

This might imply possible delayed recovery of energy metabolism of mouse brain tissue and indicate possible prolonged impairment of higher cortical function after high +G<sub>z</sub> acceleration.

#### Learning Objectives:

1. Understand the recovery process of energy metabolism in brain tissue after high +G<sub>z</sub> acceleration using a small animal model.

### [012] CHARACTERISTICS OF LOWER BODY EMG SIGNALS DURING HIGH +GZ EXPOSURE AND GENERATION OF WARNING ALARM PRIOR TO G-LOC

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**INTRODUCTION:** Sustained high +Gz exposure takes blood away from the brain causing loss of vision and consciousness (G-LOC). G-LOC is one of the primary concerns in air combat mission and aviation safety. Fighter pilots perform anti-G straining maneuvers (AGSMs) to resist G-LOC. Muscle contraction coordinated with breathing is important when pilots perform AGSMs. This study suggests that G-LOC warning alarm can be generated by lower body EMG monitoring. **METHODS:** Eighty-eight EMGs on gastrocnemius muscle were obtained from Korean Air Force pilots and pilot trainees during high +Gz centrifugal training. EMG features representing muscle contraction and fatigue were analyzed. Those were root mean square (RMS), integrated absolute value (IAV), mean absolute value (MAV) for muscle contraction, slope sign change (SSC), waveform length (WL), zero crossing (ZC), and median frequency (MF) for muscle contraction and fatigue. **RESULTS:** The EMG on gastrocnemius muscle of calf were monitored reliably in a high +Gz acceleration, and associated with the resistance to a rapidly-increasing +Gz-force. The EMG features was significantly different among individuals. Mean values of RMS, IAV, MAV, WL during high +Gz exposure were significantly decreased in 3 seconds time window prior to G-LOC, alarm phase of G-LOC. Delayed muscle contraction compare to acceleration rate in very first 1 sec time window above 6G were associated with going under G-LOC. **DISCUSSION:** Four of the EMG features, WL, RMS, MAV, and IAV, showed a sharp decay prior to going under G-LOC. WL and IAV had similar pattern with RMS and MAV, but values of WL and IAV were relatively bigger than those of RMS and MAV. Thus WL and IAV were considered key variables for creating G-LOC alarm. Consecutive decrease of WL and IAV and delayed increase of WL and IAV against +Gz acceleration were significantly related to going under G-LOC. The G-LOC prognosis could be detected through real-time monitoring of EMG on the pilot's gastrocnemius muscle and thereby warning signals could be generated during flight.

#### Learning Objectives:

1. Explain relationship between G-LOC and maintaining of muscle tension during high +Gz exposure.

### [013] THE EFFECTS OF ANTIHYPERTENSIVE DRUGS ON CEREBRAL BLOOD FLOW DURING +GZ EXPOSURE IN SPONTANEOUSLY HYPERTENSIVE RATS (SHR)

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**INTRODUCTION:** Antihypertensive such as nifedipine (calcium channel blocker) are carefully prescribed to fighter pilots, while antihypertensive medications like diuretics, ACE inhibitor or angiotensin receptor blocker (ARB) are widely used. We have reported that nifedipine did not affect the blood pressure at the level of the brain (BPLB) during +Gz exposure in spontaneously hypertensive rats (SHR) in the 86th AsMA meeting. BPLB was not directly demonstrated cerebral blood flow (CBF). In this study, we present the effects of antihypertensive drugs on CBF in SHR. **METHODS:** We used 10-week-old male SHR. Eight SHR were given normal diet and tap water for 2 weeks; non-treated-SHR (No-Tr-SHR). Eight SHR were fed a diet include 0.1 % nifedipine and normal tap water; nifedipine treated SHR (Ni-Tr-SHR). Other eight were fed normal diet and tap water include 0.025 % losaltan potassium (ARB); losaltan treated SHR

