a retrospective statistical analysis of relationship changes of the service members. This analysis has resulted in increased resources for psychological support for these airmen under extreme duress. Finally, a potential innovative tool that will alleviate some of the scheduling pressures experienced will be previewed. The support of the ISR community is of utmost importance, and highlighting these issues as well as exhibiting the progress is a crucial start for continued work in care of this community. **RESULTS:** Because of the unique problems faced by this community, there are sets of unique solution spaces that have to be developed. The lighting standards should be updated to match the technology that is available. From the social standpoint, there was a tremendous uptick in deteriorating relationships within the community compared to Air Force personnel, so additional resources should be provided. With an extreme burden placed on this community, an improved scheduling ability would alleviate some of the problems caused by a high-demand career field. **DISCUSSION:** The ISR community presents an opportunity for unique research to have a high impact on ongoing military operations, due to the high demand placed upon this unique community.

Learning Objectives:

1. The 711th HPW has committed its resources to researching and providing answers to improve the warfighter. The Operations Consult Service is one of those resources that aids in providing answers to USAF operations including the ISR community.

[333] MODELLING OF 3D ELECTRO-MECHANICAL INTERACTION OF NEURONS: A NOVEL APPROACH TO DAMAGE EVALUATION

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INTRODUCTION: Countermeasure human performance failure are critical for the success of most aerospace activities. Safety can be improved thanks to a better understanding of neural networking by using computational modelling, focused on neural interaction patterns. Modelling provides timely information to contribute to mission architecture and operation decisions in area where clinical data are lacking. It has been successfully applied to address, predict, characterize and mitigate potential risks to health and performance. Generally, modelling methodologies developed so far of the neural networks and patterns are restricted to a one-dimensional approximation of the electrical activity, which leads to an undependable countermeasure of neurocognitive processes in case of impairments and brain damage.

METHODS: Recent experimental evidence has uncovered complex interactions of electro-mechanical biophysical phenomena (such as electrostriction, piezoelectricity and thinning) at the membrane layer in nerve cells during signalling. We propose a novel approach to model

coupled electro-mechanical phenomena of neural activity at different scales, resolving three-dimensional electrical and mechanical problems at the same time. Advanced multi-disciplinary modelling is a powerful research tool to simulate the physics of complex phenomena under different conditions, such as adaptation to changing gravity conditions and spatial disorientation. **RESULTS:** A coupled electro-mechanical model of a single 3D neuron and a 3D bundle of unmyelinated and myelinated fibres are validated with previously published experimental results. Damage evaluation is, here, a function of the strain and strain rate, where electrophysiological impairments are associated to structural damage on neuron mechanics and electrical properties. **DISCUSSION:** Our hypothesis is to redefine neural computation and modelling including electro-mechanical phenomena to enhance the quality and reliability of neurophysiological, neuropathological processes, neurocognitive impairment and perception models. The mechanical characterization of the neural activity in a coupled electro-mechanical domain is capable of providing insights into the electro-mechanical behaviour of nerve cells, such as changes in ionic permeability and resting membrane potential due to damage. This approach can efficiently contribute to identify patterns in injured neurons, explaining the changes in interaction as in clinical evidences.

Learning Objectives:

1. Understand role and nature of injury and damage as electro-mechanical phenomena in nerve bundles.
2. Understand role and nature of altered electrical transmission between neurons in the causation of changing neurocognitive performance.
3. Safety enhancement in short-term and long-term mission by using innovative multi-disciplinary neural finite element modelling.

[334] GROUND-BASED PERFORMANCE EVALUATION OF A VISION+INERTIAL NAVIGATION SYSTEM FOR ISS NET HABITABLE VOLUME ESTIMATION

K.R. Duda¹, T.J. Steiner¹, R.A. DeFronzo¹, P.A. DeBitetto¹, J.J. West¹ and G.E. Chamitoff^{2,3}

¹Draper Laboratory, Cambridge, MA; ²Texas A&M University, College Station, TX; ³University of Sydney, Sydney, Australia

INTRODUCTION: The International Space Station (ISS) provides a unique opportunity to capture and quantify the architectural layout and 3-D space utilization in a microgravity environment from the astronauts living and working there. Information gathered will provide critical insight on the minimum net habitable volume (NHV) required for future spacecraft. Draper Laboratory is developing a small, unobtrusive wearable kinematic system to estimate the navigation state vector – position and orientation – of ISS astronauts or moveable equipment.

METHODS: Fourteen datasets, which include time-synchronized vision and inertial data, were collected from walking specified routes and performing representative “tasking” at NASA Johnson Space Center – the ISS mockups in the Space Vehicle Mockup Facility. The data was collected using a set of custom hardware developed for the U.S. Army which includes two monoscopic cameras and three inertial measurement units (IMUs) within a single package. All data was analyzed using the Draper multi-state constrained Kalman filter (MSCKF) algorithm as the vision-aided inertial navigation system algorithm. **RESULTS:** The multiple data sets resulted in a total cumulative traverse distance of approximately 1,943 meters (1.2 miles) over more than 60 minutes of recording. The average route was approximately 139 m (455 ft.), and 4.3 minutes in duration. Distance estimation, final position estimation error, and tasking location were estimated using the Draper MSCKF vision+inertial odometry algorithm. Results demonstrated final position errors of less than 1% of the estimated route distance. Additionally, initial testing of the position accuracy of the system demonstrated the ability to reliably estimate the sensor position with regard to a specific rack (40” wide) in the ISS Destiny module mockup. **DISCUSSION:** The ISS provides a unique opportunity to capture and quantify the architectural layout and 3-D space utilization in a microgravity environment from the astronauts living and working there. Information gathered will provide critical insight on the minimum NHV required for future spacecraft. The results were very encouraging, with the “best” results achieved when analyzing the data from the good imager, across all three IMUs – this indicates that a poor

performing imager is more detrimental to performance than a poor performing IMU, which has implications for eventual hardware selection.

Learning Objectives:

1. The audience will learn about non-GPS approaches to position and localization, using a combination of cameras and inertial measurement units.

Wednesday, May 03
Plaza F

2:00 PM

S-068: SLIDE: FUTURE OF SPACE MEDICINE: PT. 1

Co-Chair: John Charles
Houston, TX

Co-Chair: Derek Nusbaum
Houston, TX

[335] JUSTIFYING A CLINICAL TRIAL OF THE FUNCTIONAL READAPTIVE EXERCISE DEVICE FOR LUMBOPELVIC MOTOR CONTROL REHABILITATION AFTER SPACEFLIGHT

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¹Health and Life Science, Northumbria University, Newcastle upon Tyne, United Kingdom; ²UK Space Environments Association, Harwell, Oxford, United Kingdom

INTRODUCTION: Astronauts have 68% increased incidence of back pain (Sayson and Hargens 2008) and 4.3 times higher risk of herniated disc than controls (Johnston et al. 2010). Atrophy of lumbar multifidus (LM) and transversus abdominis (TrA) and difficulty controlling spinal mechanics is commonly found in post flight astronauts (Hides et al. 2011; Buckley 2006). Exercise using the Functional Readaptive Exercise Device (FRED) shows strong potential to recruit the LM and TrA muscles automatically (Debus et al. 2013) which could benefit current post spaceflight rehabilitation. The mechanistic effects of exercise on the FRED were investigated to inform decisions regarding a future clinical trial.

METHODS: A series of mechanistic studies investigated the acute effects of the FRED and designed a training protocol. Mechanistic magnitude based inference statistics were used to investigate muscle recruitment and kinematic studies. Muscle recruitment was investigated in a small sample using ultrasound. Lumbopelvic kinematics were investigated across four studies that included 308 participants in total and recruited groups with low back pain. **RESULTS:** The following effects were found during FRED exercise. The LM and TrA muscles were recruited more than at rest and increasing the movement amplitude causes a greater variability of muscle activity (effect size ≥ 0.2). Lumbar lordosis is automatically increased compared to walking in groups with and without low back pain (effect size ≥ 0.2). First time users with and without low back pain required 170 seconds to familiarise to the exercise. Visual feedback was required for users to achieve and maintain a desired target speed and use of the handles caused a trunk flexion and reduced challenge to the exercise movement (effect size ≥ 0.2). **DISCUSSION:** The mechanistic studies justify a clinical trial as exercise on the FRED appears to automatically cause LM and TrA muscle recruitment, and increased lumbar lordosis, which is likely to benefit post flight rehabilitation. It is recommended that a training protocol for a clinical trial include a 170 second minimal familiarisation period, use live visual feedback on performance linked to target speed and should not use the handles during exercise.

Learning Objectives:

1. Understand the physiological changes that occur in the spine due to gravitational unloading as happens during microgravity exposure, linked to increasing risk of spinal injury within a motor control perspective.
2. Understand the traditional rehabilitation approach to improve spinal motor control that targets deep spinal muscle recruitment including Lumbar Multifidus and Transversus Abdominis and attempts to normalise sagittal plane spinal kinematics. Also understand the challenges of a traditional approach and how the new exercise being presented might overcome these.

3. Gain knowledge of the key muscle recruitment and sagittal plane spinal kinematic mechanistic variables that are considered important to assess within a spinal motor control context.

[336] THE METABOLIC COST OF WALKING IN SIMULATED MARTIAN GRAVITY AND ITS IMPLICATIONS

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¹Microgravity Centre, PUCRS, Porto Alegre, Brazil; ²College of Medical and Dental Sciences, University of Birmingham - UK, Borehamwood, United Kingdom

INTRODUCTION: Understanding the metabolic cost of walking is vital to the success of future missions to Mars. Lower body positive pressure (LBPP) is an effective way of simulating hypogravity. A small number of studies have shown that oxygen consumption (VO_2) decreases when walking in LBPP simulated Martian gravity. This study measured the submaximal VO_2 and other respiratory gases when walking on an LBPP treadmill at 1G and simulated Martian gravity (0.38G). Specific focus was given to analysing caloric expenditure and substrates metabolised. **METHODS:** Twelve healthy participants with mean age (\pm SD) 22.75 ± 5.38 years took part in this study with full consent. The LBPP box used was designed and built by the Microgravity Centre. A VO2000 gas analyser measured respiratory gases and a Polar S610 heart rate (HR) monitor recorded heart rate. Participants walked for 8 min at a control of 1G and then for another 8 min in simulated 0.38G two weeks later. Student's t test for paired samples determined if the data from the two environments were significantly different. **RESULTS:** Mean (\pm SD) VO_2 was 1.00 ± 0.61 ml/kg/min in 1G compared to 0.68 ± 0.33 ml/kg/min in simulated 0.38G ($p < 0.05$). Average caloric expenditure was significantly reduced at simulated Martian gravity (4.79 ± 2.80 Kcal/min) when compared to the control (3.37 ± 1.49 Kcal/min) ($p < 0.05$). Mean (\pm SD) HR reduced from 118.49 ± 15.07 bpm at 1G to 106.20 ± 11.17 bpm at simulated 0.38G ($p < 0.05$). Average respiratory quotient (RQ) was significantly increased from 0.83 ± 0.13 to 1.14 ± 0.19 in simulated 0.38G ($p < 0.05$), with no significant difference seen in the fraction of expired carbon dioxide. **DISCUSSION:** Energy consumption significantly decreased when walking in LBPP simulated hypogravity. This agrees with previous studies, which also measured a reduction in VO_2 . Reduced caloric expenditure was also observed during the Apollo 15 Lunar landing. Calorimetry and respiratory gas findings can be used to calibrate EVA suits and advise on diet and exercise regimes for future astronauts. RQ indicates that a higher proportion of carbohydrates were used as an energy substrate. On Earth, LBPP can be used to remobilise patients effectively, whilst reducing joint loading. Rehabilitation regimes can now be tailored with an understanding of how metabolism changes.

Learning Objectives:

1. In lower body positive pressure (LBPP) simulated Martian gravity, metabolism is seen to decrease as measured by VO_2 , caloric consumption and heart rate.
2. Carbohydrates may be preferentially metabolised in hypogravity, resulting in a maintained burden to eliminate relatively high levels of CO_2 .
3. Understanding how learning objective 1 and 2 will affect astronauts ambulating in hypogravity and the remobilisation of orthopaedic patients using LBPP.

[337] EVALUATION OF VIRTUAL NATURE FOR RELAXATION IN ISOLATED, CONFINED ENVIRONMENTS

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¹Geisel School of Medicine, Dartmouth College, Lebanon, NH;

²University of Hawai'i, Manoa, HI; ³Department of National Defence, Government of Canada, Ottawa, ON, Canada

INTRODUCTION: Living in an isolated, confined environment (ICE) can produce stress, reduce mood, and diminish work performance. Attention Restoration Theory (ART) posits that nature exposure reduces

stress and improves mood. Virtual nature may offer the same restorative effects as actual nature for those in ICE. We deployed virtual reality (VR) to two ICEs: the HI-SEAS IV Mars Simulation and the Canadian Forces Station Alert to assess users' subjective evaluations of natural scene VR.

METHODS: HI-SEAS IV participants viewed VR scenes episodically during 12-month group isolation (n=6). At CFS Alert, participants had 5 VR sessions (n=19). The Modified Reality Judgment and Presence Questionnaire (MRJPQ) was also given after each VR scene. The 6-question Value of VR (VVR) survey was given at Alert. Interviews were conducted and coded for both locations at the end of each deployment. Users at Alert viewed scenes from Ireland, an Australian Beach, a New England fall, and a navigable, rendered UK coastal setting (Wembury). HI-SEAS participants initially viewed the Australian beach and Ireland scenes as well as a rendered Iceland experience. Additional scenes were available at later in the mission (Boston, Houston park, New England fall). **RESULTS:** At Alert, although VVR results indicated good overall value (average 2.5 out of 7, lower better), interviews showed a range of opinions with some positive and others negative. Some people preferred other relaxation resources or expected a VR game-like experience. The rendered, navigable UK scene was rated the least valuable (3.5), likely due to technical limitations that diminished presentation quality. Three subjects noted motion sickness with this scene. When permitted to choose the scene, participants most often selected urban (4 Boston, 1 Houston, 1 Fall). The HISEAS MRJPQ indicated levels of immersion comparable to lab-based studies (6.8 on a 1-10 scale), and the scores for the same scenes were comparable at Alert. In interviews HI-SEAS participants rated VR highly. **DISCUSSION:** Although VR was viewed positively at both locations, it was better received at HI-SEAS than CFS Alert, possibly due to differences in isolation, resources, and crew dynamics. Subjects at HISEAS experienced a greater degree of isolation and may have been more receptive to VR for relaxation. These studies identified important considerations for improving VR content and using VR successfully in ICEs.

Learning Objectives:

1. Understand considerations for improving VR content and using virtual nature successfully in isolated and confined environments.

[338] EFFECT ON TELOMERE LENGTH AND TELOMERASE ACTIVITY DURING THE NEEMO UNDERSEA SPACEFLIGHT ANALOG MISSION

M. O'Griffo

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INTRODUCTION: The Aquarius Undersea Laboratory is a saturated diving habitat at a depth of 63 feet located 5 miles off the coast of Key Largo where NASA conducts the NASA Extreme Environment Mission Operations (NEEMO) analog mission. Long duration spaceflight in and beyond low earth orbit may cause a decrease in telomere length. The NEEMO analog mission closely replicates the spaceflight mission environment from an operational, psychological and hormonal standpoint. **METHODS:** Buccal and blood samples were taken from 6 aquanaut crewmembers during the NEEMO 21 mission before (one day pre-splashdown), during and after (one day post-splashup) the mission. Mission length for individual crewmembers ranged from 8 to 16 days in saturation. Telomere length was measured using both TELO-FISH (Fluorescence *in situ* Hybridization with telomere probe) and Absolute qPCR methodologies. Telomerase activity was assessed using qRT-PCR TRAP (Quantitative Real Time-PCR Telomere Repeat Amplification Protocol). Institute review board approval was provided. **RESULTS:** All crewmembers demonstrated a significant relative decrease in both telomere length and telomerase activity. There was an average decrease in telomere length (Telomere/Albumin ratio) from 0.86 (pre-mission) to 0.8 (post-mission). There was also an average decrease in telomerase activity from 240 (pre-mission) to 140 (post-mission). **DISCUSSION:** The analog environment of the NEEMO mission onboard Aquarius resulted in telomere shortening. It is hypothesized that significant telomere degradation may occur in crewmembers on a long duration spaceflight mission beyond earth orbit. A variety of factors including oxidative stress, high cortisol levels, the operational environment and prolonged exposure to cosmic radiation can result in telomere shortening and resultant sequelae. Telomere shortening has also been observed in astronauts onboard ISS. The NEEMO mission has been demonstrated as a close analog for a short duration spaceflight mission including hormonal

immunological function in crewmembers. The telomere shortening in all crewmembers indicates that this mission environment results in rapid telomere shortening and decreased telomerase activity. Post-mission sampling at both 90 and 180 days post-mission will indicate whether this effect is transient or permanent.

Learning Objectives:

1. Understand the impact of a short duration spaceflight analog mission on telomere length and telomerase activity.
2. Understand the application of the NEEMO spaceflight analog mission to current and future spaceflight missions.

[339] 3D SUBTRACTIVE CAD/CAM CAN SUPPORT MEDICAL OPERATIONS IN REMOTE ENVIRONMENTS

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INTRODUCTION: Practicing medicine in remote environments (space, polar regions) has many challenges. One factor is the lack of extensive prosthetic devices and tools in inventory. We investigated 3D subtractive CAD/CAM in the context of ear surgery to evaluate its utility in remote environments with limited resources. Conventional middle ear prosthetic prosthetics, including total ossicular replacement prostheses (TORPs) and partial ossicular replacement prostheses (PORPs) require large inventories for otologic surgery services. Computer-assisted manufacture on demand in the operating room (subtractive 3D CAD/CAM) can quickly produce bone and cartilage autografts on demand, reducing the need for extensive inventories of prosthetic devices. This technique can also produce artificial prosthetics and surgical tools out of materials such as plastics. This concept is readily applicable to other surgical specialties providing services in remote environments. **METHODS:** A Roland MDX-40A 3D milling machine (Roland DGA, Irvine, CA) was utilized. This is a 3-axis CNC milling machine with a 4th axis for multiple orientations. For each orientation, all the visible surfaces are machined while a set of sacrificial supports keeps the part connected to the uncut end of the stock material. Once all the operations are complete, the supports are severed and the part is removed. Commercially available bovine byproducts and machinist's wax were utilized to provide materials for testing. A Richards Centered PORP Prosthesis was selected as an initial example to demonstrate the process. A model with the same dimensions of the actual PORP was produced with machinist's wax, then bovine and human bone. The dimensions were imported into the SRP player software included with the MDX-40A machine. The prosthesis was then milled by subtraction. **RESULTS:** Machinist's wax, bovine bone and human cadaveric bone utilization resulted in reliable production of prototype middle ear prosthetics for proof of concept. **DISCUSSION:** Computer-assisted manufacture on demand in the operating room (subtractive 3D CAD/CAM) can quickly produce bone and cartilage autografts on demand, reducing the need for extensive inventories of prosthetic devices. This technique may also be useful to produce artificial prosthetics and surgical tools out of materials such as plastics. This concept is readily applicable to other surgical specialties providing services in remote environments.

Learning Objectives:

1. The participant will be able to understand how 3D computer assisted design/manufacture (3D CAD/CAM) can facilitate medical practice in remote environments by reducing the need for extensive inventories of parts and tools.

[340] FUNCTIONAL AND DURABILITY PROPERTIES OF 3D PRINTED SPLINTS FOR WRIST INJURY TREATMENT ON EXPLORATION-CLASS SPACE FLIGHT MISSIONS

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INTRODUCTION: Advances in 3D scanning and printing enable the design and as-needed fabrication of personalized splints for treatment of wrist injuries in space flight missions. The SAM splint used in the International Space Station medical kits provides temporary treatment and is consumable limiting its utility on non-resupplied,

multi-year space flight missions. This study investigates the design and 3D printing of wrist splints that maximize splint shape, structural performance, and fabrication parameters while minimizing resources used. **METHODS:** A 3D scanner creates high fidelity wrist computer aided design (CAD) models that are processed into personalized wrists splints and fabricated on a 3D printer. Using the wrist CAD model, the wrist splint can be designed in CAD software into various shapes and configurations to support the treatment of the wrist injury. Wrist splints are 3D printed using various permutations of filament materials, print densities, and print orientations. Structural and physical analysis is conducted on each splint design and means of construction to determine functional and durability properties. **RESULTS:** This study will collect data on the physical, structural, and fabrication properties of each splint. Analysis and comparisons will be conducted between all constructed splint designs to determine the optimal configuration that maximizes functional and durability properties while minimizing material usage and fabrication duration. **DISCUSSION:** The ability to fabricate as-needed splints for orthopedic injuries could be adventitious for exploration-class space flight missions with no practical ability to resupply and limited storage for medical hardware. This study seeks to optimize the trade-off between fabricating a highly functional and durable wrist splint against the time and materials needed to 3D print it with today's technology. Further advancements in 3D scanning and printing technology could improve the max/min trade-off ratio and revolutionize the treatment of wrist injuries in austere, resource poor environments such as human space flight.

Learning Objectives:

1. The participant will understand the functional performance and resource usage of 3D printing wrist splints.

Wednesday, May 03
Governor's Square 14

2:00 PM

S-069: SLIDE: MEDICAL CAUSES OF AIRCRAFT ACCIDENTS

Co-Chair: Lindley Bark
Hollywood, MD

Co-Chair: Charles DeJohn
Oklahoma City, OK

[341] GENERAL AVIATION ACCIDENT FOLLOWING RUPTURE OF AORTIC ABDOMINAL ANEURYSM IN PILOT

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PROBLEM STATEMENT: In this Piper Cherokee crash the autopsy revealed that the pilot had died in the air due to a rupture of an aortic abdominal aneurysm (AAA). **BACKGROUND/LITERATURE REVIEW:** AAA is a common and potentially life-threatening condition. Most AAAs are asymptomatic and may be hard to detect during a standard medical renewal for PPL. **CASE PRESENTATION:** In a general aviation accident in Norway May 2016 a PA-28 crashed in a wood, ending up about 160 meters from the first point of impact. The pilot, a 67-year-old man with PPL, was the only person on board. He was found deceased close to the main wreckage. Large broken trees, extensive damage to the aircraft and major injuries to the pilot indicated a high speed crash. He had taken off 1 hour 17 min earlier for a cross country flight to a small grass airfield. The weather was good, daylight VMC. Contact with ATC had been normal, but he missed a call about 2 min before arriving at destination. The aircraft was observed passing overhead the airfield, making no attempt to land. At steady easterly course, the plane slowly lost altitude and crashed 4 minutes later. On autopsy the pilot was found to have multiple fractures to the skull, chest, spine, pelvis and extremities. The spinal cord was completely severed. There were crushing injuries to the lungs and liver, rupture of the diaphragm, and upper abdominal organs were found in

the chest cavity. All these injuries are compatible with the forces in the crash, but had resulted in very limited bleeding. The autopsy revealed general atherosclerosis of the coronary arteries and signs of an old infarct in the posterior wall of the heart. Aorta in the chest had extensive arteriosclerosis. Retroperitoneally a large, ruptured AAA with massive bleeding was found. The AAA was 10 cm long from just below the kidney arteries to the bifurcation, diameter 8 cm and the tear 9 cm. Toxicology showed no alcohol, drugs or carbon monoxide. The presumable cause of death was the ruptured AAA probably leading to immediate loss of consciousness. The pilot was not alive when the plane crashed. The aircraft was equipped with autopilot for heading control only. Pitch is controlled by power setting, trim and yoke input by pilot. **OPERATIONAL/CLINICAL RELEVANCE:** The pilot had risk factors for cardiovascular disease. His ECGs did not give a clear indication of the extensive atherosclerosis found on autopsy.

Learning Objectives:

1. Aortic aneurysms can be hard to detect, but may result in dramatic pilot incapacitation.

[342] ASSOCIATIONS BETWEEN PAST DWI CONVICTIONS AND AVIATION ACCIDENTS IN THE GENERAL AVIATION POPULATION

A. Norris, V. Skaggs and T.R. Chidester

Civil Aerospace Medical Institute, FAA, Oklahoma City, OK

INTRODUCTION: Although the Federal Aviation Administration (FAA) attempts to mitigate the potential safety risk of pilots flying with alcohol in their system, previous research suggests that pilots who have prior DWI convictions on record are more likely to be involved in future aircraft accidents. However, an updated study is needed to address limitations in prior studies and improve exposure classifications. Therefore, the purpose of this study was to evaluate the association between prior drug/alcohol-related convictions or substance abuse diagnoses and aircraft accidents in a matched case-control study among third-class pilots from 2009 to 2013. **METHODS:** Cases (N=2,485) were medically-certificated pilots who had a general aviation accident from 2009-2013. Controls (N=17,395) were medically-certificated pilots who did not have an accident, matched 7:1 to cases on age and date of accident. Using the pilot medical certificate database from the Office of Aerospace Medicine (OAM), prior drug/alcohol-related offenses and substance abuse diagnoses were identified. Covariates included baseline characteristics such as BMI, gender, and flight time recorded at the pilot's most recent medical certificate examination before the date of the index case's accident. Conditional logistic regression models were used to calculate odds ratios (ORs) and 95% confidence intervals. **RESULTS:** The prevalence of any type of prior drug or alcohol conviction or substance abuse history among cases was 7.5% compared with 5.6% prevalence in controls (OR=1.39, 95% CI 1.18, 1.63). Cases were more likely than controls to have both prior alcohol-related convictions (OR=1.41, 95% CI 1.19, 1.67) and drug-related offenses (OR=2.77, 95% CI 1.67, 4.60). The associations increased in magnitude when we restricted analyses to exposures that occurred within five years of the case's accident date. When evaluating DWI recidivism, there was a statistically significant positive trend with increasing number of DWIs. The direction of the associations did not change when we categorized the results based on cause of the accident, and the magnitude of the associations increased when results were restricted to alcohol- and drug-related accidents. **DISCUSSION:** This study provides evidence that pilots with at least one prior alcohol- or drug-related offense or substance abuse diagnoses, particularly those who recently obtained these exposures, should continue to be closely monitored by OAM.

Learning Objectives:

1. The audience will be able to understand the associations between prior drug charges/DWIs and aviation accidents in medically certificated third class pilots.

[343] FATAL AVIATION ACCIDENT DUE TO PSYCHOMOTOR IMPAIRMENT AFTER MARIJUANA USE

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¹Forensic Sciences, FAA Civil Aerospace Medical Institute, Oklahoma City, OK; ²National University of Colombia, Bogota, Colombia

PROBLEM STATEMENT: This case report describes a fatal accident involving a general aviation pilot who failed to maintain airplane control after marijuana use. **BACKGROUND/LITERATURE REVIEW:** Cannabis is the most frequently detected illicit drug in drivers. Shifts in public opinion and policies toward legalization of cannabis are poised to result in an increase in the prevalence of cannabis use. Over the past two decades, a growing body of research has demonstrated that cannabis use adversely affects cognitive performance among measures that target attention. **CASE PRESENTATION:** The subject pilot was a 30-yr old private pilot who held a third class airman medical certificate. He indicated his total aeronautical experience was 84.2 hours, of which 1 hour was in the previous 6 months. The flight originated from the Wolf Lake Airport, Palmer, Alaska, around 1200 Hrs. The purpose of the flight was to scout for locations to hunt moose. When the airplane did not return to Wolf Lake, the Air Force's Rescue Coordination Center initiated a search along its supposed route of flight. In the early morning hours of the following day, the wreckage was located. Postmortem fluid and tissue samples from the pilot were sent to the FAA's Civil Aerospace Medical Institute for toxicological evaluation. The tests were negative for carbon monoxide and alcohol in blood. Blood, liver, and lung were positive for tetrahydrocannabinol (THC), the primary psychoactive component or marijuana and its inactive metabolite, tetrahydrocannabinol carboxylic acid. **OPERATIONAL/CLINICAL RELEVANCE:** This case highlights the potential danger of marijuana use before flying activities because the ability to concentrate and maintain attention is decreased during marijuana use. Impairment of hand-eye coordination is dose-related over a wide range of dosages. Impairment in retention time and tracking, subjective sleepiness, distortion of time and distance, vigilance, and loss of coordination in divided attention tasks have all been reported.

Learning Objectives:

1. To educate the aviation community on the effects of THC on pilot's performance.

[344] HUMAN PERFORMANCE IMPAIRMENT AS A FUNCTION OF BLOOD THC LEVELS: A LITERATURE REVIEW AND ANALYSIS FROM AN AVIATION SAFETY PERSPECTIVE

S. Duque, J. Giraldo, J.C. Camacho and E. Ricaurte²
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INTRODUCTION: The percentage of marijuana users in the U.S. increased from 6.2% in 2002 to 8.4% in 2014. Previous studies show cannabis adversely affects working memory, motor control, time sense, attention and concentration; flying an aircraft is highly dependent on those capabilities. Marijuana use has recently increased among fatally injured pilots (NTSB, 2014). Blood THC concentrations reflecting driving impairment remain unknown. No recent studies have been published on the topic of blood levels of marijuana, pilot's performance, and the risk of having an accident. The purpose of this study was to conduct a literature review on THC blood levels as correlated to psychomotor function impairment and to analyze those findings from an aviation safety perspective. **METHODS:** A literature search was conducted using PubMed, MeSH, MEDLINE, Ovid, and other scientific media. Approximately 56 publications were reviewed including peer reviewed journal articles, editorials, reviews, and meeting discussions to evaluate researchers findings and opinions regarding the acute effects of THC on cognitive functions and psychomotor skills, then extrapolate those findings to pilot performance and aviation safety. **RESULTS:** Several studies concluded THC effects were most pronounced in the first 2 hours post-smoking, but a significant decrease in cognitive functions was still measurable 8 hours later. As related to THC concentrations and driving impairments in subjects on simulated drives, it has been reported that 8.2 µg/L blood THC was associated with impaired driving similar to 0.05% BAC, and 13.1 µg/L THC approximated 0.08% BAC detrimental effects. Mean plasma or serum THC concentrations of 3.9 to 34 mg/ml were found within the first hour of smoking, after the administration of doses of 8.94 to 69.4 mg. Also, THC effects on pilots' performance in flight simulators are cumulative and dependent on aging, marijuana use, and task difficulty. **DISCUSSION:** Blood THC levels that reflect driving impairment remain unknown. Implementing concentration-based cannabis-driving legislation would target individuals with residual THC in

chronic frequent smokers. Reducing marijuana-related accidents due to drivers' human performance impairment will require a better understanding of the relationships between THC blood levels and the risk of an accident. Further research is needed to determine pilots' performance impairment as a function of THC blood levels for a better forensic interpretation.

Learning Objectives:

1. To educate the aviation community on the effects of THC levels on pilots' performance.

[345] CAUSES AND SURVIVABILITY OF GENERAL AVIATION ACCIDENTS IN MOUNTAINOUS REGIONS OF THE USA

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INTRODUCTION: Flying over mountainous and/or high elevation terrain (MEHET) is challenging in general aviation due to rapidly changeable visibility, strong winds, and the potential for controlled flight into terrain/obstacles (CFIT). Herein, general aviation accident rates, mishap cause/factors and survival factors for a geographical region characterized by such terrain were determined (2001-2014). **METHODS:** Accidents in single piston engine-powered aircraft for states west of the U.S. continental divide were identified from the NTSB database. MEHET-related-mishaps were defined as satisfying any one, or more, criteria (downdrafts, mountain obscuration, wind-shear/gusts, whiteout, CFIT, instrument meteorological conditions; density altitude). Statistics employed Poisson distribution and Chi-Square tests. **RESULTS:** Although the MEHET-related accident rate declined ($p < 0.001$) 57% across the study period, the high proportion of fatal accidents showed (40-43%) little diminution ($\chi^2 = 0.935$). CFIT was the most frequent cause of fatal accidents. Of CFIT mishaps, half occurred in degraded visibility only 9% operated under instrument flight rules (IFR) and the majority (85%) involved non-turbo-charged engine-powered aircraft. Accidents which should have been survivable but which nevertheless resulted in a fatal outcome were characterized by poor accessibility (60%), shoulder harness under-utilization (41%) and an aircraft fleet infrequently (22%) equipped with 406 Mhz emergency locator beacons (ELTs) which reduce search and rescue times. **CONCLUSION:** MEHET-related accidents still carry an elevated fatality risk. Towards mitigating this risk and increasing survivability airmen should be encouraged to utilize turbo-charged-powered airplanes equipped with 406 Mhz ELTs, flying by IFR to assure terrain clearance and engage their shoulder harnesses for the flight duration.

Learning Objectives:

1. The participant will learn that general aviation operations in a mountainous/high elevation terrain environment carries a much higher risk of fatality compared with low elevation/non-mountainous regions of the country.
2. Participant will learn that by far the majority of fatal accidents for operations in this environment are due to controlled flight into terrain.
3. Participant will learn that accidents which should have been survivable were due to seat-belt under-utilization and likely an aircraft fleet equipped with emergency locators which show poor activation rates in accidents and imprecise crash locations impeding search and rescue.

[346] ROLE OF THE AVIATION MEDICINE SPECIALIST IN THE INVESTIGATION OF AIRCRAFT ACCIDENTS: LESSONS LEARNED IN THE SPANISH ARMED FORCES

B. Puente Espada^{1,2}

¹CIMA: Centro de Instrucción de Medicina Aeroespacial, Spanish Air Force, Madrid, Spain; ²CITAAM: Comisión para la Investigación Técnica de Accidentes de Aeronaves Militares, Madrid, Spain

INTRODUCTION: Aircraft Accident Investigation is a complex task. The investigation process ends in a technical report, which encloses a large amount of information and data, including medical, psychological, environmental, psychosocial and ergonomic data, commonly known as Human Factors. The purpose of this study was to analyze the role of the aviation medicine specialist throughout all phases of the investigation.

METHODS: In Spain, the investigation of military aircraft accidents, is carried out by a joint organization, created in 1994 under the umbrella of the Spanish Ministry of Defense named CITAAM (Comisión para la Investigación Técnica de Accidentes de Aeronaves Militares: Aircraft Accident Investigation Board). For the investigation, the Board is comprised of Permanent Members, including pilots (from Air Force, Army and Navy), engineers, photographers and Aerospace Medicine specialists. Both pilots and doctors are responsible for analyzing Human Factors. Data were extracted from CITAAM files. **RESULTS:** Since 1994, 245 incidents/accidents have been investigated by CITAAM: 72% Air Force aircrafts, 11% Army helicopters; 11% Navy aircrafts, 6% others: Guardia Civil or foreign aircrafts; with a mean of 10 incidents/accidents per year. 68% were fixed wing aircrafts, 29% rotary wing and the rest RPAs (Remotely Piloted Aircrafts). 33% were Class A accidents, 18% with fatalities. Human factors was the main causal factor. As a Permanent Member of the Spanish Military Aircraft Accident Investigation Board since August 2010, the author has been involved in 68 incidents/accidents investigations, including fast jets (28), transport aircrafts (17), rotary wing (19) and RPAs (5). Nine of them involved fatalities. **DISCUSSION:** Aerospace medical professionals are fully involved in accident investigation since they fulfill multiple flight safety-related roles, including the provision of aeromedical certification, aeromedical advice, pathological/forensic analysis and accident investigation expertise. In the author's experience it has been essential to be part of the investigation team from the very beginning: being at the crash site always provided unique information; attending autopsies was very helpful for both the author and the coroners. Knowledge and experience in forensic medicine made pathological and toxicological reports easier to understand and finally, taking part in the process of writing the whole report, has always been a benefit to the investigation.

Learning Objectives:

1. To highlight the role of Aviation Medicine Specialists in Aircraft Accident Investigation.

Wednesday, May 03
Governor's Square 15

2:00 PM

S-070: PANEL: U.S. NAVY AEROMEDICAL DISPOSITION – CHALLENGING CASES FROM NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI)

Co-Chair: Robert Carpenter
Pensacola, FL

Co-Chair: Joseph LaVan
Pensacola, FL

PANEL OVERVIEW: This panel represents selected challenging cases from the Naval Aerospace Medical Institute (NAMI). NAMI is the center of excellence for U.S. Navy (USN) and Marine Corps (USMC) aerospace medicine and is staffed by flight surgeons, aerospace clinical specialists, and support personnel. All USN and USMC aerospace medicine dispositions are made at NAMI. Annually, NAMI receives approximately 50,000 flight physicals from fleet flight surgeons throughout the world and conducts more than 5,500 clinical encounters in Pensacola, Florida. This multi-disciplinary panel will highlight five challenging cases dispositioned by NAMI in the past year. Cases 1 and 2 are examples of structural diseases of the eye affecting vision, case 3 involves an ENT diagnosis, case 4 is a case of a Navy pilot requiring chronic anticoagulation, and case 5 leads discussion on transgender applicant evaluation. Disclaimer: The views expressed in this panel are those of the authors and do not necessarily reflect the official position of the Department of the Navy, Department of Defense, nor the U.S. government.

[347] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: FORME FRUSTE KERATOCONUS

K. Dohm², M. Rings¹, T. Waggoner² and K. McGowan²
¹Ophthalmology, NAMI, Pensacola, FL; ²Eye Clinic, Naval Aerospace Medical Institute, Pensacola, FL

BACKGROUND/LITERATURE REVIEW: Keratoconus is a degeneration of the cornea leading to progressive thinning and steepening causing irregular astigmatism. Visual acuity may eventually be reduced to the point that vision cannot be corrected to 20/20. **CASE PRESENTATION:** A 24-yr old male aviator applicant underwent initial ocular examination in September 2014 in Newport, Rhode Island, and was found to be emmetropic with normal corneal topography. Upon arriving in Pensacola, Florida, in May 2016 to begin training, he underwent a screening examination at NAMI. This examination found the subject to have mildly reduced uncorrected visual acuity in the right eye, concurrent with a low amount of oblique, irregular astigmatism. Although correctable to 20/20 with glasses, his corneal topography revealed an area of irregular steepening in the temporal paracentral cornea of the right eye. An evaluation of the posterior cornea also revealed many red flags. A waiver was not recommended as he was found to not be physically qualified for duties involving flight due to his high risk for progression and visual deterioration. **OPERATIONAL/CLINICAL RELEVANCE:** This case highlights a relatively uncommon clinical entity, but one that has profound ramifications for duties involving flight and for the career implications of those afflicted. Typically, the younger a person is diagnosed with keratoconus (i.e., teens) the greater the chance of the disease becoming more progressive and severe. This case portrays a young man in his early 20s who noticed a slight decrease in vision in his right eye, developing over about a year. He went from having all normal findings to being diagnosed with forme fruste keratoconus in about a year and a half. Although he did not have any concrete signs of disease on slit lamp examination, his pattern of refractive error, vision and topography changes put him into a high risk category for progressive disease, despite being correctable to 20/20 and reportedly asymptomatic with correction. New treatments and post-refractive surgery ectasia will be discussed, to include the possible impact this will have on aviation applicants and designated members alike. **DISCLAIMER:** Approved for public release; distribution is unlimited. The views expressed herein are those of the authors and do not necessarily reflect the official position of the Department of Defense or its components.

Learning Objectives:

1. Describe what keratoconus is and how it can affect vision.
2. Explain the significance of any degree of keratoconus for duties involving flight.
3. Recall the newly approved treatment for keratoconus, corneal collagen cross-linking, and the impact it may have on an aviator's career.

[348] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: COCHLEAR HYDROPS

C.A. Reese
Otolaryngology, Naval Aerospace Medical Institute, Pensacola, FL

BACKGROUND/LITERATURE REVIEW: There are many causes of hearing loss ranging from noise induced loss to more esoteric forms of autoimmune or syndromic hearing loss. Endolymphatic hydrops is a term that is sometimes used to refer to a symptom complex consisting of vertigo, sensorineural hearing loss, aural fullness and tinnitus, more commonly known as Meniere's Disease (MD). Patients with Cochlear Hydrops (CH) have some or all of the aural symptoms, but do not have vertigo. What is not known is the likelihood of someone with CH developing vertigo and therefore, full blown MD, adversely affecting safety of flight. **CASE PRESENTATION:** A 33 year old Naval Flight Officer reported subjective hearing loss after deployment. An audiogram did not show evidence of hearing loss. 1 year later, he reported feeling as though there was water in the left ear and a sense of pressure in the ear that was not relieved with valsalva. He denied vertigo and tinnitus. Formal audiometry showed a significant threshold shift affecting the lower and mid frequencies of the left ear: 65 dB at 500 and 1000 Hz, 55 dB at 2000 Hz, 45 dB at 3000 Hz, 30 dB at 4000 Hz and 15 dB at 6000 Hz. Speech reception threshold was 50 dB with 60% word recognition score. Right ear testing was normal. A prednisone taper had no effect. CT and MRI showed non-specific white matter abnormalities that resulted in a work-up for multiple sclerosis which was negative. Acoustic brainstem response testing was normal; final diagnosis was cochlear hydrops. **OPERATIONAL/CLINICAL RELEVANCE:** MD is an idiopathic constellation of symptoms consisting of vertigo, aural fullness, tinnitus, and hearing

loss. Some patients also experience hyperacusis. Histopathologically, the temporal bones of individuals with MD who have died will demonstrate dilation of the endolymphatic space within the inner ear, i.e., hydrops. Individuals with active MD are clearly not fit for aviation duties. However, individuals with cochlear hydrops are not vertiginous, and if they are able to communicate effectively they may be able to perform safely and continue to contribute to the operational mission of an active duty unit. This case presentation discusses the decision process and risk mitigation for this challenging case evaluated at NAMI. Approved for public release; distribution is unlimited. The views expressed herein are those of the authors and do not necessarily reflect the official position of the Department of Defense or its components.

Learning Objectives:

1. Individuals attending this presentation will be able to characterize the clinical findings in an individual with cochlear hydrops and distinguish these patients from those with classic Meniere's disease.
2. Once an aviator with cochlear hydrops is diagnosed, the attendee will recognize the importance of obtaining appropriate vestibular testing in order to assess whether this individual can be safely returned to flight duties.

[349] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: CHRONIC ANTICOAGULATION

K. Cheng and R. Carpenter

Internal Medicine, Naval Aerospace Medical Institute, Pensacola, FL

BACKGROUND/LITERATURE REVIEW: Historically anticoagulants have not been considered waivable for naval aviators. Not only do these medications present a danger in flight due to the increase risk of spontaneous or trauma induced bleeding, they also require frequent monitoring which may not be practical in an operational environment. With the development of newer anticoagulants that require less monitoring, medications like direct factor Xa inhibitors may be acceptable under the right conditions. **CASE PRESENTATION:** The subject pilot is a 44-year-old male with over 2000 total flying hours and a medical history significant for recurrent pulmonary embolism. The pilot sustained his first episode of bilateral pulmonary embolism secondary to a provoked right deep vein thrombosis in December of 2014. The service member underwent a negative hypercoagulability evaluation and was subsequently placed on 3 months of rivaroxaban without complication. In February of 2016 the pilot was hospitalized again for his second episode of pulmonary embolism and was restarted on rivaroxaban for indefinite time course. The pilot requested and was granted a restricted waiver (service group 3) to continue flying multi-piloted transport aircraft. **OPERATIONAL/CLINICAL RELEVANCE:** It is generally recognized that the use of chronic anticoagulants in high performance aircraft presents an unacceptable risk to the safety of flight. However, the risk may be more acceptable with pilots of dual control maritime aircraft. With an overall annual risk of major bleeding approximately 1 percent and without the need for frequent monitoring, oral direct factor inhibitor anticoagulants may provide an option for pilots requiring indefinite anticoagulation. **DISCLAIMER:** The views expressed in this abstract are those of the authors and do not necessarily reflect the official position of the Department of the Navy, Department of Defense, nor the U.S. government.

Learning Objectives:

1. Review aeromedical implications of chronic anticoagulation.

[350] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: PSYCHIATRIC EVALUATION OF A TRANSGENDER ATC APPLICANT

D.P. DeCecchis, S. Chee and W. McDonald

Psychiatry, Naval Aerospace Medical Institute, Pensacola, FL

BACKGROUND/LITERATURE REVIEW: The Department of Defense is currently in the process of finalizing guidance with regard to transgender personnel serving openly in the Armed Forces. The aeromedically-significant psychiatric concerns and guidelines for aeromedical waiver consideration are still in development. **CASE PRESENTATION:** The applicant is a 25-year-old female air traffic controller applicant who had lived for several years under the preferred male

gender identity prior to entry into active duty service. The applicant deliberately discontinued testosterone treatment and returned to dressing in female attire in order to be eligible for entry into active duty service. A comprehensive psychiatric evaluation, as part of the waiver-application assessment, revealed long-standing, clinically significant anxiety unrelated to gender dysphoria. We determined this to be an unacceptable risk to duties involving flight, and thus psychiatric aeromedical clearance could not be granted. **OPERATIONAL/CLINICAL RELEVANCE:** Based on current DoD guidance, specifically DoDI 1300.28, a subject must "receive a diagnosis from a medical provider indicating that gender transition is medically necessary" in order to be eligible to receive all necessary care and treatment. The term "medically necessary" appears to be deliberately broad to allow for clinical interpretation. The consensus of the NAMI Psychiatric department was that the threshold for deeming the treatment to be medically necessary was confirmation of sufficient clinical criteria to substantiate the diagnosis of gender dysphoria. While this diagnosis would allow for relevant medical treatment, the presence of any active psychiatric condition has usually been a medical contraindication to psychiatric clearance for flight duty. It became apparent that it would be incumbent upon the department to exclude functional impairment related to the diagnosis of gender dysphoria, as well as any aeromedically-significant co-occurring psychopathology, prior to clearing the subject to participate in duties involving flight. **DISCLAIMER:** The views expressed in this abstract are those of the authors and do not necessarily reflect the official position of the Department of the Navy, Department of Defense, nor the U.S. government.

Learning Objectives:

1. Discuss the DoD policy regarding transgender members serving in the military.
2. Discuss the aeromedical psychiatric policy regarding transgender personnel serving on flight status.
3. Discuss the significance of the term "medically necessary" as defined in DoDI 1300.28.

[351] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: CENTRAL SEROUS RETINOPATHY

T. Waggoner, K. Dohm, M. Rings and K. McGowan

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BACKGROUND/LITERATURE REVIEW: Operational military personnel often fit the profile of the typical central serous retinopathy (CSR) patient: 20-50 year old males (6:1), usually associated with "type A" personalities and increased levels of stress. **CASE PRESENTATION:** The subject is a 50-yr old white male aerospace physiology technician who works in a high risk training environment to include underwater egress training. Initial symptoms of right eye blurriness occurred nine years ago in January 2007 at which time he was diagnosed with CSR. He also has a congenital color vision deficiency that is categorized as a moderate deutan (green) defect. This subject has residual edema not centrally, but adjacent to the optic disc, consistent with a small absolute visual field defect with extension of the physiologic blind spot. The patient functions safely in his job, has been stable for years, and was found fit to continue in his role as an instructor at the aviation survival training center pool. **OPERATIONAL/CLINICAL RELEVANCE:** This case highlights a relatively common clinical entity that affects military aviation and other operational personnel, perhaps more so than their civilian counterparts due to the high-stress nature of their jobs. CSR is a localized serous retinal detachment typically in the macular region of one eye. Appearing almost like a "blister" on fundusoscopic examination, the clear fluid under the transparent sensory retina distorts the central vision often with decreased visual acuity. CSR typically resolves on its own after several months, although vision may never return to baseline (i.e. 20/20). This case highlights important clinical pearls, as well as brings forth information about atypical presentations, healing patterns, expected course durations, and prognosis. Because vision is so paramount to aviation and the operational environment, normal visual function must return prior to resuming high risk duties. Information will be discussed that is relevant to not only the personnel at risk for development of CSR, but for those providers that care for them and make recommendations to military commanders. **DISCLAIMER:** Approved for public release;

distribution is unlimited. The views expressed herein are those of the authors and do not necessarily reflect the official position of the Department of Defense or its components.