(Lo-Tr-SHR). At 12 weeks old, rats were anesthetized and exposed to 4.5 Gz for 5 sec using our centrifuge for small animals. BPLB, CBF and heart rate (HR) were continuously monitored. CBF at the left cortex was measured using laser tissue blood flow meter with invasive glass fiber probe. We also used Wistar-Kyoto rats (WKY) as normal control. **RESULTS:** During +4.5 Gz exposures, the BPLB of No-Tr-SHR was significantly lower than Ni-Tr-SHR or Lo-Tr-SHR, but same as normal control. No significant difference was observed in the CBF among four groups. No significant differences were found in the HR among three SHR groups. **DISCUSSION:** During +4.5 Gz exposure, BPLB in Ni-Tr-SHR and Lo-Tr-SHR are significantly higher than No-Tr-SHR, but CBF are same. In our view points, nifedipine or losaltan might be preferable antihypertensive for fighter pilots. Significance of CBF remains to be solved.

#### Learning Objectives:

1. Non-Treated-SHR showed the lowest BPLP during +Gz exposure.
2. Spontaneously Hypertensive Rats using nifedipine or losaltan maintain same level of CBF comparing to Wistar-Kyoto Rats (normotensive rats) during +Gz exposure.
3. Significance of CBF remains to be solved.

### [014] DURATION OF PREVIOUS HEAD-DOWN TILT DOESN'T AFFECT DYNAMIC CEREBROVASCULAR AUTOREGULATION IN FOLLOWED HEAD-UP TILT

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**INTRODUCTION:** Push-pull effect would put pilots to be in risk of losing consciousness and followed aircraft crash. Our previous study showed that any increase in cerebral vascular resistance (CVR) during the head-down tilt (HDT) was not sustained on transition to head-up tilt (HUT). Dynamic cerebrovascular autoregulation (DCA) maintained intact and efficient in this simulate push-pull maneuver. While the changes of DCA under the condition of HDT duration in this maneuver was still remained unclear. We hypothesized that the duration of antecedent HDT would not affect DCA in followed HUT. **METHODS:** After being in the supine position for 5 min and 2 min of baseline, the participants will be moved to one of 3 randomized duration (control which was without previous HDT, 7s or 15s) of 55° HDT (vector component of -0.82Gz at vertical direction) prior to being moved rapidly to head-up tilt (75°) for 1min. Beat by beat mean blood flow velocity (MFV) of middle cerebral artery (MCA) and blood pressure (BP<sub>MCA</sub>) at the same level were recorded and then the cerebrovascular resistance index (CVRI) was calculated as BP<sub>MCA</sub>/MFV. **RESULTS:** Head-down tilt resulted in a significant increase of CVRI of 7s (1.71±0.16 mmHg/cm/sec) and 55° HDT (1.65±0.21 mmHg/cm/sec) as compared with baseline (1.26±0.13 mmHg/cm/sec, P<0.01). Increased CVRI during HDT dropped in followed HUT (0.56±0.17, 0.63±0.15 mmHg/cm/sec for 7s and 15s separately in initial 5s) as compared with control (0.86±0.13) and maintained lower for about 15s. No apparent difference could be detected during two HDT conditions. MFV at MCA in two conditions presented similar changes during rapid transition of HDT to HUT and showed significant decrease than that was in control state in initial 5s of HUT. **DISCUSSION:** Besides consisting with our previous finding that the rapid recovery of MFV during HUT for antecedent HDT intensity conditions reflects very efficient cerebrovascular autoregulation, the current study supports our hypothesis that the duration of antecedent HDT would not affect DCA in followed HUT, which presented entirely different pattern with peripheral arterial vascular responses during simulated push-pull maneuvers.

#### Learning Objectives:

1. Comprehension: Identify regulation of cerebral vascular during body transition and add comprehension on mechanism of simulate push-pull effect.