Learning Objectives:

1. Identify the mechanism where Central Serous Retinopathy affects safety of flight.
2. Explain active Central Serous Retinopathy's effect on visual acuity.
3. Recall typical healing patterns and possible resolution states of Central Serous Retinopathy.

Wednesday, May 03
Governor's Square 12

2:00 PM

S-071: SLIDE: APPLICATION OF AVIATION PRINCIPLES TO HEALTHCARE PRACTICES

Chair: Thomas Hoffman
Honolulu, HI

Chair: Roy Marsh
San Antonio, TX

[352] THE PROCESS OF APPLYING AIR ACCIDENT INVESTIGATION TO HEALTHCARE

S.A. Cygan¹, M. McPherson¹, S.J. Gaydos³, J. Pina³ and N. Powell-Dunford²

¹School of Aviation Medicine, U.S. Army, Fort Rucker, AL; ²Exchange Officer, USAARL, AE; ³High Reliability Organization Task Force, U.S. Army, Falls Church, VA

MOTIVATION: The healthcare system continues to draw upon aviation practices in an effort to transition towards high reliability. Gaps between the aviation and healthcare experience are increasingly recognized with respect to the investigation and reporting of error. Aeromedical specialists have unique insight into the air accident investigation process and are increasingly consulted with respect to bridging specific gaps in the aviation and healthcare experience. Knowledge regarding the process of applying an air accident investigation model postures aeromedical specialists as patient safety enablers within the healthcare system. **OVERVIEW:** The air accident investigative process is conducted in a standardized fashion by independent, professionally trained experts. Findings are disseminated broadly in order to enable maximum flight safety impact throughout the industry. Recommendations are directed to decision makers at high levels and are effected in a timely fashion. Specific gaps between the aviation and healthcare experience include transparency, accountability, independence of oversight, and enterprise-wise sharing of lessons learned. Liability concerns threaten the full implementation of the aviation industry's commitment to transparency and sharing of lessons learned, however clinical outcomes have improved following adoption of such practices. A greater commitment to accountability, transparency and sharing of lessons learned is now being realized within the healthcare industry's reporting and investigative practices. **SIGNIFICANCE:** Aviation has gained a reputation of safety and trust by ensuring a transparent and learning-focused approach to errors. Standardization of investigation training, human factor analysis and reporting requirements within the healthcare industry are early in adoption but show promise in optimizing the investigation and reporting of medical error. Transparent methods of investigation and reporting have already resulted in improved health outcomes. Reporting requirements and other programs designed to enhance accountability warrant further analysis for effectiveness. An independent safety-oriented health care investigative organization to more fully implement an aviation model has not gained traction in the U.S. but is being fielded in the UK. Aeromedical professionals are poised to inform and lead the adoption of investigative practices within the military and civilian healthcare spheres.

Learning Objectives:

1. List key aspects of reporting and investigation in which healthcare model lags behind the aviation model.

2. Identify ways in which commitment to transparency of the investigation and reporting process have demonstrated benefits within the aviation and medical fields.
3. Identify specific aspects of the aviation accident investigation model which have been adopted within the healthcare industry.

[353] LOCAL BRITISH PROGRAMMES TO INCORPORATE AVIATION PRACTICES INTO HEALTHCARE

P.D. Hodkinson¹, D.H. Riddington³ and N. Powell-Dunford²

¹RAF Centre of Aviation Medicine, Hitchin, United Kingdom; ²Exchange Officer, USAARL, AE; ³Consultant in Anaesthesia and Critical Care Medicine, University Hospitals Birmingham NHS Foundation Trust, Birmingham, United Kingdom

MOTIVATION: Aeromedical specialists are involved in both flight safety and patient safety. We are recognized for flight safety knowledge and are increasingly consulted on the adoption of aviation-based practices in healthcare. A number of local UK initiatives aim to bridge cultural gaps between the high reliability field of aviation and the UK National Health Service (NHS). It is important that aeromedical specialists be aware of emerging applications of aviation practices into the healthcare industry and help bridge gaps between the aviation and healthcare industries. **OVERVIEW:** UK efforts at building high reliability in the NHS include incorporation of mishap investigation techniques into local incident analysis, daily team brief/de-briefs and 'emergency scenario discussion' as well as an exempt from review survey directly comparing how aviation and medical organizations manage error in order to identify and propagate best practices. The University Hospitals Birmingham NHS Foundation Trust cares for over 800,000 patients and hosts the largest transplant centre in Europe. The Trust has committed to employing a core of highly trained professional investigators, whose expertise lies in investigation rather than clinical specialisms. Drawing on the expertise of clinicians and others as needed to gather evidence, investigators attend carefully to eliciting human factors contributions and address workplace and organisational factors. This is in order to deliver high quality, authoritative findings/recommendations and provide leaders and managers a clear mandate to implement recommendations, where safe and appropriate to do so. The brief /de-brief cycle as well as daily consideration of an emergency scenario are other aviation practices which have been trialled at a local level within the NHS. A UK Ministry of Defence exempted from review anonymous survey is being fielded across medical and aviation organisations in order to appreciate specific differences in reporting culture and how error is managed, with results anticipated to guide efforts at bridging such gaps. **SIGNIFICANCE:** Gap identification and local adoption of aviation based practices within healthcare shows promise in optimizing the human performance of healthcare professionals. Aeromedical specialists involved in patient safety programmes can assist healthcare facilities enact similar assessments and initiatives.

Learning Objectives:

1. List applications of aviation practices into healthcare which have improved patient outcomes.
2. Identify the parallels between the air accident investigation and the Birmingham NHS Foundation Trust's approach to medical incident investigation.
3. Describe the practice of 'emergency procedure rehearsal' within the NHS.

[354] THE BRITISH EXPERIENCE - A PROCESS OF INCORPORATING AVIATION INVESTIGATION PRACTICES INTO HEALTHCARE

N. Powell-Dunford^{1,3} and M. Bromiley²

¹Exchange Officer, USAARL, AE; ²Clinical Human Factors Group, North Marston, United Kingdom; ³Medical Centre, Army Air Corps, Middle Wallop, United Kingdom

MOTIVATION: Aeromedical specialists are recognized for flight safety knowledge and are increasingly consulted on the adoption of aviation-based practices in healthcare. The United Kingdom leads important efforts regarding the process of implementing aviation investigation practices into the healthcare system. Awareness of the UK

experience can enable aeromedical specialists to better contribute towards the healthcare industry's patient safety efforts. **OVERVIEW:** The UK's process of harnessing air accident investigation techniques for the purposes of patient safety are illustrated by the Clinical Human Factors Group (CHFG), the Association of Litigation and Risk Management-Europe (ALARME) framework of error analysis and National Healthcare Safety Investigation Branch (HSIB). The CHFG, a broad coalition of professionals partnered with experts in Human Factors, is led by a fixed wing pilot Martin Bromiley, who champions the assessment of human factors in all aspects of medical investigation. Oxford researcher Charles Vincent has drafted the comprehensive ALARME methodology for incident analysis which greatly parallels traditional air accident methodology; He and co-researcher Carl Macrae drafted a sentinel paper advocating the national adoption of an independent regulatory organisation for medical investigation. These aviation focused efforts recently culminated in the establishment of the UK Healthcare Safety Investigation Branch (HSIB). This organisation, led by former UK Air Accident Investigation Branch Director Keith Conradi, will undertake the select investigation of serious medical error within the UK using the air accident investigation model. **SIGNIFICANCE:** Implementation of an air accident investigation model, with due consideration of human factors, in-depth analysis and a centralized, independent investigative authority shows promise in optimizing the human performance of healthcare professionals across civilian and military spheres. The successful British process of incorporating air accident investigation practices into healthcare through educational, publication and advocacy programs should inspire similar efforts across the international medical community.

Learning Objectives:

1. List the ways in which the Clinical Human Factors Group fosters the adoption of aviation investigation practices into healthcare.
2. Understand key parallels between the ALARME framework for incident analysis and traditional air accident investigation methodologies.
3. Identify key similarities between the UK's Healthcare Safety Investigation Branch (HSIB) and the UK Air Accident Investigation Branch that will foster public acceptance of an HSIB investigation.

[355] DEFENSE POW/MIA ACCOUNTING AGENCY (DPAA)

OVERVIEW

T.S. Hoffman

Surgeon Section, Defense POW/MIA Accounting Agency (DPAA), Honolulu, HI

MOTIVATION: Aerospace medical professionals train to support the flight environment. The principles developed and skills acquired to support the ubiquitous nature of the flight environment can affect other operational environments as well. This presentation shows how aerospace medicine practices are effectively applied to medical operations supporting the search for our missing combatants around the world and how lessons learned from these search and identification missions can advance aerospace medicine practices.

OVERVIEW: The Defense POW/MIA Accounting Agency (DPAA) mission is to provide the fullest possible accounting for our missing personnel to their families and the nation. DPAA was created in 2015 to consolidate all Department of Defense (DoD) missing personnel accounting efforts into one DoD Agency. DPAA investigates missing personnel records and information from all sources; develops case histories; negotiates with host nations; coordinates with U.S. and foreign governments, private contractors, and NGO's; sends investigation and recovery teams to remote and austere locations around the world; recovers evidence and osseous material; analyzes the recovered evidence; and identifies missing personnel utilizing the most modern forensic techniques available. DPAA operates the largest forensic laboratory in the world. Missions are to some of the most remote locations on earth, including high altitudes in India and Burma (usually aircraft crashes), icebergs, remote jungles, mountainsides, and underwater shipwrecks. This presentation shows that investigation, mission preparation and execution, and post mission analysis and identification all employ aerospace medicine practices.

SIGNIFICANCE: Aerospace medicine practices are applied to all facets of DPAA operations. Practices include medical standards and

screening of personnel to ensure fitness for deployment, travel medicine preparation to remote/austere locations, aircraft accident and forensic science procedures, medical evacuation from remote locations, fatigue and resiliency of deployers, team dynamics, Agency cultural change, international relations, Humanitarian Assistance, environmental and hazardous exposure factors (rabies, malaria, unexploded ordnance, agent orange, etc.), and medical equipment and treatment protocols. This presentation exemplifies the 2017 Aerospace Medicine Association theme to open the doors of Aerospace Medicine to new groups and how the flight environment affects their work.

Learning Objectives:

1. Participants will understand the Mission of the Defense POW/MIA Accounting Agency (DPAA).
2. Participants will be able to describe the types of field missions DPAA teams conduct.
3. Participants will understand the general processes involved in DPAA field mission operations.

[356] DISASTER RESPONSE: EMERGENCY AEROMEDICINE AND GLOBAL HEALTHCARE

R.J. Andrews¹, L. Quintana^{1,2} and T. Khan^{1,3}

¹World Federation of Neurosurgical Societies, Nyon, Switzerland;

²Neurosurgery, Valparaíso University Medical Center, Valparaíso, Chile; ³Northwest General Hospital, Medical Center, and Medical School, Peshawar, Pakistan

MOTIVATION: An estimated 20,000 people died each day from lack of surgical facilities after the 2010 Haiti earthquake; the UN estimates disasters have cost over 1.3 million lives since 1995. To improve survival, disaster response (DR) resources must be on-site in 24 hours - not the days to weeks of current DR agencies (eg, UN and Red Cross) that are not integrated into the ongoing local healthcare system.

OVERVIEW: Trauma and stroke centers (TSCs) evolved with evidence that "24/7" immediate treatment dramatically improved morbidity/mortality. TSCs are not separate but rather TSC equipment/personnel are seamlessly integrated into local healthcare delivery/education systems. We propose that DR - like TSCs - be integrated into healthcare systems worldwide as Disaster Response Centers (DRCs). A DRC includes a mobile trauma center (operating room with a car battery-powered CT, portable by helicopter) that can be operational at a disaster site anywhere worldwide within hours. Remote-control camera telemedicine systems allow immediate on-site subspecialty medical/surgical guidance; drones can optimize utilization (eg, identify the living buried in rubble, triage medical resources for the most benefit). The DRC concept is being presented at neurotrauma and emergency/DR conferences worldwide and benefits from input/support by the World Federation of Neurosurgical Societies, the American College of Surgeons, UN disaster relief agencies, WHO emergency response, Chilean Health Ministry, etc. Initial DRC sites are planned for Iquique (northern Chile) and Peshawar (northwest Pakistan). **SIGNIFICANCE:** Fortunately, disasters evoke a humanitarian response that suspends political, cultural, and socioeconomic barriers that hinder response to other global crises. This global "mega TSC system" would improve DR, establish global standards for emergency aeromedicine and medical/surgical training, and provide an unmatched universal platform for aeromedical/trauma research. DRCs, with multinational staff, would advance healthcare in developing countries. There are political, cultural, and socioeconomic benefits - beyond the aeromedical and healthcare benefits - of integrating disaster response into the ongoing global healthcare system.

Learning Objectives:

1. The participant will learn about the healthcare impact of disasters (both natural and man-made) worldwide, and the limitations of the current disaster response systems.
2. The participant will learn about the aeromedical resources available for immediate medical/surgical care in disasters.
3. The participant will learn about the benefits - both for disaster response and for global healthcare - of integrating disaster response into ongoing healthcare systems using the trauma/stroke center model.

[357] MEDICINE FOR UNCONVENTIONAL FORCES: MEDICAL SUPPORT FOR FUERZAS COMANDO 2015 AND 2016L.R. Rivero^{1,2}, J. Dominguez², G.M. Hansen² and C. Ortiz²¹U.S. Army Cadet Command, Glendale, KY; ²Special Operations Command South, U.S. Special Operations Command, Homestead, FL

INTRODUCTION: Every year the United States Southern Command (SOUTHCOM) sponsors a competition among Special Operations and Special Police units from partner nations in the Caribbean, Central, and Southern America. The military competition event, known as Fuerzas Comando, fosters cooperation and partnership among all participating countries and showcases the efforts of each country to effectively train and maintain ready and resilient forces that can work together when called upon to do so. The competition combines physical aptitude tests, such as obstacle courses, water swimming events and a road march, and marksmanship tasks under stress. Special Operations Command South (SOC SOUTH), a sub-unified Command that supports SOUTHCOM, has the delegated task to conduct this event every year. The SOC SOUTH Command Surgeon is in charge of providing medical support to this 2-week event. **METHODS:** The SOC SOUTH Command Surgeon planning team, part of the overall event planning team, organized and designed the concept of medical support and operations for these events. Medical planning consisted of (1) identifying the local medical threats and mitigation strategies, (2) identifying and partnering with local medical personnel and treatment facilities for support, (3) identifying ground and air transportation resources for emergency evacuation, (4) designing and organizing the medical support team for each event, and (5) obtaining medical insurance cover for all participants. Once the medical plans were established and approved, the planning team then proceeded to execution phase. **RESULTS:** SOC SOUTH conducted two very successful events in Guatemala (2015) and in Peru (2016). All Fuerzas Comando events had medical support and only minor, non-life-threatening injuries were reported. Both events had a medical plan for initial treatment at point of injury, rapid evacuation to local hospital and all the way back to country of origin, if required. **CONCLUSION:** SOC SOUTH conducted two Fuerzas Comando events, one for 2015 and one for 2016. Solid team effort and meticulous risk assessment reduced the risk to life and/or injury for all participants. During these events, the medical team prepared for issues such as local and endemic illnesses (flora, fauna, endemic diseases), the possibility of gunshot and musculoskeletal injuries, heat injuries, altitude sickness, and aeromedical evacuation. Lessons learned were identified and discussed for application to next year's event.

Learning Objectives:

1. Be familiar with medical planning for a complex, high-risk athletic event that requires a comprehensive medical system of immediate care, prompt evacuation and stabilization for support.
2. Be familiar with how risk management is used to assign medical support to physically-demanding and high-risk training events.
3. Recognize the process for identifying medical threats endemic to foreign regions and formulate mitigation strategies.

Wednesday, May 03**Governor's Square 11****2:00 PM****S-072: PANEL: THE ADAPTABILITY RATING FOR MILITARY AVIATION – PAST, PRESENT, AND FUTURE****Chair: Terry Correll**

Wright-Patterson AFB, OH

PANEL OVERVIEW: The United States Air Force School of Aerospace Medicine (USAFSAM) is an internationally renowned center for consultation, education, and operational research. USAFSAM promotes readiness and protects force and community health in a variety of areas, including clinical aeromedical evaluation of rated aircrew to determine readiness to return to flying status. The purpose of this panel is to review the storied history of the Adaptability Rating for Military Aviation (ARMA), highlight current dilemmas and some of the best ARMA cases seen at USAFSAM's Aeromedical Consultation Service, and share a proposal for a new approach to trained aviators being assessed for ARMA, potentially

classifying them as behaviors inconsistent with flying duties. We will round out the panel with an Air Force flight surgeon/National Aeronautics and Space Administration (NASA) psychiatrist discussing his experience as it relates to ARMA issues in aviators in the USAF and NASA. The NASA process for assessing astronauts' "fit" and "fitness" for flying will be described.

[358] THE ADAPTABILITY RATING FOR MILITARY AVIATION – CASE EXAMPLEST.L. Correll

Aerospace Medicine Consultation Division, United States Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH

The United States Air Force School of Aerospace Medicine (USAFSAM) is an internationally renowned center for consultation, education, and operational research. USAFSAM promotes readiness and protects force and community health in a variety of areas, including clinical aeromedical evaluation of rated aircrew to determine readiness to return to flying status. The purpose of this panel is to review the storied history of the Adaptability Rating for Military Aviation (ARMA), highlight current dilemmas and some of the best ARMA cases seen at USAFSAM's Aeromedical Consultation Service, and share a proposal for a new approach to trained aviators being assessed for ARMA, potentially classifying them as behaviors inconsistent with flying duties. We will round out the panel with an Air Force flight surgeon/National Aeronautics and Space Administration (NASA) psychiatrist discussing his experience as it relates to ARMA issues in aviators in the USAF and NASA. The NASA process for assessing astronauts' "fit" and "fitness" for flying will be described.

Learning Objectives:

1. The purpose of this session is to highlight current dilemmas and some of the best ARMA cases seen at USAFSAM's Aeromedical Consultation Service.

[359] ANACHRONISMS AND APHORISMS: A BRIEF HISTORY OF THE ADAPTABILITY RATING FOR MILITARY AVIATIONR. Peirson^{1,2}¹Aeromedical Consultation Service - Neuropsychiatry, United States Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH;²Psychiatry, Wright State University Boonshoft School of Medicine, Dayton, OH

PROBLEM STATEMENT: The various branches of the U.S. military ask flight surgeons to consider an applicant's ability to adapt to the military aviation environment when evaluating a flying candidate. The history of this "adaptability" is rich and storied. To attempt to assess the history of the Adaptability Rating for Military Aviation (ARMA) without this history removes the framework upon which it is built. **TOPIC:** To construct an argument for modifying the use of ARMA, a history of its development will be presented. Although its current form is different from service to service, it has a common origin. Successive generations promulgated distinct iterations, and the details of those iterations will be presented using contemporary sources. **APPLICATIONS:** The concept of adaptability to military aviation exists in all branches of the U.S. military, and the concept of "fitting in" to a corporate culture is important in commercial aviation. The role of mental health providers in assisting leadership deserves clarification.

Learning Objectives:

1. Understand the basic history of ARMA in the U.S. Air Force.
2. Appreciate the extant concept of ARMA and how it compares to previous iterations.

[360] BEHAVIORAL HEALTH AND PERFORMANCE OPERATIONS AT THE NASA JOHNSON SPACE CENTERG. Beven

Space Medicine, NASA Johnson Space Center, Houston, TX

PROBLEM STATEMENT: NASA astronauts on active status require medical certification for aircraft flying duties as well as readiness for long duration spaceflight training, launch to the International Space Station

(ISS), and mission continuation during spaceflight operations. Behavioral fitness and adaptability is an inherent component of medical certification at NASA and requires a unique approach that spans the professional life-span of all active astronauts. **TOPIC:** This presentation will address the Behavioral Health and Performance (BHP) operations program at the Johnson Space Center. Components of BHP operations include astronaut selection, as well as annual, elective, preflight, inflight, and postflight BHP assessments. Each aspect of the BHP operations program will be discussed, with a focus on behavioral fitness determination and resultant outcomes. Specifically, astronaut selection generates a rating of suitability for long duration spaceflight as well as psychiatric qualification; annual, preflight and postflight BHP assessments provoke a decision regarding the presence of any aeromedical concerns; and inflight assessment requires a conclusion pertaining to mission impact. The combination of these elements provide for a unique, comprehensive approach to flight and spaceflight adaptability. **APPLICATIONS:** Attendees will understand the differing facets of NASA's comprehensive BHP operations program that occurs over the course of an astronaut's career and be able to compare and contrast this to the Adaptability Rating for Military Aviation (ARMA) and proposed models presented by others on this panel. **RESOURCES:** N/A

Learning Objectives:

1. Understand NASA's need for a comprehensive and career-long BHP operations program that ensures and augments long duration space-flight mission success.
2. Describe the different components of NASA's BHP operation's program.
3. Understand the different conclusions generated by each BHP operations event during an active astronaut's career.

[361] BEHAVIORS INCONSISTENT WITH FLIGHT DUTIES

T. McBride

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH

PROBLEM STATEMENT: Historically in the U.S. Air Force, any evaluation of behavioral and characterological adaptability in both untrained assets and trained aviators has been termed "ARMA Determination," even though the populations and associated issues may be very different. **TOPIC:** This presentation will address a new model for evaluating trained assets whose behavior change has prompted evaluation of their continued aviation duties. Behavior inconsistent with flight duties (BIFD) urges the requisite "Why the change in behavior from their earlier 'ARMA Sat' and why now?" questions that may have a medical or administrative outcome. The BIFD model will be described and the application elucidated. **APPLICATIONS:** Attendees will appreciate the need for a novel tool to augment ARMA determinations. They will be able to describe the components of the BIFD model, apply to case examples, and implement when assessing trained aviators.

Learning Objectives:

1. Understand the need for a new model to evaluate trained aviators who have demonstrated concerning behavior.
2. Describe the components of the BIFD approach.
3. Be able to implement the BIFD approach when evaluating trained aviators.

Wednesday, May 03

1:30 PM

Exhibit Hall

S-073: POSTER: DISPLAYS, PERFORMANCE, FATIGUE, & VISION

Co-Chair: Amanda Lippert
California, MD

Co-Chair: Timothy Welsh
Bethesda, MD

[362] USE OF fNIRS TO ASSESS AIRMEN'S TRUST IN AUTOMATION

A.K. Heironimus¹, S. Guznov² and M. Pfahler³

¹ORISE, Dayton, OH; ²Wright-Patterson AFB, Dayton, OH; ³CSRA International, Dayton, OH

MOTIVATION: Automation is increasingly used in a variety of military applications (e.g., automated landing) designed to improve airmen-machine team performance, reduce risk for airmen, and reduce mission cost. However, automation is often not completely reliable, requiring airmen to maintain supervisory control over the system to ensure optimal performance. Airmen need to appropriately rely on often imperfect automation to reduce under- or over-use. Previous research suggests that trust is a major factor that determines decisions of reliance on automation. Accurate assessment of trust is critical for applications including but not limited to human-machine interface development and error diagnosis. The majority of trust metrics are self-report and might be susceptible to biases (e.g., social desirability). These metrics are typically administered post-task and might not capture real-time fluctuations of trust. Psychophysiological metrics (e.g., fNIRS) have been beneficial for measuring constructs such as workload and may be applied to trust measurement. Increased research in functional near-infrared spectroscopy (fNIRS) technology has become customary due to its robustness and ease of use for integration into realistic environments.

OVERVIEW: fNIRS assesses changes in blood flow volume to measure specific areas of brain activation. This is accomplished by measuring the changes in absorption of near-infrared light. The fNIRS device is capable of measuring outer cortex regions. The main areas of the brain linked to trust are the orbitofrontal cortex, left and right frontal lobes, medial prefrontal cortex, temporoparietal junction, and anterior cingulate cortex. High trust is associated with (1) low activation in the orbitofrontal cortex and temporoparietal junction and (2) high activation of the left and right frontal lobes, medial prefrontal cortex, and anterior cingulate cortex.

SIGNIFICANCE: Accurate trust measurement is critical for understanding patterns of airmen's reliance on automation. In addition to self-report metrics, fNIRS can provide valuable insight to measure trust in real-time and be integrated into operational environments.

Learning Objectives:

1. Measuring trust is useful for determining patterns of reliance in automation technology. Using fNIRS to measure trust will provide additional support for self-report metrics.

[363] INDIVIDUAL DIFFERENCES IN ADAPTABILITY FOR LONG DURATION SPACE MISSIONS

P.T. Bartone^{1,2}, G. Krueger³, R. Roland³, A.A. Sciarretta¹, J.V. Bartone⁴ and B. Johnsen²

¹Center for Technology & National Security Policy, National Defense University, Washington; ²Psychosocial Sciences, University of Bergen, Bergen, Norway; ³Operational Psychology Consultant, Pebble Beach, CA; ⁴Private Consultant, Annapolis, MD; ⁵Krueger Ergonomics, Alexandria, VA

INTRODUCTION: An identified risk area in NASA's Behavioral Health & Performance program concerns astronaut adaptation to isolated, confined, extreme (ICE) conditions in long duration space missions. Since individuals vary in how well they adapt to spaceflight and other ICE environments, it's important to understand the nature and causes of these differences in order to optimize selection, training and risk mitigation strategies for such missions. **METHODS:** This exploratory study performed a systematic literature review and interviewed 10 operational experts to identify factors influencing adaptability for long duration missions. The review examined published studies from 1900 to 2016 addressing human adaptability in space or analog ICE environments, searching databases PubMed, Embase, Web of Science, PsychINFO, and NASA's NTRS and JTRS. After screening 3141 eligible reports, 73 met all inclusion criteria. Operational experts were chosen by NASA and included astronauts, former astronauts, flight surgeons/psychologists, Antarctic workers and explorers. Experts were all male, aged 38-64. Interviews were done by phone, with 2-3 researchers recording. Anonymized notes were content analyzed and major themes identified. This research was exempt from human subjects review under 45CFR46.101(b). **RESULTS:** Reviewed studies and interviewees largely agreed on factors associated with individual adaptability for long duration missions. Not in order of importance: (1)intelligence, cognitive ability; (2) emotional stability; (3)openness; (4)optimism; (5) self-control; (6)hardiness; (7)positive coping strategies; (8)past experience; (9)adequate sleep; and (10)physical abilities. Also important for operational experts: support from family, friends and ground control; motivation and

passion to learn and improve oneself; reliability, striving and discipline. Experts and reviewed studies suggest a balance between introversion and extraversion is best for ICE. Results were mixed on gender. Experts indicated effects of women in ICE environments can be positive or negative, depending on leader and crew attitudes. **DISCUSSION:** This study provides preliminary evidence for factors related to individual adaptability for long duration missions. Results can be applied to improve future astronaut selection and training for such missions. Further research is needed to clarify how these factors might interact, and to what extent they may be modifiable through training.

Learning Objectives:

1. Following this presentation, the student will be able to recognize and understand individual factors associated with astronaut adaptability to long duration missions.
2. Following this presentation, the student will be able to apply knowledge on adaptability factors to improve selection strategies for those performing long duration missions.
3. Following this presentation, the student will be able to apply knowledge on adaptability factors to improve training programs for those performing long duration missions.

[364] WHAT YOU NEED TO KNOW ABOUT STAMP: SYSTEMS-THEORETIC ACCIDENT MODEL AND PROCESSES

S.M. Powell¹, B. Thornberg¹ and N. Powell-Dunford²

¹Synensys, Peachtree City, GA; ²Exchange Officer, USAARL, AE

PROBLEM STATEMENT: What you need to know about STAMP.

Rapidly evolving technology drives a requirement for new error causation models. The STAMP (Systems-Theoretic Accident Model and Processes) Model, developed by Nancy Leveson of MIT's Aeronautics and Astronautics Department, hold promise in optimized investigation of error in the fast paced modern aviation and healthcare industries. **TOPIC:** Accident Models have changed dramatically over the years. Many social-scientists have observed a human tendency to affix blame and the initial thrust of a traditional investigation into error centered on the assignment of culpability. The concept of Just Culture and Reason's Human Error developed a more mature analysis taking into account human factors. Military and civil aviation enabled dissemination of lessons learned through serial coded methodologies to capture recurrent data and assess trend analysis. Organizational factors were taken into account. STAMP enables a superior assessment of error in both the aviation and healthcare industries compared to previous models because it addresses human-machine interaction, an evolving public view of safety, new types of hazards, the changing pace of accidents and less tolerance for catastrophic error. Unlike other models, it assesses the control structure embedded in an adaptive socio-technical system. **APPLICATIONS:** Aviation and healthcare are both confronted with rapid technological breakthroughs that have exceeded the capacity of current accident models to identify the best recommendations. The STAMP methodology of error causation can optimize recommendations as well as be used in a proactive fashion to identify the best metrics with which to monitor a system.

Learning Objectives:

1. Explain the STAMP Process.
2. Integrate the STAMP model for incident management in health care settings.
3. Examine the benefits of STAMP over traditional root cause analysis (RCA) methods.

[365] WHAT DO GENERAL AVIATION PILOTS KNOW ABOUT THUNDERSTORMS?

J.M. King¹, Y. Ortiz¹, B. Blickensderfer¹, T.A. Guinn², J. Lanicci², R. Thomas³, J. Cruik¹ and N. Defilippis¹

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INTRODUCTION: The NTSB highlighted General Aviation (GA) weather-related incidents as an area in need of improvement. GA incurs 88% of weather related-incidents, resulting in a 62% fatality rate. The

most dangerous of all weather phenomena are thunderstorms. Thunderstorms can result in an array of severe weather, such as convection, wind shear, and icing. Although pilots have access to a variety of real-time weather information, research indicates that interpretation of these products requires an understanding of thunderstorm phenomena and the capability to decipher weather product information and apply it. The purpose of this paper is to investigate the relationship between pilot certificate and/or rating and their knowledge of thunderstorm phenomena and interpretation of convective weather products. **METHODS:** Seventy-nine pilots (with certificate and/or ratings ranging from Student, Private, or Instrument and higher; median flight hours = 120; mean age = 20.6) completed a thunderstorms knowledge assessment consisting of 17 multiple choice questions (Cronbach's alpha = 0.65) relating to thunderstorm phenomena and weather products. This included, lightning, thunderstorms, convective SIGMETs, and radar.

RESULTS: A one-way ANOVA for ratings on knowledge score (percentage correct) revealed ($F(2,76) = 9.03, p < 0.05$) that for overall knowledge of thunderstorms and related material, student pilots scored lowest ($M = 56.73$ ($SD = 11.96$)); and instrument rated pilots scored highest ($M = 71.5$ ($SD = 11.90$)). A 3 x 4 Mixed ANOVA (Student, Private and Instrument by Applied Thunderstorms, Lightning and Thunderstorms, Convective SIGMETs, and Radar) revealed (Wilks' Lambda = 0.70, $F(3, 74) = 10.80, p < 0.05$, partial eta squared = 0.31) that all pilots scored significantly higher on applied thunderstorm ($M = 62.82$ ($SD = 17.33$)) and convective SIGMET interpretation questions ($M = 70.18$ ($SD = 18.01$)) than they did on lightning and thunderstorm questions ($M = 53.59$ ($SD = 20.96$)). Lastly, all pilots scored higher on convective SIGMET interpretation questions than on weather radar interpretation questions ($M = 59.70$ ($SD = 26.10$)).

DISCUSSION: The low scores on the thunderstorm knowledge assessment may indicate gaps of knowledge about convective weather and GA flight. Further research is needed to assess a larger, more generalizable sample and to develop strategies (e.g., training, performance support tools, etc.) to mitigate the possible lack of knowledge in this area.

Learning Objectives:

1. The audience will gain knowledge that General Aviation Pilots who are not instrument rated have a lack of knowledge of convective weather principles.

[366] PILOT CUEING SYNERGIES FOR DEGRADED VISUAL ENVIRONMENTS

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INTRODUCTION: Operating in degraded visual environments (DVEs) can cause a loss of spatial orientation and situational awareness, which has on several occasions led to controlled flight into terrain, ground obstacle collisions, and the loss of aircraft and personnel. In this study, the compatibility and effectiveness of forward looking infra-red (FLIR) sensor imagery, displays, and cueing sets were assessed using quantitative measures of flight performance and pilot subjective reports. **METHODS:** In a full-motion DVEs simulation study with seven test pilots, we evaluated aural and tactile cueing along with sensor imagery displayed on either a helmet mounted display (HMD) or panel mounted display (PMD). The symbology and FLIR imagery were presented on a UH-60M panel mounted display or a SA Photonics high definition, wide field-of-view, binocular HMD. Tactile cues were presented via belt, shoulder harness, and seat cushion using electromechanical tactors. Aural cues were presented via an HGU-56/P rotary-wing aircrew helmet. The compatibility and effectiveness of each combination of FLIR sensor imagery, selected display, and aural and tactile cueing sets were evaluated with quantitative measures of flight performance and pilot's subjective reports.

RESULTS: The type of display utilized had a statistically, but not operationally, significant effect on flight performance. The pilots were minimally better able to maintain an ideal flight path with the PMD than with the HMD. When symbology was provided on the HMD and PMD concurrently, pilots gave the PMD symbology a higher rating than the HMD. There was no difference in the NASA Task Load Index (TLX) scores or the Situational Awareness Rating Technique (SART) scores when using HMD versus using PMD. There was no difference in flight performance, handling quality ratings, the NASA TLX scores or the SART scores with Cues on versus Cues off. **DISCUSSION:** Pilots considered imagery, aural cueing, and tactile cueing as effective counter-measures during DVE flights. However, their subjectively effective rating of cueing did not translate into a difference in any of the performance metrics.

The results were derived from highly experienced test pilots who are not representative of a more general population of Army aviators. Future studies should use less experienced pilots and a larger sample size.

Learning Objectives:

1. Recognize the effect of display type and tactile cueing on pilot performance during flights in degraded visual environments.

[367] DESIGN AND DEVELOPMENT OF AN ALGORITHM FOR AN ACHIEVABILITY LIMIT DISPLAY FOR CREWED PLANETARY LANDING

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INTRODUCTION: The Apollo moon landings were each successful, albeit the risks associated with the landings were very high. With NASA planning to send future crewed missions to Mars, a need to minimize landing risks is crucial to crew safety and mission success. Therefore, we proposed an Achievability Limit Display (ALD) which will assist astronauts' decision making for safe/reasonable landing point designations. The ALD consists of two components, a display map of hazardous terrain and a closed curve displaying the limit of the achievable landing locations given the fuel remaining. However, an approach to accurately estimate the achievable limit has yet to be developed. **METHODS:** We are currently developing two algorithms for the calculation of the achievable limit. Both algorithms leverage planetary landing guidance equations. The first relies on analytical calculations and the second simulates ordinary differential equations (ODE) using a simple model of pilot/automated control inputs. A preliminary test will be performed to determine how the two algorithms vary. The testing of the ALD will focus on three different test groups to perform landing scenarios: the first using the analytical calculation approach, the second by simulating ODEs, and the third with no ALD. Subjects will be provided information about points of scientific interest (PoSI), the hazard map, and the amount of fuel remaining and will be judged on landing success and performance. **RESULTS:** In evaluating the performance of the two guidance trajectory algorithms, preliminary results suggest that the ODE-integrated algorithm is more computationally expensive, but the resulting ALD is more precise. We hypothesize that landing performance and success will be improved when the ALD is displayed compared to when it is not present. A set of ongoing human subject experiments are evaluating this hypothesis. **DISCUSSION:** The ALD is expected to improve planetary landing performance and safety by providing astronauts with information to make more informed decisions while landing. The most critical benefit of the ALD will occur for re-designations of the landing point during descent. The astronauts would need to re-designate to a new PoSI, but will have a smaller range of achievable locations due to the use of fuel. The ALD will improve astronauts' decision making such that they can more rapidly re-designate to a location that they know they can achieve.

Learning Objectives:

1. An achievability limit display, which depicts the limit of landing points which can currently be achieved, may help astronaut decision-making during future planetary landings.

[368] PERFORMANCE IN A HEAD-MOUNTED DISPLAY IS DEGRADED BY VARYING LATENCY

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INTRODUCTION: Virtual environments and head-mounted displays (HMDs) have been shown to generate motion-sickness-like symptoms known as cybersickness. Research has shown that varying display latency is innate in head-tracked HMDs and can increase sickness symptoms. This is of interest because virtual environments are used for training, and cybersickness can impede training—possibly affecting transfer of training. There is a lack of research examining the effects of varying latency on task performance and the interaction between performance and sickness. The purpose of this study was to determine how different patterns of latency in

an HMD affect human performance. **METHODS:** 29 subjects (14 female) signed an institutional review board approved informed consent form and participated in a repeated-measures study involving performing a point-and-shoot task while wearing an HMD. Each participated in two sessions separated by 14 days to minimize carry-over effects from adaptation. Subjects were exposed to constant (70 ms) and varying (70 ms – 270 ms) latency conditions in each session. Subjects completed the point-and-shoot task by making head-eye movements to locate targets and shooting the targets with a laser pointer, while wearing an HMD. Subjective sickness scores were reported. Performance was measured using accuracy and time-to-hit each target. **RESULTS:** Subjects scored fewer hits overall and took longer to hit targets in the varying latency condition, $F(1,54) = 35.20, p < .01, h^2_p = .40$, than in the constant latency condition $F(4,51) = 13.50, p < .01, h^2_p = .51$. There was an interesting difference in sickness between conditions such that varying latency resulted in greater sickness, but this effect fell just short of significance; $t(29) = -1.58, p = .06$ (1-tailed), $d = .60$. **DISCUSSION:** Results show individuals performed worse when exposed to varying latency compared to constant latency. It is unclear whether performance differences are due to varying latency itself or an underlying causal influence such as simulator sickness. It is possible that the performance task lessened subjects' experience of simulator sickness, and more research is needed to explore whether a performance task can mitigate sickness.

Learning Objectives:

1. This experiment aids in understanding the effects of different types of latency on performance and simulator sickness while wearing a head-mounted display.

[369] HISTORY OF MOTION SICKNESS DOES NOT CORRELATE WITH EXPERIENCED SICKNESS A HEAD-MOUNTED DISPLAY

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INTRODUCTION: Research has shown that varying latency occurs in head-tracked head-mounted displays (HMD) and can create feelings of simulator sickness. While research has studied history of sickness and sickness in a head-tracked HMD, the relationship between the two measures has not been examined thoroughly. This is important because virtual environments are becoming more common as a method for training and often history questionnaires are used to gauge whether or not a subject will get sick in a simulated environment. The purpose of this study was to explore if those with high history of motion sickness reported more simulator sickness when experiencing varying latency in an HMD. **METHODS:** Eighty-nine subjects (46 women) were drawn from three separate studies in which they were exposed to varying latency in an HMD with a programmed delay ranging from 70 ms – 270 ms to simulate that of head-tracked devices. All subjects signed an institutional review board approved informed consent form. Subjects completed the Motion Sickness History Questionnaire (MSHQ) before the task and the Simulator Sickness Questionnaire (SSQ) after each of the five trials during the task. The highest (peak) SSQ score from the five trials was used to measure sickness. **RESULTS:** The median MSHQ score was used to define a "high history" and "low history" group for analyses. The high group scores ranged from 14.4-60.75 while the low group scores ranged from 0-13.5. The high group ($M = 50.2, SD = 40.3$) reported mean SSQ scores that did not differ significantly from the low group ($M = 61.0, SD = 45.0$), $t(87) = 1.19, p = 0.24$. In addition, no correlations between MSHQ and SSQ was observed $r(87) = .002, p > 0.05$. **DISCUSSION:** These results do not follow the expectation that a history of sickness would be related to simulator sickness when exposed to varying latency in a HMD. A potential explanation for this finding is that the MSHQ does not account for sickness history in an HMD, or more generally simulator sickness. Further research should be done to examine how to best predict susceptibility to simulator sickness and more generally HMD provoked sickness as these devices become more commonly used amongst the public.

Learning Objectives:

1. This study aims to show the challenges associated with using motion sickness history as a means of predicting simulator sickness in a head-mounted display with varying latency.

[370] HAWKEYE HABITABILITY: A SEAT CUSHION EVALUATION

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INTRODUCTION: Aircrew of the E2-C/D Hawkeye experience restricted movement during flight operations which can affect comfort, fatigue, and, ultimately, mission readiness. With plans to enable in-flight refueling capabilities, the Hawkeye will remain airborne for substantively longer periods of time, thereby heightening habitability concerns. The current pilot study addressed these concerns by examining a prototype seat cushion against the current model for its potential to reduce the burden of prolonged sitting.

METHODS: Active duty subjects ($n = 21$; 20 male) sat for at least 2 hours on the prototype Continuous Wave Cushion (CWC) and the existing Non-Ejection Seat Endurance (NESE) cushion. Objective measurements were obtained on tissue oxygenation index (TOI) and skin blood flow (SBF), and subjective measurements were obtained on perceived comfort and fatigue. Repeated measures analysis of variance assessed measurement changes from baseline to 120 min across conditions (with weights at baseline, 60 min, and 120 min, as available). This research was approved by the Naval Health Research Center Institutional Review Board (Protocol Number: NHRC.2014.0026).

RESULTS: Statistically significant results were obtained for SBF, comfort, and fatigue but not TOI. The significant main effect for cushion on SBF ($F(1, 14) = 5.408, p < 0.05$) indicated, regardless of time spent sitting, subjects exhibited increased SBF while sitting on the CWC versus the NESE. Although subjects reported decreased comfort for both cushions, the significant interaction between cushion and time on comfort suggested this decrease was more pronounced for the NESE ($F(1, 18) = 7.043, p < 0.05$). The significant main effect for time on fatigue indicated subjects reported increased fatigue over time, regardless of cushion ($F(1, 18) = 16.602, p < 0.001$). **DISCUSSION:** These results suggest the CWC is more comfortable and allows for increased SBF compared with the NESE. Results also confirmed that sitting for extended periods leads to increased fatigue. With extended flight operations on the horizon, future studies should examine the CWC over increased time intervals to further evaluate the impact of this seat cushion design on Hawkeye aircrew habitability concerns.

Learning Objectives:

1. Describe habitability concerns associated with prolonged flight operations.
2. Explain methods for evaluating habitability considerations.

[371] USING THE MODIFIED MULTI-ATTRIBUTE TASK BATTERY AS A DISTRACTOR TASK IN SIMULATOR TESTING WITH EXPERIENCED PILOTS

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INTRODUCTION: Few studies have validated the use of additional distractor tasks during simulated flights. The need for such tasks is evident when conducting studies with highly experienced pilots, who are less susceptible to workload manipulations. This study utilized the Modified Multi-Attribute Test Battery (mMATB; Cline et al., 2015) as a visual stimuli intended to increase workload, in order to demonstrate the inclusion of additional tasks capable of producing performance changes in experienced pilots. It was hypothesized that conditions using the mMATB would increase workload resulting in poorer performance. **METHODS:** Seven male test pilots, with an average of 2600 flight hours, participated in this study. All testing was conducted in USAARL's full-motion Black Hawk flight simulator. Testing consisted of multiple iterations of a takeoff, enroute, approach to hover, hover, and landing maneuvers. The systems monitoring task of the mMATB was used to increase pilot workload. The reported data is a portion of a larger test that examined cueing and visual displays, results are only presented for comparisons between conditions using and not using the mMATB. Participants also completed the NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988) at the end of each flight. **RESULTS:** Each maneuver was examined separately using the following deviations as performance metrics: lateral, longitudinal, heading, and speed. Comparisons were made using Wilcoxon

signed-rank test. Both the hover ($p = 0.02$) and landing ($p = 0.02$) portions of the flight found greater deviations in heading when the mMATB was active. The enroute portion of the flight found greater lateral deviations in the condition where the mMATB was used, $p = 0.04$. Analyses of the NASA-TLX subscale scores and overall score found no significant differences in ratings between conditions.

DISCUSSION: The mMATB task can be successfully incorporated into simulator studies as a means of increasing workload, as determined by performance changes. Subjective workload was not impacted by the use of the mMATB, which may be due to higher experienced pilots reporting lower perceptions of workload (Borghini et al., 2014). Future research should utilize a larger sample size, as well as different levels of experience, to further validate the use of this task.

Learning Objectives:

1. mMATB is an adequate distractor task to use in simulator studies involving experienced pilots.

[372] COMPARISON OF PILOT SCAN PATTERNS DURING UNUSUAL ATTITUDE RECOVERY IN GLASS VS ANALOGUE COCKPITS

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INTRODUCTION: Proper scan pattern is a vital skill for pilots to learn and master. This is particularly essential when flying in an abnormal situation, such as recovering from an unusual attitude (UA). Achieving and maintaining scan patterns is further challenged during recovery when flying in an aircraft with different instrument display and information layout, such as a 'glass cockpit' or an 'analogue cockpit'. The aim of this study was to determine if pilot scan patterns were different in an analogue cockpit compared to a glass cockpit during UA recovery.

METHODS: Twelve fixed-wing pilots, 9 male and 3 female, participated in this study. The study received institutional ethics approval and was conducted in a reconfigurable fixed-wing flight simulator. Each pilot encountered the scenario twice, once in a glass cockpit and once in an analogue cockpit. The aircraft was placed in a 35° nose-up pitch and 10° bank to the right at 5,000 feet above sea level. The pilot, unaware of the UA, had to take control of the aircraft and recover immediately. Objective data was collected using a head-mounted eye tracker. Fixation time was expressed as a percentage of the total recovery time. **RESULTS:** Pilots scanned the outside world 7.53% more in a glass cockpit than an analogue cockpit. The outside world scan patterns were not significantly different between a glass and an analogue cockpit. The inside instruments were scanned 6.82% more in an analogue cockpit than a glass cockpit. The inside instruments scan patterns was not significantly different between a glass and an analogue cockpit. The saccade rate of the subjects was 8.15% more in an analogue cockpit than a glass cockpit. The saccade rate was not significantly different between a glass and an analogue cockpit. **DISCUSSION:** The results of this study show that there was no significant difference in pilot scan patterns between glass and analogue cockpits during unusual attitude recovery. This is in contrast to previous studies that show a difference in scan patterns between the two types of cockpits in normal flying conditions. The severity and the time-critical nature of the UA situation forces pilots to have similar scan patterns during recovery, despite the type of cockpit. This study is part of a bigger project investigating pilot scan patterns in different types of cockpits.

Learning Objectives:

1. Participants will be able to understand the issues involved in recovery from unusual aircraft attitudes in different cockpit types.