### [015] ANALYSIS OF DIVE PROFILES OF SEVEN ARTISANAL FISHERMEN DIVERS USING DCIEM PROBABILISTIC BUBBLE GROWTH MODEL

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**INTRODUCTION:** Artisanal fishermen divers (AFD) in the Yucatán Peninsula use surface-supplied air to dive for lobster and sea cucumber. AFD conduct multiple repetitive dives that are high risk and often result in decompression sickness (DCS). We evaluated dive profiles of seven AFD utilizing the Defense and Civil Institute of Environmental Medicine (DCIEM) probabilistic bubble growth model<sup>1</sup> to predict the risk of DCS. **METHODS:** Dive profiles were recorded via a SENSUS ULTRA dive recorder, ReefNet Inc. (accuracy of  $\pm 1$  foot of seawater (FSW)), set to collect data every ten seconds. The growth of bubbles following 35 dives (32 no DCS, 3 DCS) was calculated with the maximum bubble radius attained, BRmax, used as an indicator of DCS risk. **RESULTS:** Four divers carried out the 32 dives without DCS. The average BRmax for their dives was less than 64  $\mu\text{m}$ . The only dives which resulted in DCS were examined for the other three divers. BRmax was over 70  $\mu\text{m}$  for these dives. **DISCUSSION:** Overall, 10 dives had BRmax > 70  $\mu\text{m}$ . Thus, dives which generate BRmax > 70  $\mu\text{m}$  have a high risk of DCS (95% CI 6.7-65.2%). The analysis of other empirically derived multiple repetitive dives<sup>2</sup> in the past has shown a high risk of DCS with BRmax > 60  $\mu\text{m}$ . The application of this model could help to define diving limits that could reduce the risk of DCS for this group of fishermen divers.

**Learning Objectives:**

1. Understand decompression stress among artisanal fishermen.

**[016] PROCESS FOR DISCOVERY OF HIGH-ALTITUDE MOUNTAIN MEDICAL AND PERFORMANCE INTERVENTIONS**

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**MOTIVATION:** Military operations by units in the high elevation sectors of Afghanistan prompted unit commanders to inquire whether any innovations were soon to be ready for use in the field in regard to preventing high-altitude illnesses as well as in regard to human performance sustainment/human performance enhancement in that environment. This topic is pertinent to the many AsMA members who oversee personnel who engage in high-altitude ground operations.

**OVERVIEW:** Prior to these present actions, much was already known regarding the prevention of high-altitude illnesses as well as regarding high-altitude human performance sustainment/human performance enhancement. A literature review revealed a new intervention not yet commonly known by all personnel that was subsequently publicized. Trips to several bases revealed an educational gap that was corrected. Interaction with external organizations including the U.S. Navy and U.S. Army led to a collaboration with India that is ongoing. A human performance issue was reframed in the form of a study question. A research proposal was produced. The above process and its development will be presented. **SIGNIFICANCE:** Knowledge gained, and experience accumulated, in high-altitude medicine/high-altitude performance has immediate impact on improving mountain operational safety and enhancing mountain operational mission success. The high-altitude trials of various interventions in India will result in discovering effective interventions and/or rejecting ineffective interventions; effective interventions, appropriately cleared, if required, by indicated organizations such as the Food and Drug Administration, can be considered by senior leaders for use in the field. These high-altitude trials will generate knowledge in the realms of both clinical prophylaxis and treatment as well as the realm of enhanced human performance. This knowledge is useful to units of all U.S. military branches as well as to all international military and civilian organizations that conduct activities at high altitude, including combat operations as well as search and rescue.

**Learning Objectives:**

1. Describe the recent intervention that was documented during the literature search.
2. Discuss the educational gap that was documented during the trips to bases.
3. State the study question in the proposal sent to the U.S. Army lead point of contact for consideration by India.

**[017] IN-FLIGHT MONITORING OF HIGH PERFORMANCE AIRCRAFT PILOT BREATHING AIR QUALITY VIA A REAL TIME AIR QUALITY SENSOR SUITE (RTAQS)**

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**INTRODUCTION:** High performance aircraft deliver different oxygen (O<sub>2</sub>) concentrations based on their operating altitude using an onboard O<sub>2</sub> generation system (OBOGS). To compensate for the reduced partial pressure of O<sub>2</sub> at higher altitudes the OBOGS will increase its O<sub>2</sub> production up to as high as 93%, as compared to 21% at ground level. In OBOGS equipped aircraft there are no sensing mechanisms in place to confirm delivery of 93% O<sub>2</sub>. Additionally, there are no broad specificity sensors that gauge the overall breathing air quality that could quickly identify potentially hazardous contaminants contained in the breathing air-line. The RTAQS solve this problem.