[373] INTEGRATION OF PHYSIOLOGY AND COGNITIVE MODELS TO PREDICT HUMAN BEHAVIORAL OUTCOMES IN AERONAUTICAL ENVIRONMENTS

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INTRODUCTION: Aeronautical environments are mentally and physically challenging, often inducing excessive stress in both physiological and cognitive systems. Currently predictive human modeling methodologies focus independently on simulation of either the cognitive or physiological realm, not both simultaneously. This effort was to combine these dependent domains and produce a holistic prediction of response to stress in the aeronautical environment. **METHODS:** Physiologically based pharmacokinetic (PBPK) models predicting chemical blood and tissue concentrations for actual human exposures to toxins (toluene, ethanol) and drugs (caffeine) were interfaced with the well-validated computational theory of human cognition called ACT-R (Adaptive Control of Thought – Rational) accounting for physiological, cognitive, and behavioral changes at different doses of pharmacologically active substances. We focused on a cognitive model of the psychomotor vigilance test (PVT) developed in our laboratory. **RESULTS:** PBPK models reproduced the blood time-course concentrations in humans for all chemicals/drugs simulated, spanning inhalation of volatile organics, orally consumed ethanol or sublingually absorbed caffeine in chewing gum. Blood time course concentrations of each chemical were inputs to ACT-R to control parameters for information processing mechanisms associated with components of cognition. The resulting integrated model was used to predict actual human cognition changes with chemical/drug exposure observed in controlled studies. **DISCUSSION:** The long-term goal is to integrate the PBPK model approach with multiple components of cognition (e.g. perception, declarative and procedural knowledge) to account for cognitive and behavioral changes observed in more complex tasks. Our results so far suggest that toluene primarily affects motor and/or perceptual encoding. This supports the mechanistically sound correlation between known protein receptors, like gamma-Aminobutyric acid receptor, for the toxins/drugs studied being reflected in the cognitive test results measured in the controlled human laboratory studies. A simple, illustrative example demonstrated changes in the likelihood of retrieving task-critical information as toluene concentration increased and or was metabolized.

Learning Objectives:

1. Aeronautical flight can have a complex interaction at both the physiological and mental state of the pilot, resulting in divergent and unpredictable outcomes that currently are being addressed medically and scientifically, by newer complex analysis systems. The results of these analyses will provide safer flight practices that would not necessarily be known from more classical treatments of the problems of stress, fatigue, and medicinal countermeasures.

[374] THE IMPACT OF FATIGUE ON NON-TECHNICAL PERFORMANCE IN AEROMEDICAL CLINICIANS

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INTRODUCTION: Strong non-technical skills are needed for optimal performance in safety critical workplaces. Fatigue is presumed to have negative effects on both technical and non-technical aspects of clinical performance, though the nature of this relationship is not well understood. Practical tools are needed to assess fatigue effects and our group has adapted the Anaesthetists' Non-Technical Skills system for use in the aeromedical clinical setting. In this study we used the adapted tool to evaluate the effects of fatigue on the non-technical performance of aeromedical clinicians. **METHODS:** A convenience sample of aeromedical clinicians undertook two different simulated air ambulance missions, once when rested, and once when fatigued following a night shift in ICU (randomised crossover design). Ethical approval was granted by the University of Otago Ethics Committee. Trained assessors blinded to subjects' fatigue status performed detailed structured assessments in 4 domains: teamwork, situational awareness, task management, and decision-making. Each domain had specific elements, where expected behaviours were rated numerically from 5 (excellent) to 1 (completely absent or inadequate), based on predefined criteria. Scores were calculated for each domain

and also summed to provide a single numerical rating of non-technical performance. Rank-based statistical testing compared each subject's 'rested' and 'fatigued' scores. **RESULTS:** Subjects scored significantly higher on overall non-technical performance when rested versus fatigued ($p = 0.04$). Scores across individual domains of teamwork (0.04), situational awareness (0.04), and decision-making (0.04) were consistently higher when clinicians were rested; task management scores did not differ ($p = 0.34$). **DISCUSSION:** This adapted assessment tool appears to identify degraded non-technical performance in this preliminary result, though more observations are needed to improve precision in the analysis (and are being performed). It also provides detailed results concerning performance degradation within the 4 non-technical skill domains, where fatigue consistently affected performance. This type of assessment tool may be useful in the study of how fatigue affects different aspects of clinical non-technical performance in medical crews. Also, a reliable, pragmatic, and workplace-specific assessment instrument is needed to assess effects of anti-fatigue interventions on non-technical performance at the 'sharp' end.

Learning Objectives:

1. Attendees will gain an understanding of how a non-technical skills measurement framework can be used to: 1. Assess the impact of clinician fatigue in air transport settings; and 2. Assess effects of anti-fatigue interventions on the non-technical performance of clinicians.

[375] THE EFFECT OF MODAFINIL ON SLEEP INERTIA IN A COGNITIVE PERFORMANCE MODEL OF FATIGUE

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INTRODUCTION: Sustained operational environments may cause fatigue due to lack of sleep. While the use of alertness aids such as modafinil may reduce cognitive impairment, substantial research shows that the use of strategic, or "combat" naps, of varying lengths can also alleviate these impairments; however, sleep inertia following a short nap may itself contribute to reductions in performance. We hypothesized that subjects who take modafinil prior to napping will perform better on objective assessments taken within 15 minutes of waking compared to subjects assigned placebo medication. **METHODS:** Males ($n=18$) and females ($n=6$) between the ages of 18 – 40 completed a battery of cognitive and physiologic tests to obtain baseline results over 20 hours, after which they were placed in napping rooms and given the opportunity to take a two hour nap. Thirty minutes prior, the subjects were given either 200mg of modafinil or placebo. After waking, the subjects immediately continued the test battery; only the baseline and session completed immediately upon awakening were included in this analysis. Within the first fifteen minutes of wakefulness, each subject completed a Psychomotor Vigilance Task (PVT) and integrated cognitive testing (NovaScan). **RESULTS:** Subjects immediately waking from a short nap were found to have significant deficits in reaction time performance ($F(1,21) = 81.215, p < .001$), NovaScan reaction time ($F(1,22) = 5.996, p = .023$) and time out errors ($F(1,22) = 7.437, p = .012$). However, the addition of modafinil was found to have no significant effect on sleep inertia compared to placebo in any task. **DISCUSSION:** The results suggest that 200 mg of modafinil does not provide any relief from subject sleep inertia. Further analysis of cognitive tests may reveal other relationships to napping and modafinil.

Learning Objectives:

1. The objective of this poster is to discuss the results of the study.

[376] THE EFFECTS OF "SMART" SLEEP PLUGS ON AUDITORY ATTENTION AND AUDITORY REACTION

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MOTIVATION: Excessive noise in the combat environment due to aircraft/flight line noise, generators, and combat operations disrupts sleep and interferes with sleep quality. Forward Operating Bases (FOBs) and air

fields are continuously noisy environments due to 24/7 operations. The potential for increased accidents, poorer reaction times, and poorer compliance with safety measures due to lack of sleep is a threat to mission completion, aviator fitness, and performance. **OVERVIEW:** Recent research has shown that insufficient sleep and poor sleep quality can negatively impact performance and increase health risks. Researchers who study the effects of sleep deprivation have revealed that interrupted sleep can impair a subject's reaction times and alertness. Critical thinking skills and sharp reaction times are crucial to the success of any mission particularly in the unforgiving world of flight. The ability to recall information, maintain composure, and make clear decisions is critical for the aviator who relies on quick decision-making to operate aircraft. **SIGNIFICANCE:** Quality of sleep may be improved by reducing outside noise thereby decreasing the amount of interrupted sleep and increasing the amount of actual sleep during rest time. In this presentation we offer solutions to the critical area of reducing interfering noise during sleep hours, determine the level of noise reduction offered by sleep plugs and advanced technology smart plugs, and review the literature concerning the relationship between aviator performance and interrupted sleep. Future research proposals will be overviewed in two phases. In phase I, we will outline the proposal to investigate the amount of attenuation sleep plugs provide to common operational noises such as air field noise, generator noise, and FOB noise. In phase II, we will outline the proposal to investigate the impact of sleep plugs on operational performance. Phase II research will endeavor to address whether "smart" sleep plugs: 1. improve sleep subjectively, 2. improve auditory attention tasks, and 3. improve auditory reaction times. This work is of interest to professionals who may be interested in improving human performance and fitness in operational environments.

Learning Objectives:

1. The learner will be exposed to the potential effects of interrupted sleep on aviator health and performance and oriented to how these effects will be studied in upcoming research. Additionally, potential products proposed to mitigate noise during sleep with noise cancellation and attenuation sleep plugs will be introduced.

[377] PARSING OUT THE INFLUENCE OF PRACTICE AND TESTING FATIGUE ON COGNITIVE PERFORMANCE

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INTRODUCTION: Repeated testing potentially induces testing fatigue, or the impairment of performance with increased time on task, resulting in a decline in performance (Steinborn, Flehmig, Westhoff, & Langner, 2009). Given that many operational tasks involve sustained performance, understanding the capabilities/limitations of repeated performance over time is warranted. The present study determined the effects of testing fatigue on cognitive performance, while accounting for mood (i.e., sleepiness), in an effort to optimize sustained performance while minimizing testing fatigue. **METHODS:** The study selected a subset of data from a study examining the effects of napping and modafinil on sleep deprivation. A sample of 25 participants were tested over 13 hrs on a cognitive task battery. Each participant completed 5 2-hr testing sessions; test length was abbreviated during sessions 1 and 2 for test familiarization. The Profile of Mood States was completed at the end of each session and used as a subjective measure of sleepiness. Repeated measures ANOVAs were conducted on task reaction times (RTs) to assess performance and practice effects, and reaction time coefficient of variation (RTCV; $RTSD/Mean\ RT \times 100$) to measure testing fatigue. Decreased RTs conveyed learning, while increased RTCV indicated testing fatigue. Performance asymptote was reached when no significant difference between test sessions occurred. Pearson correlations were used to analyze associations between task performance and subjective sleepiness. **RESULTS:** All tests reached performance asymptote by session 3 as evidenced by a lack of changes ($p > 0.05$) between consecutive sessions on task RT. Testing fatigue was not evident for any task ($p > 0.05$) as RTCV did not significantly change across sessions. Subjective fatigue was not correlated with performance of any task. Longer length tests within test sessions will additionally be examined for testing fatigue evidence. **DISCUSSION:** The lack of testing fatigue could indicate testing fatigue resiliency in short latency tasks, in that short tests (< 5 min) spread across multiple testing sessions potentially allows for mental task

separation. Repeated task switching lessens cognitive demand. Tasks completed utilizing such designs are less likely to exhibit confounded performance by time on task. These results are useful for future study designs examining continuous and prolonged performance, as well as for optimization of sustained operational missions.

Learning Objectives:

1. To determine an adequate testing timetable schema that both maximizes performance and minimizes cognitive testing fatigue.

[378] SUBJECTIVE FATIGUE IS INFLUENCED BY DUTY DURATION AMONG SHORT-HAUL AIRLINE PILOTS

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INTRODUCTION: Pilot fatigue associated with circadian rhythm disruptions (light/dark cycle) and disturbances of sleep/wake cycle is of concern in aviation operations. Crew members are often required to work irregular schedules. As a result, they can experience sleep loss and increased fatigue. We aimed to determine whether perceived fatigue levels varied by time of day, time awake at duty end, duty duration and sleep time obtained by pilots on the previous night. **METHODS:** Forty-four pilots (4 female) aged 30.8 (± 7.1) years flew a roster consisting of a cycle of five days of short duty hours followed by four days off, five early duty followed by three days off, five daytime starts with many sectors followed by three days off and then five late duties with finishes that generally ended during the night followed by four days off. The pilots completed several questionnaires about demographics, sleep and fatigue. They wore an Actiwatch throughout the study and completed a fatigue scale several times every day. Early starts (05:00-06:59 hrs) and late-finish (00:00-01:59 hrs) duties were examined to compare fatigue levels based on flight duty period (FDP), sleep time and time awake at duty end. The study was approved by NASA IRB and all participants signed a consent form prior to participating in the study. **RESULTS:** Perceived fatigue increased with time awake and time of day, reaching levels of moderate fatigue after 18 hrs of being awake. There was a significant difference of the fatigue level between early start and late finish duties as reported by pilots ($p < .01$) with the late finish being higher. The FDP duration was significantly longer for the late-finish duties ($p < .001$) as was the time awake at duty start ($p < .001$). **DISCUSSION:** Consistent with Vejvoda et al., (2014) we found that fatigue was higher after late duty relative to early duty suggesting that time awake and not prior sleep duration might be an important factor in elevated subjective ratings of fatigue. Future research could focus on performance effects of duty times.

Learning Objectives:

1. Duty duration was the main predictor of pilots having elevated levels of fatigue at the end of duty.

[379] WHY ARE ONBOARD REST FACILITIES IMPORTANT TO CFR PART 117 AND PILOT FATIGUE MANAGEMENT?

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PROBLEM STATEMENT: Title 14 Code of Federal Regulations (CFR) Part 117, Flightcrew Member Duty and Rest Requirements were officially implemented on January 04, 2014, and were designed to improve pilot fatigue management. All aircraft used in augmented flight operations require functional rest facilities that must obtain Federal Aviation Administration (FAA) approval and qualification for either Class 1, 2, or 3 specifications as outlined in 14 CFR § 117.3 and Advisory Circular (AC) 117-1. Rest facilities are subject to the aircraft's Minimum Equipment List (MEL) requirements and refer to a bunk or seat accommodation providing flightcrew members with a sleep opportunity. **TOPIC:** Why is this important? Part 117 allows longer flight duty periods for carriers providing additional crew and appropriate on-board rest facilities. Each rest facility classification delineates the maximum flight duty period (FDP) predicated on the number of pilots and their assigned start time as found in Table C of the regulation. With newer aircraft designed to fly longer routes, it is imperative to also design rest facilities that not only meet specifications but provide the best quality sleep experience for pilots on

those routes. The FAA's classification limits (or rest credit) were, in part, based on the Simons and Spencer (2007) study providing science-based guidance on the maximum permissible FDP, related to the quantity and quality of sleep attained in each rest facility. A Class 1 facility affords the longest FDP; Class 2, the second longest; and Class 3, the third longest (i.e., the shortest) FDP. **APPLICATION:** If the rest facility does not meet required specifications, §117.7, Fatigue Risk Management System (FRMS), contains an optional systematic approach to test whether a non-compliant rest facility operationally meets or exceeds sleep afforded by a compliant facility. The FRMS application procedure requires data collection, analysis, and validation before authorizing continued use. This poster will describe examples of such proposals and their disposition as equivalent facilities. **RESOURCES:** 1. 14 CFR Part 117 Flightcrew Member Duty and Rest Requirements, Final Rule. 2. FAA Advisory Circular (AC) 117.1 Flightcrew Member Rest Facilities. 3. FAA Advisory Circular (AC) 120-103A Fatigue Risk Management Systems for Aviation Safety.

Learning Objectives:

1. Participants will learn about the importance of onboard crew rest facilities for augmented flight operations in the U.S.
2. Participants will learn that there are procedures for determining rest facility equivalence for those that do not meet the design specifications identified in the Advisory Circular 117-1 Flightcrew Member Rest Facilities.

[380] TEST-RETEST RELIABILITY OF COMPUTER BASED BINOCULAR FUNCTION MEASURES

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INTRODUCTION: Military pilots experience visual fatigue when using optically misaligned Head Mounted Displays (HMD) and binocular Night Vision Devices (NVD). We are interested in identifying accurate and reproducible predictors of degraded task performance as induced by visual fatigue. These predictors will be used to establish practical tolerance limits for optical misalignment that will warrant optimum task performance without compromising safety. Previous research showed that measures of binocular function are good predictors of task performance. Currently used methods to assess binocular function provide only coarse measures that are difficult to relate to individual variability in task performance decrements. Therefore we employed a set of computer based vision tests developed by U.S. Air Force School of Aerospace Medicine's Operational Based Vision Assessment Laboratory as part of the Automated Vision Testing (AVT) system. We present here the results of preliminary investigations into test-retest reliability and practice effects on near and far stereoacuity and binocular fusion tests as implemented in AVT. **METHODS:** Experimental work is underway to recruit a representative sample of participants. Twelve participants have been assessed to date. Ethics approval was granted by the Defence Science and Technology Group Ethics Review Panel. Participation involved two consecutive days of testing to investigate test-retest variability. Near and far stereoacuity and binocular fusion were measured on both days. Three of these participants completed a further 8 days of testing in order to determine if there are any practice or training effects. **RESULTS:** Preliminary data shows good test-retest reliability of far stereoacuity ($R^2=0.87$) and binocular fusion ($R^2=0.91$). The reliability of near stereoacuity test was lower ($R^2=0.60$). Performance on near stereoacuity test and binocular fusion improved over time indicating potential practice/training effects. **DISCUSSION:** Stereoacuity and binocular fusion tests are good candidates as objective predictors of task performance decrements as induced by visual fatigue. Further investigations are required to fully characterise practice effects on measuring these parameters with the AVT system. As practice effects might impact

on test-retest reliability our experimental protocol will be modified to allow more time between test and retest.

Learning Objectives:

1. Understand the test-retest variability and practice effects for computer based tests of binocular vision.

[381] ARMY AIRCREW MEMBERS PERSPECTIVES ON USE OF DIETARY SUPPLEMENTS AND ENERGY DRINKS

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INTRODUCTION: This study was conducted to address the challenges faced by Army aviation personnel and their perceptions regarding the use of dietary supplements and energy drinks to overcome fatigue. It was hypothesized participants perceived energy drinks as a tool to help maintain alertness while also being concerned about violating military policies regarding use of these products. **METHODS:** Questionnaires were administered to 189 Soldiers from an Army Combat Aviation Brigade. A subset of 47 Soldiers was subsequently invited to participate in a focus group session. Questionnaires obtained information on dietary supplements, energy drinks, and their perceived benefits. Focus group questions were open-ended and addressed decision making, benefits, motivating factors, safety, supplement preference, and education about energy drinks and dietary supplements. **RESULTS:** Of the participants, 74% used dietary supplements and 51% used energy drinks. Select focus group data indicated: 1) Energy drinks are perceived as important for coping with shift schedule and work environment; 2) Energy drinks are routinely consumed and easily accessible, especially during deployments; 3) Aircrews are aware of aeromedical policies and use judgement and take personal responsibility for using supplements/drinks; and 4) Participants attributed energy-drink usage in part to inaccessibility of healthy food options, inadequate nutrition and performance-based education, and demanding work environments. Respondents expressed a preference for autonomy regarding energy-drink choice and were skeptical about the Army's ability to develop an energy drink that would meet their needs. Participants were receptive to nutrition education and ways to improve performance.

DISCUSSION: Energy drinks and other dietary supplements are important to the Army aviation community for a variety of reasons. It appears aircrew members are taking calculated risks and accept personal responsibility for using energy drinks given existing aeromedical policies. Long-term dietary safety education and implementation of approved strategies are needed to help aviators overcome work-related stressors and improve alertness.

SUPPORT: Supported by DHP and USAMRMC. The views expressed in this work are those of the author and do not reflect the official policy of the Department of Army/Navy/Air Force, Department of Defense, or U.S. Government.

Learning Objectives:

1. Understand the usage of dietary supplements and energy drinks within the Army Aviation Community.

[382] DETERMINANTS OF SLEEP QUALITY IN AIR FORCE CADETS DURING BASIC FLIGHT TRAINING

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INTRODUCTION: Basic flight training for Air Force cadets demands full mental and physical effort. Researchers have shown that poor sleep quality could degrade training efficiency. The stressors for cadets during basic flight training such as job stress, fatigue, depression may affect their sleep quality. Few studies have examined their sleep quality and its determinants. The goal of this study is to investigate the determinants and sleep quality of cadets during this training phase. **METHODS:** A longitudinal study with three measurement occasions spread over the

course of six-month long basic flight training was presented. Data were collected at beginning of training, while qualified for solo flight and at the end of basic flight training. Pittsburgh Sleep Quality Index was used to measure the sleep quality. Swedish occupational fatigue inventory was used to evaluate fatigue. While Demand-control-support model and Effort-reward imbalance were used to measure job stress. Else Center for Epidemiology Studies Depression Scale was used to evaluate depression status **RESULTS:** The results showed that at least 50% of cadet was in poor sleep quality at the beginning of the study and even worse in latter training phase. Physical exertion and depression gradually worsening. CES-D analysis confirmed that depression affected the sleep quality. Environmental factors such as uncomfortable bedding and temperature also adversely affected sleep quality. After adjusted for environmental factors, job stress and fatigue were not associated with the sleep quality. Fatigue, job stress, depression and sleep quality were not determinants associated with successful completion of basic flight training.

DISCUSSION: Although the sleep quality and depression of cadets worsen with the progression of the training, the factors did not affect the success rate of flight training. This may reflect the personality characteristics of the cadets. Poor sleep quality will decrease human performance and could threaten the flight safety. It's important to understand the determinants and to improve cadets' sleep quality.

Learning Objectives:

1. At least 50% of cadet was in poor sleep quality at the beginning of the study and even worse in latter training phase.
2. After adjusted for environmental factors, job stress and fatigue were not associated with the sleep quality.
3. Fatigue, job stress, depression, and sleep quality were not determinants associated with successful completion of basic flight training.

[383] DEVELOPMENT OF A COLOR PALETTE DESIGNED TO IMPROVE USABILITY FOR INDIVIDUALS WITH COLOR-VISION DEFICIENCIES

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INTRODUCTION: Colors used to code information should be legible, recognizable, and distinguishable from one another. Designing a palette that meets these criteria is especially challenging if the users include people with color-vision deficiencies (CVDs). **PURPOSE:** Develop a candidate color-coding palette, suitable for color-normal and CVD air traffic controllers (ATCs), for testing in a subsequent formal experiment. The palette contains foreground colors for coding symbols and alphanumeric, plus background colors for coding weather severity.

METHODS: In Phase 1, groups consisting of one color-normal, protan, deutan, and tritan examined an LCD showing 22 foreground-color swatches and matching character strings derived from previous research on color normals. The background colors consisted of black plus six others, ranging from a desaturated green to a desaturated red and having low luminances, chosen to provide adequate contrast for the foreground colors. Over the course of testing four groups, the experimenter adjusted some colors and eliminated others based on the participants' feedback, resulting in a set of 11 foreground and 4 weather/background colors, which the participants deemed legible, discriminable, and recognizable in all foreground/background combinations. In Phase 2, legibility was tested with a search for a three-character string among 48 data blocks; discriminability, by selecting targets from an array of distractors; and recognizability, by identifying an alert color presented as a target. Participants used a computer mouse to designate the targets. **RESULTS:** The percentage of correct identifications was high for all color-normal and CVD groups (~89% correct). Discussions with participants indicated that halving the luminances of the weather/background colors would likely improve performance while retaining their discriminability and recognizability. Future pilot studies will test these ideas before we proceed to the formal experiment. **CONCLUSIONS:** The candidate palette has promise for color-normal and CVD air traffic controllers and warrants further testing. We expect the resulting palette, which will appear in the FAA HF-STD-010 ATC Display Color Standard, will provide a better and larger color set for display designers to use when developing systems for controllers with CVDs than the sets used presently; and, may be useful for other applications that have CVD users.

Learning Objectives:

1. The participant will understand the critical factors for a color palette to be deemed usable.
2. The participant will understand how to evaluate a color palette for discriminability, recognizability, and legibility.

[384] LIGHT-EMITTING DIODES, LASER EYE PROTECTION, AND AVIATION SIGNAL LIGHTING: CHALLENGES AND POTENTIAL SOLUTIONS

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PROBLEM STATEMENT: The purpose was to explore the effect of laser eye protection (LEP) devices on color perception of signal lighting. Aviation signal lighting devices can use either single-die (single-color) or red-green-blue (RGB) light-emitting diodes (LEDs). RGB LEDs create light using mixtures of red, green, and blue light from three primary color emitters. LEP glasses work using notch filters that block the specific emissions from commercially available lasers. Many of these lasers emit in the same band as the green primaries in RGB LEDs. This means that aviators using LEP glasses will generally experience erroneous color perceptions from some RGB LEDs. The effect is that of removing one or more of the LED's primary colors from the perceptual environment rendering the LED dichromatic or potentially monochromatic. This same phenomenon could generally be analogous to a person with a color vision deficiency (CVD) viewing an RGB LED. **TOPIC:** An experimental device developed at CAMI aided in exploring the challenges of using RGBs for aviation signal lighting. Participants with normal color vision (NCV) and CVDs were tested on their ability to identify colors created by single-die and RGB LEDs. The primary benefit of this project was the development of training materials for aviators alerting them to the potential hazards of misinterpreting signal lighting while wearing LEP glasses or visors. Materials include a training video that distinctly shows the differences in aviation signal lights when viewed with and without LEP devices. **APPLICATIONS:** Aviators are encouraged to familiarize themselves with color perception through their LEP devices prior to flight by viewing lighting in the airport environment prior to departure. During flight operations, pilots are advised to cross-check signal lighting information with other visual cues, ground and traffic warning systems, and flight deck displays. A long-term solution might benefit from the fact that emissions from LEDs are theoretically infinitely tunable during the manufacturing process. This characteristic presents the possibility of manufacturing RGB LEDs that emit in portions of the visible spectrum that are less problematic when using LEP glasses or for those with CVDs.

Learning Objectives:

1. Develop an understanding of the effects on colored aviation signal light perception while wearing laser eye protection (LEP).
2. Identify possible interventions for the identification of aviation signal lights for aircrew that use LEP devices.
3. Discuss implications for aircrew with color vision deficiency waivers that use LEP devices in flight.

[385] QUANTIFYING OPTICAL DISTORTION IN LASER EYE PROTECTION

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INTRODUCTION: Optical distortion is the effect by which a transparent object warps the perception of a visual target. All developed Air Force (AF) visors that incorporate Laser Eye Protection (LEP) are required to pass the military standards outlined in the MIL-V-43511D. The current technique for evaluating optical distortion in AF visors is entirely qualitative, with a panel of several human evaluators weighing in on the acceptability of a distortion. The assessment of distortion is not explicitly tied to a visual acceptability rating and has no consistency over time or across evaluators. **METHODS:** The proposed experimental technique utilizes the same set-up as required in the current MIL-STD, but replaces the vertical Ronchi rulings with Ronchi grids. Ronchi grids allow for the detection of feature points and enable the complete characterization of the distortion. The differences between test images and a reference

image are analyzed for changes in feature location and magnification. These results are visualized as maps over the imaged LEP and evaluated for acceptability based on the magnitude and location of the distortions. **RESULTS:** These experimental and analysis techniques have been applied successfully over a set of test images. A divergence map will show the local non-uniformities and the rate of area change during the presentation where areas of the lens possessing large non-uniformities are the areas with high distortions. Depending on the magnitude and location of the distortion, the lens is characterized as acceptable or unacceptable. **DISCUSSION:** Quantification of the standards for optical distortion will be presented as the initial step toward determining the effects of distortions on human visual performance.

Learning Objectives:

1. Understand an objective technique to quantify local distortion patterns induced by refractive irregularities in LEP and evaluate their acceptability related to human visual performance.

[386] OPERATIONAL BASED VISION ASSESSMENT COLLABORATIVE RESEARCH: AUTOMATED STEREO TESTING

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INTRODUCTION: Two objectives of operational based vision assessment research at the U.S. Air Force School of Aerospace Medicine (USAFSAM) and at DSO National Laboratories (DSO) are to 1) provide quantitative data defining the visual performance capability that will contribute to success of the mission and 2) modernize aircrew vision screening. **METHODS:** To support vision standards and screening modernization, USAFSAM and DSO conducted Institutional Review Board-approved research to evaluate the feasibility of adopting computer-based tests to replace existing chart-based vision screening methods. USAFSAM and DSO each examined two different computer-based stereo acuity tests. DSO examined an electronic version of the Titmus test ("eTitmus"), compared the eTitmus to the standard Titmus booklet test, and examined test-retest reliability. USAFSAM conducted a similar evaluation using an electronic version of the standard Air Force stereo acuity screening test. The automated stereo tests were administered at both locations using Windows-based computers and three-dimensional displays. **RESULTS:** Data for 108 subjects were collected at DSO to compare the eTitmus test to the standard booklet test. The results show that the format of the test (electronic vs. booklet) does not substantially alter the outcome of the test. However, when subjects were asked to provide a more complex response (identify position in depth – crossed vs. uncrossed disparity), the correlation between the two tests was greatly reduced. Data for approximately 30 subjects were collected at USAFSAM to examine a similar stereo acuity test, but using only the more complex response method. The results indicate that the test-retest reliability was high, but only moderately correlated with the Air Force standard stereo acuity test. **DISCUSSION:** Normative data for each test format are reported in detail, and the potential for replacing existing chart-based stereo tests with computer-based stereo acuity tests, using modern adaptive threshold estimation procedures, randomized trials, and supporting electronic data records and operational medicine concept of operations, is discussed.

Learning Objectives:

1. Discover evolving trends and best practices in aerospace medicine concerning vision screening.
2. Apply principles of evidence-based medicine, operational risk management, and aeromedical decision-making in aircrew selection and clinical aerospace medicine practice.
3. Identify medical/visual factors that impact optimal human performance.

[387] PROPOSED VISION TESTERS FOR FUTURE F.A.A. APPROVAL AND A REFERENCE DATABASE OF REGIONAL CLINICS SPECIALIZING IN AIRMEN VISION SCREENINGS

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MOTIVATION: In the U.S., airmen must complete and pass a comprehensive medical examination under the guidance of a designated Aviation Medical Examiner (AME) in order to exercise the privileges of their licenses per Federal Aviation Administration (FAA) regulations. Assessments of distance, intermediate, and near vision, color vision, and the presence of any ophthalmologic conditions of concern must be made using pre-approved devices detailed in the latest editions of the FAA Guide for Aviation Medical Examiners. Many instruments listed, however, have been out of production for decades and are no longer serviced by their respective manufacturers. Pilots and healthcare professionals alike further experience difficulty in locating providers in possession of these rare machines. Hence, our preliminary database of regional AME practices and locations of available testing equipment in the southwestern United States will improve the physician's and the pilot's ease-of-access to such services. A list of widely-used vision screeners able to perform all FAA-mandated examinations was also compiled for the agency's consideration when updating future evaluation parameters for airmen medical eligibilities. **OVERVIEW:** Regional experts familiar with the FAA's implemented policies and medical regulations were initially consulted by both phone and e-mail. Each individual reached was asked if he or she could offer the names, telephone numbers, or e-mail addresses of possible organizations or persons who may own any machines of interest. Preliminary search criteria for newer vision testers eligible for future approval included instruments 1) able to perform all FAA-required inspections, 2) still in production, 3) not specifically prohibited from use by the FAA Guide for Aviation Medical Examiners, and 4) priced under \$5,000.00 at the time of investigation. **SIGNIFICANCE:** Current vision screeners unable to be serviced by their manufacturers and a lack of updates to established FAA guidelines leave AMEs and their clients seeking airmen certification vulnerable to preventable instrumentation errors during visual exams. Inaccuracies in the ophthalmologic assessments alongside wrongful medical approvals, if not methodically evaluated and corrected, could put the national airspace at risk.

Learning Objectives:

1. The participant will be able to recognize vision screeners that are currently available and in use by general practitioners and that may be eligible for future approval by the Federal Aviation Administration medical guidelines.
2. The participant will be able to locate and contact aviation medical examiners in the southwestern United States able to administer appropriate vision screenings for airmen seeking to exercise the privileges of their licenses.
3. The participant will be able to understand why revisions and updates to current F.A.A. vision screening guidelines are necessary in order to better ensure the safety of the national airspace.

Wednesday, May 03
Grand Ballroom

4:00 PM

S-074: PANEL: THE 10TH ANNUAL RAM BOWL

Sponsored by American Society of Aerospace Medicine Specialists

Co-Chair: Rebecca Blue
Fayetteville, NY

Co-Chair: Robert Johnson
Oklahoma City, OK

Co-Chair: Allen Parmet
Kansas City, MI

Co-Chair: Jan Stepanek
Scottsdale, AZ

PANEL OVERVIEW: The American Society of Aerospace Medicine Specialists presents the 10th Annual RAM Bowl contest for the Louis H. Bauer Trophy.

[388] THE 10TH ANNUAL RAM BOWL

A.J. Parmet⁵, R.S. Blue⁴, J. Stepanek³, R. Johnson², G.K. Anderson⁶, C. Lowry⁷, B. Pinkston⁸ and W.S. Silberman¹

¹Aviation Certification Services, LL, Oklahoma City, OK; ²Medical Management, Humana Government Business, Boerne, TX; ³Mayo Clinic, Scottsdale, AZ; ⁴Emergency Medicine, SUNY Upstate Medical University, Syracuse, NY; ⁵Aviation Safety & Security, University of Southern California, Kansas City, MO; ⁶Fairplay, CO; ⁷USAF, Hurlburt Field, FL; ⁸FAA, Oklahoma City, OK

The 10th Annual RAM Bowl features teams from the Air Force, Navy/Army, Mayo Clinic, Wright State and University of Texas competing for the Louis H. Bauer Trophy. For the first time, international residents will be able to participate. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Teams complete in a college bowl format that tests aerospace medicine competencies, recall speed, teamwork and individual knowledge. Topics include the specialty aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, federal aviation regulations, passenger transport, restraint and escape, cockpit resource management and Aeromedical transportation. Questions are divided into toss-up questions and bonus questions. Multiple rounds of competition will lead to the selection of this year's victor and awarding of the Louis H. Bauer Trophy, sponsored by the American Society of Aerospace Medicine Specialists.

Learning Objectives:

1. Preparation of Residents in Aerospace Medicine for the American Board of Preventive Medicine Examination.
2. Review of Aerospace Medicine for attendees seeking recertification by the American Board of Preventive Medicine.

Wednesday, May 03

4:00 PM

Plaza D/E

S-075: SLIDE: DODGING DISORIENTATION

Co-Chair: Frederick Bonato

Montclair, NJ

Co-Chair: Glenn Knox

Jacksonville, FL

[389] WHY CAN'T WE ORIENT LIKE BIRDS? IMPLICATIONS FOR HUMAN SPATIAL DISORIENTATION IN FLIGHT

B. Cheung

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INTRODUCTION: Orientation in a complex three dimensional aerial environment increases demands on the vestibular system. The semicircular canals are necessary to sense angular acceleration (rotation) in any direction while the macular end organs provide the gravitational frame of reference. It has been suggested that creatures that evolved to fly such as birds (Aves) share the same sensory system, and probably the same limitations as creatures (humans) that did not evolve to fly (Stott, 2013). However, bird semicircular canals have previously been noted for their large size relative to body mass as early as 1908 (Gray). **METHODS:** A systematic literature review was conducted regarding the morphological structure of the vestibular systems in birds, their evolutionary and functional significance as compared to that in humans. **RESULTS:** The size and shape of avian semicircular canals with the same body mass (Spoor et al., 2002) varies considerably. Unlike human semicircular canals, avian canals rarely approach circularity and all three canals typically undergo torsional excursions out of their respective planes. Reconstruction of the vestibular structures from computed tomography (Sipla, 2007). of many species of extant birds and non-avian theropods suggested that the

pattern seen in volant avians is found to correlate strongly with different flying behaviours while many flightless birds reflect their status as bipedal cursors. **DISCUSSION:** For any given body mass, qualitatively more "agile" species have quantitatively larger-arc semicircular canals (Spoor, 1993; Spoor and Zonneveld, 1998; Sipla et al., 2003; Walker et al., 2003). Specifically, the anterior and lateral canals were found to be preferentially larger than those of non-avian theropods and humans. Increase in the length of the semicircular canal is associated with greater sensitivity to rotational stimuli (Rabbitt et al., 2004). As a result, highly maneuverable birds of prey have the largest overall canal dimensions relative to body mass, most plausibly to match the rapid body rotations that characterize variable speed maneuvering during pursuit. By comparison, the three semicircular canals in humans are morphologically symmetrical in size and shape. This teleological symmetry presents another inherent but less understood vestibular limitation during air combat manoeuvres that can lead to spatial disorientation.

Learning Objectives:

1. A brief review on the morphological difference between avian and human semicircular canals will be presented.
2. The significance of the morphological difference and its implication on spatial disorientation in flight will be discussed.
3. An example on the effects of the inherent vestibular inadequacy on air combat manoeuvres will be presented.

[390] DEVELOPMENT OF VISUAL-VESTIBULAR NORMATIVE STANDARDS FOR U.S. MILITARY PILOTS

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¹Auditory Protection and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL; ²Laulima Government Solutions, Orlando, FL

MOTIVATION: Vestibular and visual-vestibular function is rarely evaluated systematically at time of accession for military pilots. Additionally, baseline balance function is not routinely assessed after completing flight school or pre-deployment. This creates a situation in which "pre-injury" normative values do not exist, making return-to-duty or fitness-for-duty standards difficult to determine by military physicians and flight surgeons. It has been shown that the visual-vestibular function of pilots and astronauts are not equivalent to the general non-aviator population. Therefore, utilizing limited civilian and non-pilot published normative data may be insufficient in determining functional pilot performance. This presentation will discuss the efforts the U.S. Army Aeromedical Research Laboratory is undertaking to address this critical safety gap in selection and fitness-for-duty/return-to-duty standards. **OVERVIEW:** Normative standards for balance and visual-vestibular performance do not exist for U.S. military pilots. This is a critical gap in safety, since spatial awareness and orientation in air or on ground relies heavily from inputs from the three components that comprise balance function (i.e., vision, vestibular, somatosensory). The U.S. Army Aeromedical Research Laboratory has proposed to establish normative values for non-symptomatic, healthy pilots with regards to functional balance and visual-vestibular performance. Normative values will be established utilizing a rotary chair and balance platform system like those found in military medical treatment facilities around the world. A rotary chair evaluates visual-vestibular function during whole-body rotation, while a balance platform evaluates both functional balance and vestibularly-mediated gaze performance. Project status and interim findings will be discussed. **SIGNIFICANCE:** This type of research is specifically called for by the Military Operational Medicine Research Program focus area Injury Prevention and Reduction. The need for tri-service aeromedical standards for normal and clinically abnormal performance further drives this effort. This work would be of interest to professionals who determine selection, fitness-for-duty and return-to-duty for pilots following vestibular injury due to barotraumas or head acceleration (e.g., falling, vehicle accidents, combative training). This research effort may have broader interest in the civilian sector for either commercial or private aviation.

Learning Objectives:

1. The participant will be able to identify how the U.S. Army Aeromedical Research Laboratory is working towards addressing potential aviation normative values of vestibular function in normal physiologic U.S. military trained aviators.

[391] ROTOR WING SIMULATORS FOR SD TRAINING - CONTINUAL PROCESS IMPROVEMENTA. Bushby¹, A. Estrada³ and N. Powell-Dunford²¹HQ Army Air Corps, Stockbridge, United Kingdom; ²Exchange Officer, USAARL, AE; ³USAARL, Fort Rucker, AL

MOTIVATION: Spatial disorientation (SD), the incorrect perception of one's physical orientation in space, can occur even in highly experienced pilots. Despite advances in technology and training sophistication, SD remains a major cause of lethal mishaps and severe incidents amongst rotor wing (RW) pilots. An immersive and interactive program of SD training using high fidelity flight simulators is a promising development in the spectrum of approaches to the RW SD problem. Continual process improvement is essential to ensure the efficacy of such resource and time intense training efforts. **OVERVIEW:** In an effort to deliver more interaction, realism and focused training effect, high fidelity simulators are being increasingly viewed as potential SD training devices. Traditional disorientation simulators focus on vestibular misinformation as the key factor for SD development but analysis indicates that inattention and visual misinformation are more relevant for RW pilots. Simulator SD training has been assessed favourably in subjective surveys and evidence exists for its positive impact on actual flight performance in at least one controlled RW trial. Improvements in synthetic flight modelling, visual fidelity and terrain databases provide increasingly authentic, immersive training environments; similarly the ability to incorporate workload, crew cooperation and multiship simulation allow crews to experience and develop disorientation in representative RW environments. It is unclear which technological advances will be most useful in RW SD training delivery. Efforts at UK's Army Aviation Centre and U.S. Army Aeromedical Research Laboratory are underway to enhance and validate rotor wing simulator SD training with a goal of establishing evidence based best practice as part of a program of immersive SD training. **SIGNIFICANCE:** Spatial disorientation remains a significant and often fatal aviation hazard. High fidelity simulators afford realistic, interactive SD training compared to demonstrative SD training but at significant time and resource investment. Interventions should therefore be focussed, effective and where possible, supported by robust evidence. Continuous process improvement efforts are essential to maximize RW safety within the resource constrained environment. SD training programs should commit to deliberate assessment of simulator technology in terms of training satisfaction and efficacy in the development of situational awareness and coping skills.

Learning Objectives:

1. Identify the main objective of immersive SD training.
2. Characterize the effectiveness of various forms of rotor wing SD training.
3. Identify emerging technologies currently deployed for rotor wing SD training.

[392] THE CORRELATION OF MOTION SICKNESS SUSCEPTIBILITY AND AIRSICKNESS IN PILOT TRAINEESH. Chu^{1,2} and T. Ko²¹Aviation Physiology Research Laboratory, Kaohsiung, Taiwan;²Institute of Aerospace and Undersea Medicine, National Defense Medical Center, Taipei, Taiwan

INTRODUCTION: Motion sickness is a maladaptive response in a motion environment due to the conflict among visual, somatosensory and vestibular stimuli. Airsickness, the motion sickness in flight, affects 10-30% of military cadets during initial period of flight training and may lower cadets' flight training efficiency, degrade their performance, reduce their G tolerance and predispose them to spatial disorientation. The purposes of the present study are to evaluate the susceptibility of motion sickness by past experience and by Coriolis stimulation on rotary chair; and to study the association of ground motion sickness susceptibility with airsickness in pilot trainees. **METHODS:** Total of 141 healthy young subjects (114 student pilots, 27 medical officers) participated. The susceptibility to motion sickness on the ground is evaluated with the Motion Sickness Susceptibility Questionnaire-Short (MSSQ-S), reflecting previous experience as well as Motion Sickness Symptom Ratings (MSSR)

under Coriolis stimulus, reflecting response to provocative stimuli.

Airsickness severity in first flight is also evaluated using MSSR.

Physiological parameters including systolic and mean blood pressure, respiratory rate, Galvanic skin response, skin temperature, and heart rate variability are recorded during Coriolis stimulation. **RESULTS:** We found positive correlation between motion sickness susceptibility to Coriolis stimulation (MSSR on the rotary chair) with previous experience (MSSQ-S) ($r=0.48$, $p<0.001$), and airsickness (MSSR of first flight) ($r=0.35$, $p<0.001$). After Coriolis stimulation, participants' Galvanic skin response increased (0.9 ± 0.8 kohm, $p<0.001$), skin temperature decreased (-1.4 ± 1.4 °C, $p<0.001$). LF/HF (2.28 ± 2.81 to 3.74 ± 6.90) and LF/(LF+HF) (0.54 ± 0.23 to 0.57 ± 0.25) ratio of HRV increased. HF (6989.9 ± 7477.5 ms² to 3933.4 ± 6493.0 ms², $p<0.01$) and HF/(LF+HF) (0.46 ± 0.23 to 0.43 ± 0.25) of HRV decreased. **DISCUSSION:** Positive correlation exists between the susceptibility evaluated with response to Coriolis stimulation (MSSR) and previous experience of motion sickness (MSSQ-S). Motion sickness symptoms provoked with rotary chair associated with airsickness symptoms in cadets. These findings could be used as basis for preventive airsickness desensitization in pilot trainees in the future.

Learning Objectives:

1. Understand the definition and mechanism of motion sickness.
2. Understand motion sickness susceptibility and methods to evaluate it.
3. Evaluate the correlation of motion sickness susceptibility and airsickness. Possible impact of this correlation in airsickness prevention and treatment.

[393] ANALYSIS OF SWAY INTENSITY IN HEALTHY SUBJECTS DURING POSTUROGRAPHY WITH PROVOCATIVE SETTINGS

C. Gammel, A. Gens and C. Ledderhos

German Air Force Center of Aerospace Medicine, Fuerstenfeldbruck, Germany

INTRODUCTION: Posturography is used to objectively measure a person's balance. In an aeromedical context, the subjects are generally healthier and more trained than the average person. This results in good performance during posturographic examinations. In order to challenge a healthy person's equilibrium and to disclose small disturbances of balance control, data can be gathered while the posturographic platform is tilted in antero-posterior or lateral directions. Frequencies measured during these examinations provide information as to which part of body stabilization is challenged the most. The aim of this analysis was to find out how the sway intensity at the different frequencies changes with the platform being inclined in diverse directions and what conclusions can be drawn for a healthy person's balance. **METHODS:** A commercially available system (TETRAX IBS) was used to gather data both on the original horizontal platform and on the platform tilted by 15 degrees in antero-posterior and lateral directions. The sway intensity at eight different frequencies (ranging from 0.01 to more than 3.00 Hz) was determined and compared between the two conditions. **RESULTS:** 178 healthy persons (male/female; age 18 to 55) participated in the testing. Inclination of the platform resulted in an increase of all eight frequencies. Generally the effect was more pronounced with the platform being tilted laterally than being tilted to the back or to the front. The inclination with the subject's toes pointing downwards revealed the widest span of increase. Frequencies F2 to F4 representing the vestibular system of the balance control system showed the smallest increase (between 2% and 21%), whereas frequency F7 as one indicator of central balance control showed the highest increase with 64%. **DISCUSSION:** Tilting procedures on the posturographic platform used in our study allowed the disclosure of even small derogations in balance control. The inclination of the posturographic platform to both lateral positions challenged the balance system of healthy subjects in the most effective way. This included all subsystems of the balance control system (visual, vestibular, somatosensory and central control).

Learning Objectives:

1. Understand the influence of a modified posturographic testing procedure on the sway intensity of the human body.
2. Objective measurement of postural balance.

[394] PREVENTATIVE AIRCREW ROTATIONAL TRAINING

J. Recklau

Aerospace Physiology, USAF, Enid, OK

MOTIVATION: airsickness is a common response for individuals to experience during flight. During United States Air Force Undergraduate Pilot Training (UPT), airsickness can affect the ability of student pilots to progress and ultimately result in removal from the program. Preventative measures that are put in place prior to UPT are critical to the retention of student pilots. This poster will describe specific preventative measures taken at Vance AFB for student pilot populations identified as high risk for airsickness during UPT. **OVERVIEW:** Vance AFB has a comprehensive airsickness management education and acclimation program in place to help student pilots identify, manage and overcome many of the factors that may be contributing to their airsickness. Airsickness management includes Aircrew Rotational Training (ART), which utilizes multiple 10 or 2 minute sessions in the Barany Chair, commonly referred to as "spins," to desensitize the semicircular canals. Identifying students who are at a higher risk of airsickness and targeting ART training prior to the start of UPT may expedite vestibular acclimation and reduce the number of students who are removed, or fall behind during pilot training. The Vance AFB student registrar identifies students who experience active airsickness at the USAF Initial Flight Training course which is conducted prior to UPT. This student population is offered a preventative 3 day ART program in addition to general education all students receive prior to their first UPT flight. **SIGNIFICANCE:** Since the beginning of CY 2016, 10 students have been given preventative 3 day ART training prior to their first flight in the T-6A. Since the beginning of CY 2016, zero students who received this preventative treatment have been removed from UPT due to airsickness. Although not yet statistically significant, this preventative approach may improve pilot training graduation rates while saving the government money and contributing to military readiness.

Learning Objectives:

1. In concert with other treatment modalities and behavior modification, sessions in the Barany Chair have been effective in decreasing airsickness rates, via vestibular system desensitization, in military aviators.