**METHODS:** The RTAQS device was evaluated under simulated altitude conditions ranging from ground level up to 24000 ft. in a custom altitude and chemical exposure chamber. Oxygen composition and flow rate were varied in addition to altitude. To validate the chamber results, the RTAQS was installed on a high-performance training aircraft at Edwards Air Force Base. Data for the RTAQS sensors were logged and analyzed. Laboratory and in flight data were directly compared. The TD tubes collected during flights were analyzed using GC/MS. **RESULTS:** During laboratory experiments there was a strong relationship between the initial change in altitude and the readings taken from the sensors. Partial pressure of the compounds is correlated with the absolute pressure (altitude equivalent in this case) with regards to the sensor readings. Flow rate and O<sub>2</sub> composition did not significantly alter the readings. More gradual increases in altitude during flight will alter this response. We expect to develop an algorithm that will compensate for pressure effects over the readings. **DISCUSSION:** The primary goal of this work is to generate calibration curves for the sensors to compensate for variable environmental conditions. These results will also support efforts in identifying targets sensor design for future iterations. We intend to increase the capabilities of the next generation version of RTAQS to install on all USAF craft. With the RTAQS incorporated, the process of switching from OBOGS air to backup O<sub>2</sub> could be automated after the detection of detrimental contaminants.

**Learning Objectives:**

1. To address these gaps, we have developed and tested a first-generation sensor suite for real-time monitoring of the pilot breathing air quality for oxygen, nitric oxide, carbon monoxide, carbon dioxide, and hydrocarbons, as well as broad-range VOC detection (via thermal desorption tube) post-sortie.

**[018] MECHANISTIC INTERPRETATION OF HYPOBARIA AND HYPEROXIA IN A RAT MODEL**

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**INTRODUCTION:** U-2 pilots and altitude chamber technicians show increased incidence white matter hyperintensities (WMH) in T2 weighted magnetic resonance imaging (MRI), indicative of hypodensities linked to neuronal loss, demyelination and gliotic scarring. It has been hypothesized that exposure to extreme hypobaria, excess oxygen, or a combination of both stressors is the primary causative factor for these WMH. However, the exact etiology and underlying mechanisms are unknown. **METHODS:** Rats were exposed to pressures corresponding to 30,000ft above sea level and 100% oxygen for 3 hr/day for 3 days. At the end of the final exposure brains were collected. Proteomic characterization of proteins and pathways was developed using high resolution LTQ-Orbitrap Velos mass spectrometer and SEQUEST algorithms for protein identification and quantitation. High resolution <sup>1</sup>H and proton-decoupled <sup>31</sup>P and <sup>13</sup>C nuclear magnetic resonance spectroscopy was used to characterize lipid and small molecule profiles. Biochemical assays for inflammation and oxidative stress were performed on blood, heart

and lung. **RESULTS:** Serum C-reactive protein, a marker of inflammation, was increased in rats exposed to hypobaric pressure relative to rats exposed to 100% oxygen at normobaric pressures. Thalamus from rats exposed to a more moderate altitude of 20,000 ft showed modulation of proteins involved with DNA damage repair, calcium signaling, lipid metabolism and microtubule organization. Cerebellum showed altitude specific changes in lipid metabolism and response to energy levels.

**DISCUSSION:** WMH may be caused by hypobaric exposure or oxygen toxicity. Proteomic and metabolomic analyses can provide knowledge of the mechanistic basis of the adverse effects of hypobaric and hyperoxia that can set the foundation for understanding the pathophysiological changes associated with these exposures. The potential payoff of the knowledge gained from these studies is a better approach to mitigating or preventing operational risks and long term adverse health outcomes associated with high altitude flight.

#### Learning Objectives:

1. Understand the mechanistic basis at the cellular and molecular level of the adverse effects of extreme hypobaric and hyperoxia.