Wednesday, May 03
Plaza F

4:00 PM

S-076: SLIDE: FUTURE OF SPACE MEDICINE: PT. 2

Chair: Mark Campbell
Paris, TX

Co-Chair: Keith Brandt
Houston, TX

[395] MEDICAL OPTIMIZATION NETWORK FOR SPACE TELEMEDICINE RESOURCES

R.V. Shah¹, R.A. Mulcahy¹, D. Rubin³, E. Antonsen², E. Kerstman¹ and D. Reyes¹

¹Aerospace Medicine, UTMB/KBRWyle/NASA, Galveston, TX;

²Medicine, Baylor/NASA, Houston, TX; ³KBRWyle, Houston, TX

INTRODUCTION: Long-duration missions beyond low Earth orbit introduce new constraints to the space medical system such as the inability to evacuate to Earth, communication delays, and limitations in clinical skillsets. NASA recognizes the need to improve capabilities for autonomous care on such missions. As the medical system is developed, it is important to have an ability to evaluate the trade space of what resources will be most important. The Medical Optimization Network for Space Telemedicine Resources was developed for this reason, and is now a system to gauge the relative importance of medical resources in addressing medical conditions. **METHODS:** A list of medical conditions of potential concern for an exploration mission was referenced from the Integrated Medical Model, a probabilistic model designed to quantify in-flight medical risk. The diagnostic and treatment modalities required to address best and worst-case scenarios of each medical condition, at the terrestrial standard of care, were entered into a database. This list included tangible assets (e.g. medications) and intangible assets (e.g. clinical skills to perform a procedure). A team of physicians working

within the Exploration Medical Capability Element of NASA's Human Research Program ranked each of the items listed according to its criticality. Data was then obtained from the IMM for the probability of occurrence of the medical conditions, including a breakdown of best case and worst case, during a Mars reference mission. The probability of occurrence information and criticality for each resource were taken into account during analytics performed using Tableau software. **RESULTS:** A database and weighting system to evaluate all the diagnostic and treatment modalities was created by combining the probability of condition occurrence data with the criticalities assigned by the physician team. **DISCUSSION:** Exploration Medical Capabilities research at NASA is focused on providing a medical system to support crew medical needs in the context of a Mars mission. MONSTR is a novel approach to performing a quantitative risk analysis that will assess the relative value of individual resources needed for the diagnosis and treatment of various medical conditions. It will provide the operational and research communities at NASA with information to support informed decisions regarding areas of research investment, future crew training, and medical supplies manifested as part of the exploration medical system.

Learning Objectives:

1. The participant will understand the MONSTR tool to evaluate the trade space of what resources will be most important in an exploration mission.

[396] EXISTING PROVISION FOR EMERGENCY MEDICAL SERVICES AT CANDIDATE SITES FOR A UK SPACEPORT

K.E. Middleton and T.G. Smith

Aerospace Medicine Research Group, University of Oxford, Oxford, United Kingdom

INTRODUCTION: The UK government is currently deciding on the location of a national British spaceport, which is intended to be operational by 2018, with the aim of becoming the European centre for space tourism. The government is following a systematic process for selecting the spaceport location from among competing sites based on key operational, safety, meteorological, environmental and economic criteria, and has narrowed down the list of possible sites to six candidates. Wherever it is located, the spaceport will require a robust emergency medical plan, and we hypothesised that there is significant variation in the current provision for emergency medical services across these sites, which has not yet been considered as part of the ongoing selection process. **METHODS:** Existing emergency medical services were investigated for each of the candidate sites: Campbeltown Airport, Glasgow Prestwick Airport, Llanbedr Airfield, Newquay Cornwall Airport, Stornoway Airport and RAF Leuchars (temporary candidate only). All hospitals within a large radius were surveyed in order to develop a comprehensive picture of available emergency medical resources surrounding each site, and road and air ambulance transfer times to relevant facilities were estimated. As UK trauma services aim to achieve primary ambulance transfer to a major trauma centre within 45 minutes, this capability was specifically investigated. Site bidding teams were also invited to provide relevant information on medical services. **RESULTS:** More than 30 hospitals were identified and surveyed in this analysis. There is wide variation in current provision for emergency medical services across the candidate spaceport sites, both onsite and with regards to proximate hospital facilities. Road ambulance times to the nearest 24-hour Emergency Department range from ~10 minutes to ~90 minutes. Only two permanent candidate sites, Glasgow Prestwick Airport and Newquay Cornwall Airport, are located within 45 minutes of a major trauma centre. **DISCUSSION:** Existing provision for emergency medical services, which will be an important element of the spaceport's emergency medical plan, varies greatly between the candidate sites and this may be worthy of consideration as an additional factor in the government's selection process.

Learning Objectives:

1. Outline standard requirements for medical service provision at candidate spaceport sites.
2. Identify criteria for comparison between spaceport sites, sources of information, and methods for collection of these.
3. Recognise gaps between ideal service provision and existing service provision, to guide spaceport planning teams in future site development.

[397] EVALUATION OF THE PERFORMANCE OF EXTERNAL CHEST COMPRESSIONS DURING HYPOGRAVITY SIMULATIONC. Mackaill¹, G. Sponchiado², A.K. Leite², P. Dias², M. Da Rosa², E.J. Brown⁴, J.M. de Lima³, L. Rehnberg² and T. Russomano²¹School of Medicine, University of Glasgow, Glasgow, United Kingdom; ²Microgravity Centre, PUCRS, Porto Alegre, Brazil; ³School of Engineering, PUCRS, Porto Alegre, Brazil; ⁴College of Medical and Dental Sciences and MicroG Center, University of Birmingham - UK and MicroG Center PUCRS, Brazil, Borehamwood, United Kingdom

INTRODUCTION: CPR guidelines aim for at least 50mm depth when giving external chest compressions (ECCs). This may be unachievable in hypogravity conditions. A way to compensate for this is to flex and extend the arms during CPR. A new position was also trialled, in which the volunteer straddled the mannequin using its legs for stabilization. **METHODS:** 10 volunteers (19-30yr) performed 3 sets of 30 ECCs with a 6s interval between sets (2 ventilations), in accordance with 2015 CPR guidelines. Nine positions (1 Gz, Mars and Moon simulations with and without braces in the CPR terrestrial and straddle positions) were tested. A body suspension device with counterweights was used to simulate the volunteer's body weight in hypogravity environments. ECC depth and rate, angle of arm flexion via elbow electrogoniometry, post-ECC heart rate (HR) and rate of perceived exertion (RPE) were measured. A metronome was set to 100bpm and volunteers did not perform their next set of ECCs until their HR returned to baseline. **RESULTS:** All volunteers completed the 9 runs, and ECC rate was achieved for all gravitational conditions (100-120bpm). Mean (\pm SD) ECC in the straddle position at 0.38 Gz was 54.1 \pm 5.5mm with braces and 50.5 \pm 1.7mm without braces ($p>0.05$). However, ECCs were below 50mm at 0.17 Gz (47.5 \pm 1.47mm with braces; 47.4 \pm 0.87mm without braces, $p>0.05$). In the terrestrial position, ECCs were more effective without braces (49.4 \pm 0.26mm at 0.38 Gz; 43.9 \pm 0.87mm at 0.17 Gz) than with braces (48.5 \pm 0.28mm at 0.38 Gz; 42.4 \pm 0.3mm at 0.17 Gz). Elbow flexion increased from approximately 2 degrees (with braces) to 8 degrees (without braces). HR did not change for each of the positions when compared to 1 Gz. **DISCUSSION:** 2015 CPR guidelines were achieved in the straddle position at 0.38 Gz, but no significant difference in mobile and immobile arms was found. Volunteers were closer to reaching the required ECC depth in the terrestrial position without wearing braces during Mars simulation. ECC depth was not achieved at 0.17 Gz, due to the more intense decrease in body weight.

Learning Objectives:

1. To compare the effectiveness of ECCs performance in hypogravity simulations (0.38G Mars; 0.17G Moon) with braces (immobile arms) and without braces (mobile arms), using the terrestrial and new straddle CPR positions.

[398] COMPARISON OF ULTRASOUND AND MRI ASSESSMENTS OF THE CERVICAL AND LUMBAR SPINE: LESSONS FROM THE INTERNATIONAL SPACE STATIONM.F. Harrison^{1,2}, K. Garcia³, D. Ebert³, A. Sargsyan³ and S. Dulchavsky⁴¹Department of Emergency Medicine, Henry Ford Hospital, Detroit, MI; ²Department of Critical Care Medicine, Henry Ford Hospital, Detroit, MI; ³NASA-Wyle, Houston, TX; ⁴Department of Surgery, Henry Ford Hospital, Detroit, MI

OBJECTIVE: Back pain is one of the most common complaints of astronauts during spaceflight. Ultrasound (US) represents the only imaging modality available on the International Space Station (ISS) to assess space-related back pain. The present study investigated the utility of spinal U.S. assessments in comparison to results of pre- and post-flight MRI studies. **METHODS:** Seven astronauts deployed to the ISS underwent U.S. examinations before, during, and after long duration spaceflight U.S. examinations for comparison to pre- and post-flight MRI findings. Measurements of interest included anterior disc height, anterior intervertebral angles, and cumulative disc heights. Statistical analysis was performed with repeated measures ANOVA, Pearson-r correlation, and Bland-Altman plots; significance was determined as $p\leq 0.05$. **RESULTS:** Bland-Altman plots revealed statistically significant disagreement for pre- and post-flight MRI and U.S. measurements of lumbar and cervical anterior disc heights ($p<0.01$ and $p<0.01$, respectively) and disc angles

($p<0.01$ and $p<0.01$, respectively) for pre- and post-flight MRI and U.S. measurements. However, Pearson-r correlation analysis provided statistically significant results for lumbar and cervical anterior disc height ($r^2=0.83$, $p<0.01$; and $r^2=0.26$, $p=0.03$; respectively) and angle ($r^2=0.89$, $p<0.01$; and $r^2=0.02$, $p=0.20$; respectively). Furthermore, the U.S. imaging identified 33 anomalous or pathological findings during the pre-flight examination and at least 14 new findings or progression during the post-flight examination. These findings correlated well with the MRI results.

CONCLUSION: U.S. has long been used as the portable and versatile imaging modality for practicing medicine under austere conditions. We have expanded its utility in assessing a common musculoskeletal complaint in the most austere outpost humankind has ever inhabited – the ISS. While the analysis revealed statistically significant disagreement between the modalities, strong and statistically significant correlations were observed between U.S. and MRI assessments. This suggests consistency in the choice of imaging modality is important for trending measurements and a change of modality should only be considered when clinically indicated. With further refinement, U.S. assessment of spinal anatomy and pathology has potential applications to the management of acute and sub-acute traumatic spinal injuries for civilian and military patients in pre-hospital and hospital settings.

Learning Objectives:

1. Even in the hands of novel users with remote guidance, U.S. provides a diagnostic imaging modality for the assessment of spinal changes associated with spaceflight. These findings correlated well with findings and measurements obtained with MRI assessments pre- and post-flight.
2. While strong correlations were obtained between U.S. and MRI measurements, the level of agreement indicated a margin of error between the two measurements that suggests a change in imaging modality should only be considered when clinically indicated (i.e. need for improved image fidelity).
3. U.S. may have a larger role in pre-hospital assessments of spinal injuries in austere, military, or EMS settings.

[399] INTRAABDOMINAL AND INTRAESOPHAGEAL PRESSURE IN REDUCED GRAVITY: IMPLICATIONS FOR LAPAROSCOPIC SURGERY DURING EXPLORATION SPACE MISSIONSG.M. Pantalos¹, T. Kennedy², C. Mallonee², S. Harrison³ and E. Sutton⁴¹Cardiovascular and Thoracic Surgery, University of Louisville, Louisville, KY; ²Cardiovascular Innovation Institute, University of Louisville, Louisville, KY; ³School of Medicine, University of Tennessee Health Sciences Center, Memphis, TN; ⁴Surgery, University of Louisville, Louisville, KY

INTRODUCTION: Healthcare planning for exploration space missions has considered capabilities for surgical treatment, including laparoscopy. The amount of insufflation needed for laparoscopy in reduced gravity may be different from the 1-G condition due to the anatomic changes experienced in reduced gravity and the corresponding changes in intraabdominal and intrathoracic pressures. The objective of this investigation was to determine changes in intraabdominal and intrathoracic pressures during reduced gravity and to speculate on the amount of insufflation required. **METHODS:** Archived data was analyzed from four male test subjects instrumented with an acceleration-insensitive nasogastric pressure catheter (Millar Instruments) with one sensor at the mid-thoracic level (T-3) measuring intraesophageal pressure (IEP, which approximates intrathoracic pressure) and a second sensor in the proximal duodenum measuring intraabdominal pressure (IAP). Subjects assumed the supine posture while being exposed to 1-G, 0-G, and 1.8-G range of acceleration for nine consecutive parabolic maneuvers preceded by a push-over from 1-G during flight on the NASA KC-135 aircraft. **RESULTS:** Compared to the 1-G data, IAP always decreased (9.1 \pm 4.0 mm Hg to 2.5 \pm 4.1 mm Hg, $p=0.013$, $\Delta P=6.6$ mm Hg) and IEP always decreased (7.1 \pm 2.3 mm Hg to 1.2 \pm 3.6 mm Hg, $p=0.009$, $\Delta P=5.9$ mm Hg). **DISCUSSION:** The drop in IEP and IAP are consistent with the interactive increases in intrathoracic and intraabdominal volume in response to the structural unloading upon entry into weightlessness. Since the thorax and abdomen are closed chambers, Boyle's Law requires a reduction in chamber pressure in the setting of increased chamber

volume. This change in position in the pressure-volume relationship for the thorax and abdomen results in each chamber operating at a higher compliance point, as also observed in previous animal investigations in reduced gravity. These data suggest less insufflation pressure may be sufficient for adequate abdominal visualization and access during laparoscopy in reduced gravity.

Learning Objectives:

1. Understand how intrathoracic pressure (as indicated by intraesophageal pressure) and intraabdominal pressure can be simultaneously measured without the influence of an acceleration field.
2. Understand how intrathoracic pressure and intraabdominal pressure may be different in a patient in 0-G compared to 1-G.
3. Understand how changes in abdominal and thoracic compliance in 0-G may influence the level of insufflation pressure necessary for adequate visualization and access during laparoscopy in 0-G.

[400] A QUANTITATIVE RISK-BENEFIT ANALYSIS OF PROPHYLACTIC SURGERY PRIOR TO EXTENDED-DURATION SPACEFLIGHT

D. Carroll¹, D. Reyes², M. Walton², E. Kerstman² and E. Antonsen²
¹General Surgery, UC San Diego, La Jolla, CA; ²Johnson Spaceflight Center, NASA, Houston, TX

INTRODUCTION: Among otherwise healthy astronauts undertaking deep space missions, the risks for acute appendicitis (AA) and cholecystitis (AC) are not zero. If these conditions were to occur during spaceflight, they may require surgery for definitive care. The proposed study quantifies and compares the risks of developing de novo AA and AC in-flight to the surgical risks of prophylactic laparoscopic appendectomy (LA) and cholecystectomy (LC) using NASA's Integrated Medical Model (IMM). **METHODS:** The IMM is a Monte Carlo simulation that forecasts medical events during spaceflight missions and estimates the impact of these medical events on crew health. In this study, four Design Reference Missions (DRMs) were created to assess the probability of an astronaut developing in-flight small-bowel obstruction (SBO) following prophylactic 1) LA, 2) LC, 3) LA and LC, or 4) neither surgery (SR# S-20160407-351). Model inputs were drawn from a large, population-based 2011 Swedish study that examined the incidence and risks of post-operative SBO over a 5-year follow-up period. The study group included 1,152 patients who underwent LA, and 16,371 who underwent LC.

RESULTS: Preliminary results indicate that prophylactic LA may yield higher mission risks than the control DRM. Complete analyses are pending and will be subsequently available. **DISCUSSION:** The risk versus benefits of prophylactic surgery in astronauts to decrease the probability of acute surgical events during spaceflight has only been qualitatively examined in prior studies. Within the assumptions and limitations of the IMM, this work provides the first quantitative guidance that has previously been lacking to this important question for future deep space exploration missions.

Learning Objectives:

1. Understand the risks of prophylactic surgery for astronaut health and the potential impact on extended-duration space missions.

Wednesday, May 03
 Governor's Square 14

4:00 PM

S-077: SLIDE: EYES-ON

Chair: Nicholas Green
 Henlow, Bedfordshire, United Kingdom

Co-Chair: Harriet Lester
 New York, NY

[401] ILLUMINATION OF AIRCRAFT BY LASERS PART 1: INCIDENCE

E.M. Forster¹, J. Larcher¹, C.A. DeJohn¹ and H. Lester²
¹FAA CAMI, Oklahoma City, OK; ²Office of Aerospace Medicine, FAA, New York, NY

INTRODUCTION: The Federal Aviation Administration's (FAA) Advisory Circular AC 70-2A provides information to the aviation community, including aircrews operating within the National Airspace System (NAS) on measures taken by the FAA to address incidents of unauthorized illumination of aircraft by lasers. The FAA Modernization and Reform Act of 2012, passed into public law on 14 February 2012, established a prohibition against aiming a laser pointer at an aircraft. In addition, the AC provides guidance to aircrews and reflects current guidance for air traffic control (ATC) on the formal reporting of laser illumination incidents. Reporting laser incidents assists law enforcement and provides support for recommended mitigation actions to be taken to ensure continued safe and orderly flight operations. The aim of the presentation is to provide the incidence and characteristics of these events in the U.S. and its territories during the 2008 – 2015 period. **METHODS:** Information was obtained from two sources: (1) The FAA Laser Incident Tracking System, maintained by the FAA Air Traffic Organization and (2) the Incapacitation Registry, maintained by the FAA Civil Aerospace Medical Institute's (CAMI) Medical Research Team. **RESULTS:** A total 27,438 events occurred over the stated time period. Most common was the use of green lasers (94%). Most laser strikes occurred in California (n= 5,577) followed by Texas (n= 2,692) and Florida (n= 2,246). The number of events has increased over the years from 915 in 2008 to 7,346 in 2015. Of the 27,438 events, a total of 390 (1.4%) reported at least one temporary effect. The most common were: blindness (24%), blurred vision (10%), eye pain (7%), and headache (7%). Of the 85 cases reviewed by CAMI to date, 60% involved air carrier operations. Permanent injury has not been reported to date.

DISCUSSION: Per AC 70-2A, laser illumination may cause hazardous effects which could compromise safety by adversely interfering with the ability of aircrews to carry out their responsibilities during critical phases of flight. The FAA, in coordination with local law enforcement and other governmental agencies, is taking action to safeguard flights against these unauthorized illuminations and expeditiously locate the sources.

Learning Objectives:

1. Incidence of illumination of aircraft by LASER devices

[402] ILLUMINATION OF AIRCRAFT BY LASERS PART 2: VISUAL THREAT AND MITIGATION

H. Lester², E.M. Forster¹ and K.M. Gildea¹
¹CAMI, FAA, Oklahoma City, OK; ²Office of Aerospace Medicine, FAA, New York, NY

MOTIVATION: Vision is one of the most important senses for aviation and is rendered dysfunctional by a laser strike. Laser strikes are an increasingly frequent aviation safety hazard despite current mitigation strategies. Emerging technology offers additional prospects for mitigation. Fortunately no civil aviation accident has been caused to date by laser strike, however the magnitude of this problem is growing. **OVERVIEW:** The goal is to raise awareness of the scope of visual threat from laser strikes, and encourage critical thinking about mitigation strategies to ameliorate this hazard. A range of current and emerging mitigation options will be discussed. Vision challenges are unique in the aviation environment, especially at night, when most laser strikes occur. Blasting the dark adapted eye with high intensity laser light "bleaches" the photoreceptor pigments, and disrupts visual perception, causing flash blindness and other disabling or distracting symptoms. The eye is vulnerable to collimated laser light, which is used therapeutically to disrupt and burn tissues. Injuries are energy dose dependent, a function of power, duration, distance, attenuation. Injuries, usually temporary, are reported in a minority of laser incidents, however a blue laser strike was reported in association with a peripheral retinal burn. Green lasers strikes are by far most common; green is perceived as brighter than comparable energy red and blue lasers due to spectral shift in the dark. The mainstay of mitigation is pilot procedural modifications that crew are trained to perform. Law enforcement prosecution and public education serve as deterrents, but are disproportionate to the volume of laser strikes, which was 7346 in 2015. Lasers are widely available, which has added to the problem. A variety of protective optical interfaces exist, evolve, and continue to offer possibility. The challenge is to protect from laser strikes without compromising vision and color perception during normal flight. Color filters, nanocomposite glass coatings and films have been developed in

various forms, for application to windows, goggles and visors. Sci-fi anti-laser lasers are being explored for drones, but are probably not feasible for manned aircraft in the near future. **SIGNIFICANCE:** Laser strikes are a significant and unrelenting hazard to aviation safety. There are many variables and unknowns. Discussion of the threats as well as mitigation options will hopefully promote accident prevention.

Learning Objectives:

1. Describe 2 types of visual threat from laser strikes.
2. Describe 3 types of mitigation strategies to protect against laser strikes.

[403] EDUCATION: DIAGNOSTIC INDICATORS FOR RETINAL LESIONS FOLLOWING A LASER STRIKE, ARE WE THERE YET?

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PROBLEM STATEMENT: This case report describes the eye examination results of an Army helicopter aviator who reported being struck by a green laser. **BACKGROUND/LITERATURE REVIEW:** Incidence of laser strikes and possible ocular injury are increasingly occurring. Laser pointers with an output of 100 mW and more can cause retinal injury at a close range and may cost less than \$30. Multiple cases have been reported of laser injuries in children with laser pointers in the last two years. Lasers strikes of aircraft reported to the FAA have skyrocketed, with 7,703 incidents reported in 2015. In 2016 (Gosling et al.) reported "what may be the first evidence based report of a retinal release injury to a pilot." Marshall et al (2016) refuted this report. **CASE PRESENTATION:** A 46 yo Army aviator, as well as two other aircrew members in the same aircraft reported being hit by a green laser originating from a distance of about 400 m while landing at night. The aviators reported the incident per DoD policy to the DoD laser injury hotline. They were subsequently examined by the local optometrist. The Army aviator's entering unaided visual acuities were 20/20 in each eye. He did not report any other persisting visual symptoms. Fundus examination revealed a white spot near the fovea of about 35 µm in size. Color fundus photos were taken within 24 hours of the reported incident to document the white spot and OCT was performed. The OCT demonstrated an elevated hyper-reflective spot at the level of the RPE in the right eye, but no retinal separation or fluid was evident. Examination of the left eye was normal. The correct diagnosis is that the lesion was preexisting, and not caused by the laser exposure.

OPERATIONAL/CLINICAL RELEVANCE: Some patients have been incorrectly diagnosed with laser damage. Seeing a laser from an aircraft, along with observation of a retinal anomaly or pathology is not sufficient to diagnose laser retinal damage. With an acute laser retinal lesion, visual symptoms would be expected. At a distance of 600 meters, per the incident report, a laser pointer with an output of 100 mW and a 0.5 mrad divergence would not have been expected to cause this lesion. As clinicians, we should be certain of a laser lesion diagnosis before informing a patient that they have a retinal injury that was caused by a laser. Reassurance by the clinician is important so that patients do not develop a psychological fear that their eyes may have been permanently damaged.

Learning Objectives:

1. To provide information to better diagnose whether a laser eye injury has occurred to anyone who sees a laser while flying.
2. To provide information about the lasers that are commonly involved in laser strikes of aircraft and the visual symptoms and distances that might be expected to be associated with eye injury.
3. To present a case study of an aircrew member who observed a laser and include fundus photos, and OCT images of the retina of a retinal abnormality.

[404] A FATAL ACCIDENT CAUSED BY DEGRADED VISION AT NIGHT DUE TO CATARACTS

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PROBLEM STATEMENT: This case report describes the role cataracts played in a fatal nighttime airplane accident involving a civilian pilot who was found to have progressive cataracts but tested visual distant acuity was 20/20

one month before the crash. **BACKGROUND / LITERATURE REVIEW:** Current medical certification examinations and standard eye tests cannot easily detect cataracts; more in-depth examination using additional technology is required to do so (slit lamp). Cataracts are a common aviation hazard; at any given time, about 12,000, or about 4 percent, of active pilots may have cataracts that could progress and impair their ability to see well enough to safely operate aircraft, particularly at night. **CASE PRESENTATION:** Three weeks before the accident, the 72-year-old private pilot with 1500 total flight hours demonstrated difficulty seeing well enough to safely taxi from a familiar lighted runway onto the taxiway at night. Although the pilot's corrected visual acuity remained 20/20 bilaterally, he had previously complained to his optometrist of vision problems with halos around stars. The optometrist documented the pilot's progression of bilateral cataracts and vitreous opacities during annual examinations over the 4 years before the accident. During the accident flight, the pilot made multiple attempts at a night landing at an unfamiliar airport but subsequently crashed. No mechanical or operational issues were identified and the NTSB determined the probable cause of the accident to be the pilot's failure to maintain adequate clearance from trees while on approach, which subsequently led to a loss of airplane control. Also causal was the pilot's continued operation of the airplane at night with a diagnosed medical condition that degraded his night vision. **OPERATIONAL / CLINICAL RELEVANCE:** This case highlights the potential dangers of progressive cataracts especially during flight at night and will discuss recommendations made by the NTSB to prevent future accidents.

Learning Objectives:

1. Understand cataract induced degraded vision at night.
2. Understand the limitations of the current visual examination in predicting operational visual performance during night flight.
3. Understand the importance of referring pilots with cataracts to appropriate care.

[405] USAF AVIATION VISUAL STANDARDS ASSOCIATED WITH CORNEAL-CROSSLINKING AND TOPOGRAPHY GUIDED PHOTOREFRACTIVE KERATECTOMY

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TOPIC: There are currently 110 USAF aircrew personnel who are afflicted with a form of corneal ectasia, ranging from keratoconus (KCN) to pellucid marginal degeneration (PMD) to post refractive surgery ectasia. The USAFSAM Aeromedical Consultation Service Ophthalmology Branch has undergone several research protocols that have improved the ability to predict and engage in screening members for KCN. Despite these improvements, the USAF still trains aircrew members who eventually develop KCN or PMD. Thirty-one of these aircrew require special contact lens fit and distribution, including rigid gas permeable (RGP), hybrid, and scleral lenses in order to meet USAF aircrew visual standards. Based on the progressive nature of KCN approximately 10% of affected USAF aircrew will have their career cut short prematurely. The use of corneal collagen-crosslinking (CXL) or topography-guided photorefractive keratectomy (TG-PRK) combined with CXL has the potential to halt progression of KCN and to possibly correct irregular astigmatism, helping the member meet USAF aircrew vision standards, without the need for expensive visual aids. **TOPIC:** This presentation will report on a research protocol examining the change in USAF aircrew vision testing in relation to corneal-crosslinking (CXL) and topography-guided photorefractive keratectomy (TG-PRK) combined with CXL. **APPLICATIONS:** Current aeromedical vision standards and guidelines will be reviewed related to a history of progressive corneal ectasia and how the use of CXL and TG-PRK/CXL may potentially change DoD warfighter and aircrew policy in terms of KCN and its related refractive sequelae.

Learning Objectives:

1. To become familiar with the history of keratoconus in USAF aviation assets.
2. To become familiar with corneal crosslinking and topography-guided photorefractive keratectomy combined with corneal crosslinking.
3. To become familiar with the short term outcomes in regards to USAF aviation vision standards in relation to treatment for keratoconus, PMD, and post refractive corneal ectasia.

[406] EVALUATION OF ULTRAVIOLET RADIATION LEVELS ON COMMERCIAL AIRPLANES

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INTRODUCTION: Statistical studies suggest that pilots and cabin crew have a rate of melanoma and mortality associated with this disease higher than those of the general population. Exposure to the UV radiation (UVR) is one of the main risk factors for this type of cancer. The purpose of this study was to evaluate the level of UVR in an airliner in flight. **METHODS:** A measurement campaign was carried out, from July to October 2016, with an equipped three sensor-integrated electronics UV radiometer (A, B and C), during fourteen medium and long-haul flights. The measurements were performed during daylight hours, once reached cruising altitude. **RESULTS:** The planes have flown over an area ranging from 69° N to 1° S and 138° E to 119° W. Nearly twelve hundred measures have failed to find UVR of type C. They don't have either highlighted UVR A or B in any parts of the cabins of the planes tested, nor in the Airbus cockpits. UVA radiation (and accessorially B) was however found in the cockpit of Boeing 777. But UVA levels remained low (average value = 0.34 mW.cm², maximum value = 1.22 mW.cm²) and well below the values found on the ground. They were also strongly reduced (more than 10 times) by the sun visor windshield's airplane. **DISCUSSION:** Few studies had so far searched to assess the level of UV radiation in an airplane. They suggested that the windshield of the aircraft reduced more or less this type of radiation (according mainly to the wavelength of the radiation and the nature of the windshield). Our study strongly confirms these results and suggests that excess of melanoma and mortality by this type of illness found among pilots and airlines cabin crew may not be related to an UVR exposition during flight.

Learning Objectives:

1. Provide the means to assess the reality and/or the importance of a possible link between excess melanoma found for flying airline crew and their exposure to ultraviolet radiation in flight.
2. Check the other alternatives to explain the melanoma incidence excess for pilots and flying attendants.

Wednesday, May 03
Governor's Square 15

4:00 PM**S-078: SLIDE: HEALTH AND WELFARE OF AIRCREW: PT. 2**

Chair: Kai-Wood Ma
San Antonio, TX

Co-Chair: Pierre Morissette
Dunrobin, Ontario, Canada

[407] THE STUDY ON EVALUATION PARAMETERS OF PHYSIOLOGIC FUNCTION FOR FEMALE PILOTS

Y. Zhang, Y. Chen, Z. Wang, Q. Yao, D. Tian, Z. Jin and L. Yu
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OBJECTIVE: For the purpose of suitability of flying fighter aircraft for female, this study chose physical fitness, ocular vestibular-evoked myogenic potentials, neurobehavioral ability index as special evaluation parameters of physiologic function. The study will provide scientific evidence to set up medical standard for selecting female fighter pilots. **METHODS:** The subjects were 62 Chinese Air Force student pilots including 30 men and 32-matched women aged 20-22yr, mean age 20.5yr. The subjects were tested physical fitness, ocular vestibular-evoked myogenic potentials (oVEMP), neurobehavioral ability index (NAI) by different equipments. **RESULTS:** 1.) Physical fitness: The female student pilots' grasp force was 34.0±4.0kg, jump up was 32.6±4.2cm, Forward bending was 17.6±4.8cm. The male student pilots grasp force was 55.4±5.3kg, jump up was 47.5±5.3cm, Forward bending was 17.1±4.4cm. 2.) oVEMP: The

latencies of N1 and P1, peak-to-peak N1-P1 amplitude and ratio asymmetry of VEMP were 10.36±0.73ms, 15.13±0.94ms, 6.25±4.68μv, 9.57%±8.40 in male student pilots, and 10.22±0.61ms, 15.19±1.19ms, 3.27±1.83μv, 11.53%±6.80 in female student pilots respectively. No significant difference was found between male student pilots and female in N1, P1 latency, the only significant difference was N1-P1 amplitude between age-matched male and female student pilots. 3.) NAI: memory scan (MS) was 6.47±1.15, Digital scan (DS) was 6.33±0.85, simple visual reaction time (SVRT) was 24.78±1.57, complex visual reaction time (CVRT) 17.09±1.97, pursuit aiming (PA) was 2.28±0.37, consecutive performance (CP) 2.54±0.28 in male student pilots, and memory scan (MS) was 7.59±1.19, Digital scan (DS) was 7.00±0.74, simple visual reaction time (SVRT) was 24.78±1.57, complex visual reaction time (CVRT) 18.04±1.71, pursuit aiming (PA) was 2.10±0.44, consecutive performance (CP) 1.64±0.24 in female student pilots respectively. The differences of MS, DS, CP between male and female student pilots were significant statistically. No significant difference was found in other items. **CONCLUSIONS:** 1.) For female student pilots, it is essential to increase their physical strength. 2.) oVEMP should be interpreted with AR rather than amplitude. Normal values should be determined for female and male pilots. 3.) MS and DS of female student pilots are better than that of male student pilots, CP worse than male student pilots. It is important to select, train, and assess scientifically for female fighter pilots.

Learning Objectives:

1. Vestibular function assessment for pilots.
2. Neural-behavior assessment for pilots.
3. physical fitness assessment for pilots.

[408] EFFECTS OF DELAMINATION SIZE AND DEPTH ON IMPACT RESPONSE AND TEAR RESISTANCE OF COMPOSITE LAMINATES USED IN AIRCREW HELMETST.S. Bonts^{1,2}, K. Rybarczyk¹ and F. Brozoski¹

¹Injury Biomechanics Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL; ²Oak Ridge Institute for Science and Education, Belcamp, MD

INTRODUCTION: A common problem in composite laminates is the delamination of adjacent layers, which are often the result of air trapped between layers during production, cyclic stresses, or impacts to the laminate. Delaminations have been found in the composite shells of Army aircrew helmets, but it is not known how they affect the blunt impact and tear penetration performance of the composite helmet shells. **METHODS:** Fiberglass/epoxy composite panels were manufactured with predetermined delaminations of varying size and depth. The delamination sizes were 12.5, 25.0, or 50.0 percent of the panel surface area and were placed between the 1st and 2nd, 4th and 5th, or 7th and 8th layers (out of 8) in the panels. Composite panels were subjected to blunt impact tests in which panels were backed by a 1-inch layer of polystyrene and impacted on a monorail drop tower with a 5-kilogram spherical impactor at 19.7 feet per second. Impactor acceleration, force, and high speed video were collected. The panels were also subjected to tear penetration testing where they were placed in a shear test fixture on a Tinius-Olsen quasi-static load frame and tested at a rate of 2 inches per minute. Shear force as a function of tear length was recorded. A two-way ANOVA was used to determine the effect of delamination size and depth on peak impactor acceleration and peak shear force measured during blunt impact and tear resistance tests, respectively. **RESULTS:** Composite panels with predetermined sizes and depths of delaminations were successfully manufactured and the delaminations confirmed using cross-sectioning and visual examination of the laminate profiles under magnification post impact, as well as thermal imaging pre-impact. Preliminary impact results indicate that there may be a trend of increasing impact acceleration with respect to delamination size and increased impact acceleration with depth between 4th and 5th layers. Preliminary tear results illustrate that the presence of delaminations leads to a drop-off in tear resistance in the area of delamination. **DISCUSSION:** Army aviation helmets are designed to protect against blunt impact, helmet shell penetration, and excessive noise exposure. While the helmet shell plays a role in all three, it has the greatest

influence on blunt impact and penetration protection. These preliminary findings indicate that the protection provided by composite helmet shells may be effected by delaminations.

Learning Objectives:

1. To better understand the effect of delaminations in the blunt impact and tear resistance of composite panels.

[409] HEAD INJURY PATTERNS IN SPORTING AIRCRAFT ACCIDENTS: AN EVALUATION WITH SPECIAL REGARD TO THE EFFICIENCY OF AIRCREW PROTECTION SYSTEMS

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INTRODUCTION: The assessment of injury patterns from deadly mishaps contributes to the ongoing improvement of safety systems in traffic medicine in general and in aviation medicine in particular. The present study was aimed to identify weak spots in the cockpit design of sporting aircraft leading to head injuries associated with hard landings.

METHODS: The forensic medical files of 20 decedents from 13 sporting aircraft accidents in south-eastern Bavaria over the recent 7.5 years were assessed. Head injury patterns were studied. Correlation with fundamental biomechanical principles and the results from the technical accident investigation were compiled. **RESULTS:** Fractures of the skull were frequent observations involving 11 of 20 decedents in our study. In 5 cases, the direction of the force leading to the respective fracture was extrapolated from the morphology of the bone lesion: Sagittal force was presumed in 2 cases, which involved 1 separation of the sagittal suture and 1 oblique fracture of the petrous bone. In 3 cases, force acting along the transversal axis was presumed from cross fractures of the petrous bone. In all these cases direct contact between the pilot's head and at least one hard surface within the cockpit must have occurred. Impulsion of the head to e.g. the dashboard would explain fractures along the sagittal axis. Impact of the head to lateral structures can be presumed for injuries along the transversal axis. In one of these cases, mutual injuries between the pilot and the copilot sitting to his right were observed: Cross fractures of the petrous bone and corresponding midface injuries between the two crew members were present. In this accident, the whole-airplane parachute had been released without preventing the deadly outcome. **DISCUSSION:** The skull fractures described above indicate insufficient retaining of the pilots from hard surfaces in their cockpits along the sagittal and the transversal axis at the moment of impact. This occurs in at least 25% of deadly mishaps and probably also in an unknown figure of nonlethal hard landings. Improved retaining systems such as seat-belt tensioners and/or airbag solutions should be considered.

Learning Objectives:

1. The participant should know the basic biomechanical mechanisms leading to blunt force injuries in aircraft accidents.
2. The participant should be able to correlate characteristic bone injuries with the course of events in aircraft accidents.
3. The participant should be able to consider the efficiency of personal protection systems for the air crew in aircraft accidents.

[410] HOW USEFUL IS THE PRACTICAL HEARING TEST?

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INTRODUCTION: Adequate hearing is required to communicate effectively in the aviation environment. Canadian commercial and recreational pilots undergo hearing screening examination using the whispered voice test or audiometric evaluation at each medical certificate renewal. In accordance with the International Civil Aviation Organization (ICAO), the acceptable Canadian hearing threshold limits are 35 dB at 500 Hz, 1000 Hz, and 2000 Hz and 50 dB at 3000 Hz. In Canada, pilots with hearing loss greater than ICAO standards are required to undergo a practical hearing test. The practical hearing test is conducted in an aircraft for which the applicant's license and ratings are valid. The pilot is

required to demonstrate adequate communication both on the ground including obtaining a weather briefing and in all phases of flight. If a hearing aid or headset is required to pass the practical hearing test, this restriction will be noted on the pilot's medical certificate. The purpose of the study was to evaluate the utility of the practical hearing test in Canadian civilian aviators. **METHODS:** A database search of the Transport Canada Civil Aviation Medical Information System was performed to identify all pilots who underwent a practical hearing test between July 2006 and June 2016. Both pathology codes and aeromedical restriction codes were used to identify subjects. **RESULTS:** 209 pilots with hearing loss beyond ICAO audiometric standards underwent a practical hearing test. Most of these pilots were over 60 years of age. The majority were noncommercial pilots. Practical hearing tests were typically performed in light aircraft. The mean total time required for a practical hearing test was less than 1 hour. Nearly all practical hearing tests were successful although pilots could be restricted to the use of a hearing aid or headset.

DISCUSSION: The practical hearing test is an effective method to apply flexibility to the ICAO hearing standards in civilian pilots while ensuring flight safety.

Learning Objectives:

1. To understand the utility of the practical hearing test for civilian aviators.
2. To review how a practical hearing test is performed.
3. To be aware of the increasing incidence of hearing loss in older civilian aviators.

[411] CONTEMPORARY AEROMEDICAL EXPERIENCES BY MILITARY PILOTS 1916-1918

R. Allnutt

USAFSAM, Beavercreek, OH

MOTIVATION: The history of environmental and physiologic stress on aviators during the Great War, and the actual compensating behaviors performed by pilots, has (in some cases) been misreported in received Aerospace Medicine history. **OVERVIEW:** A careful reading of contemporary accounts written by pilots during the Great War, in some cases recorded on paper the same day as the events occurred, reveals episodes of hypoxia, spatial disorientation, cold, battle fatigue, and visual problems. **SIGNIFICANCE:** Understanding what these pilots experienced and how they compensated for the stress is useful in designing our current approach to similar stresses of flight. We presently believe we understand these stresses to a much greater extent than the early pioneers of military flight. However, what we teach and have been taught about these early flight experiences is sometimes not consistent with the actually recorded events. Two examples, of stresses much better tolerated 100 years ago than current doctrine allows, include 1) unpressurized flight above 6000 m without supplemental oxygen, and 2) ascent/descent through clouds with only a compass, bubble level, and altimeter to avoid spatial disorientation.

Learning Objectives:

1. Understand that current doctrine about the physiological experience of Great War pilots has gaps and errors.
2. Understand the typical altitude that Great War pilots reached without supplemental oxygen.
3. Understand what flight instruments Great War pilots used to enter Instrument Meteorological Conditions.

[412] THE HISTORY OF USAF VISION STANDARDS: BACK TO THE FUTURE? - PART II (AFTER THE ARMISTICE)

D.J. Ivan¹, A.D. Ivan² and T.J. Tredici³

¹ADI Consultants, San Antonio, TX; ²Social and Behavioral Sciences, Vernon College, Wichita Falls, TX; ³Ophthalmology, University of Texas Health Sciences Center, San Antonio, TX

The second installment of this series tracing the historical origins of modern USAF aircrew vision standards will build on the aeromedical lessons learned during World War One. Although the seeds of another eventual military confrontation were planted in the immediate aftermath of the First World War, most WWI combatants were quick to dismantle their war machines after the war, to include abandoning robust aeromedical research efforts. In the US, other events conspired to impact the aeromedical foundations established during the war. In most cases after

WWI, international aviation enthusiasm shifted away from military applications of the aircraft to other endeavors, including commercial, passenger, and recreational applications. Although U.S. military vision standards remained somewhat stagnant after the Armistice, the period between the war was not completely devoid of significant aeromedical developments, especially related to color vision testing. This presentation will review the standards and pertinent developments between the wars, many of which carried over from WWI into the opening phase of the next armed confrontation. Because of the tempest of war, practical aeromedical problems related to significantly increased aircraft performance and related threats necessitated renewal of vigorous aeromedical research programs which were pursued against the backdrop of mass medical population screenings in preparation for the impending larger military conflict.

Learning Objectives:

1. The participants will learn the historical context and scientific foundations of modern USAF aircrew vision standards from this period.

THURSDAY, May 4, 2017

Thursday, May 04
Grand Ballroom

8:15 AM

52nd ANNUAL HARRY G. ARMSTRONG LECTURE

Kevin Fong, B.Sc., M.Sc., M.B.B.S.
"Extremes: The Fastest Century"

Thursday, May 04
Plaza A/B

10:00 AM

S-079: SLIDE: VISION

Chair: Harriet Lester
New York, NY

Co-Chair: James Gaska
Wright-Patterson AFB, OH

[413] COLOUR ASSESSMENT OUTCOMES – A NEW APPROACH TO GRADING THE SEVERITY OF COLOR VISION LOSS

M. Rodriguez-Carmona and J.L. Barbur
Applied Vision Research Centre, City, University of London, London, United Kingdom

INTRODUCTION: Recent studies have shown that a significant percentage of subjects with anomalous, congenital trichromacy can perform the suprathreshold, colour-related tasks encountered in many occupations with the same accuracy as normal trichromats. In the absence of detailed, occupation-specific studies, an alternative approach is to make use of new findings and the statistical outcomes of past practices that have been considered safe to produce graded, justifiable categories of colour vision that can be enforced. **METHODS:** We analyzed traditional color assessment outcomes and measured severity of colour vision loss using the CAD test in 1363 subjects (336 normals, 705 deutan, 319 protan and 3 tritan). The severity of colour vision loss was measured in each subject and statistical, pass / fail outcomes established for each of the most commonly used, conventional colour assessment tests and protocols. **RESULTS:** The correlation between the number of Ishihara (IH) test plates subjects fail and the severity of RG colour vision loss was very poor. The 38 plate IH test has high sensitivity when no errors are allowed (i.e., only 0.71% deutan and 0.63% protans pass). Protocols based on zero errors are uncommon since 18.15% of normal trichromats fail. The most common protocols employ either the 24 or the 14 plate editions with two or less errors. These protocols pass almost all normal trichromats, but the deutan and some protans that also pass (when two or less errors are allowed) can be severely deficient. This is simply because the most challenging plates have not been included in the 24 and 14 plate editions. As a result, normals no longer fail, but the deutan and protans that pass have more severe loss of colour vision since they fail less challenging plates. The severity of colour vision loss was measured in

each subject and statistical, pass/fail outcomes established for each of the most commonly used, conventional colour assessment tests and protocols.

DISCUSSION: Historical evidence and new findings that relate severity of loss to the effective use of colour signals in a number of tasks provide the basis for a new colour grading system based on six categories. A single colour assessment test is needed to establish the applicant's Colour Vision category which can range from 'supernormal' (CV0), for the most stringent, colour-demanding tasks, to 'severe colour deficiency', when red / green colour vision is either absent or extremely weak (CV5).

Learning Objectives:

1. To learn about the statistical outcomes of the various editions of the Ishihara test
2. To understand how severity of colour vision loss can be quantified using a single test
3. To become aware of a new system (that can be enforced) based on six categories for grading severity of colour vision loss.

[414] EFFECT OF OPERATIONAL MILITARY AIRCREW VISORS ON VISUAL CONTRAST SENSITIVITY FUNCTION IN COMPARISON WITH VISUAL ACUITY

A. Chandra and V.V. Joshi

Indian Air Force, Institute Of Aerospace Medicine, Secunderabad, India

INTRODUCTION: Maintenance of all aspects of optimum vision during all phases of flight is paramount. The available research finds contrast sensitivity (CS) correlating better to air-to-ground or ground-to-air visual tasks compared to conventional visual acuity tests. Aircrew tinted visors are supposed to maintain optimum vision in bright light and against glare while not affecting the visual performance adversely. Literature on the effect of visors on visual performance, especially contrast sensitivity, is scarce and conflicting. This study was conducted with an aim to evaluate the effects on visual parameters, viz. Visual Acuity and Contrast Sensitivity (CS), while viewing through different currently operational visors within IAF. The adherence of present aircrew visors to laid down recommendations and validity of these recommendations was also explored. **METHODS:** In a controlled ambient illumination, visual acuity and contrast sensitivity scores (at four spatial frequencies 3, 6, 12 & 18 cpd) were obtained for 47 visually healthy males, using 05 neutral grey tinted and 01 yellow tinted currently operational visors. Data was analysed using repeated measures ANOVA and Bonferroni's post hoc test for pair wise significance. Pearson correlation coefficient was calculated to find out the strength of linear dependence of contrast sensitivity upon luminous transmittance of the visors. Ethical clearance was granted by the institute level committee. **RESULTS:** All the neutral density grey visors significantly degraded the CS at all the frequencies tested. No significant effect on visual acuity was noted with any of the visors. Yellow visors performed significantly better than the neutral grey tinted visors in all the conditions and at all spatial frequencies. The Pearson correlation also showed strong positive dependence ($r = 0.95$) of contrast sensitivity upon luminous transmittance of the visor. The visor with least transmittance (7.02%) was found to give worst contrast sensitivity scores. **DISCUSSION:** The currently operational neutral grey visors failed to maintain optimal vision and significantly degraded contrast sensitivity function of the wearer, which is directly correlated to their tint density and in turn their luminous transmittance. Yellow tinted visors neither degraded nor enhanced the visual performance significantly. CS testing was also found to be a better metric to assess visual deterioration which might go undetected with visual acuity testing alone.

Learning Objectives:

1. Contrast sensitivity is directly dependent upon luminous transmittance of the transparencies as in aircrew visors.
2. Contrast sensitivity is a better metric to identify any vision decrement as compared to visual acuity when using visors.

[415] VALIDATION OF A TABLET-BASED WAGGONER COMPUTERIZED COLOR VISION TEST

M. Rings and T. Waggoner

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INTRODUCTION: Tablet-based Computerized color vision tests (CCVT) are very portable and practical in the military environment at sea or in clinical practice. This study was undertaken to validate the