### [019] SYMPTOMS OF HYPOXIA OR DECOMPRESSION SICKNESS? IN-FLIGHT INCIDENT ON A EUROFIGHTER AIRCRAFT AT 42,000 FT

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**PROBLEM STATEMENT:** This case report describes a Eurofighter pilot who developed symptoms during a high-altitude flight. It has not been clearly identified whether the symptoms were caused by hypoxia or decompression sickness (DCS). The symptoms continued after landing, which is unusual for symptoms of hypoxia. **BACKGROUND / LITERATURE REVIEW:** In modern fighter aircrafts the cockpit altitude could exceed 20,000 ft. The risk for hypoxia and DCS is continuously present. A small but significant number of DCS cases have occurred during exposure to altitudes between 22,000 and 25,000 ft. If symptoms occur during or after flight the challenge is to differentiate between hypoxia and DCS symptoms. As the treatment for both entities is different. **CASE PRESENTATION:** A 35-yr old Eurofighter pilot had flown at an altitude of 35,000 ft for 25 minutes. During a climb to 42,000 ft, the audible cabin low pressure alarm was activated and a cabin altitude of 26,000 ft was displayed. The Molecular Sieve Oxygen Concentrator System (MSOC) did not show any malfunction. At a descent altitude of 34,000 ft, the cabin altitude dropped to 24,000 ft. Suddenly the pilot developed severe symptoms: Tingling hands and feet, feeling hot, blurred vision. He recognized some of his own hypoxia symptoms and activated the auxiliary oxygen bottle. He descended to below 10,000 ft and landed safely. The symptoms continued for 15 minutes after landing. The investigation revealed a leaking Emergency Air Valve which regulates the pressure differential between cabin altitude and aircraft altitude. **OPERATIONAL / CLINICAL RELEVANCE:** This case emphasizes the potential threat of DCS and hypoxia due to loss of cabin pressure. Although the MSOC was working properly the pilot thought he would experience hypoxia symptoms due to a loss of cabin pressure. A clinical assessment after flight is mandatory, if symptoms occur. In this case the prolonged exposure (60 min) to cabin pressures between 20,000 ft and 25,000 ft in combination with the extended presence of symptoms after flight makes the diagnosis DCS more likely. This case illustrates the need for a growing awareness of a DCS risk in modern fighter aircraft with cabin altitudes above the threshold for DCS.

#### Learning Objectives:

1. Understand the physiological disturbances induced by exposure to the hypobaric environment during flight at high altitude.

### [020] USEFULNESS OF AEROBIC/ANAEROBIC EXERCISE HABITS TO HYPOXIA AND COGNITION

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**INTRODUCTION:** Hypoxia is one of the most dangerous flight safety risks in aviation. Biomedical monitoring of pilots during flight is gaining more attention recently. The objective of this study was to raise our

knowledge about usefulness of aerobic/anaerobic performance against hypoxic cognitive functions. **METHODS:** 42 pilot candidates (age range 21-25) were included in this study. With the help of a survey about their sporting habits, 30 subjects were grouped as group A that have mostly aerobic exercise habits (jogging, cycling, swimming, team sports) 12 subjects were grouped as group B that have mostly anaerobic exercise habits (body building, jumping, wrestling). Hypoxia test was performed in an altitude chamber at 30,000 feet altitude. Oxygen saturations were measured with a finger pulse oximeter in 3 phases (S1: before procedure, S2: before mask-off, S3: about 150 seconds of mask-off hypoxia). **RESULTS:** Mean S3 of anaerobic Group B (67.50%) was higher than mean S3 of aerobic Group A (63.47%) and this was statistically significant ( $p < 0.05$ ). Other measurements and BMI mean differences between two groups were not significant. **DISCUSSION:** Usefulness and quality of consciousness of pilots during hypoxia considered to improve survival rates in hypoxia mishaps. There are not much studies about effects of exercise type on hypoxia tolerance. According to these findings anaerobic exercise habits seems to have more advantageous over aerobic exercise habits in terms of hypoxia tolerance, however, various factors effects hypoxia tolerance and further studies including cognitive functions are required to support this outcome. The next step will be evaluating consciousness of subjects with cognitive tests and devices during hypoxia. Also aerobic/anaerobic performance tests will be applied to the subjects.

#### Learning Objectives:

1. Define the relations between effects of exercise types and saturation changes in hypoxic condition.

### [021] COMPARISON OF SLEEP QUALITY IN AVIATION PHYSIOLOGICAL TRAINING BETWEEN AIR FORCE CADETS AND AEROMEDICAL FLIGHT PERSONNEL

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**INTRODUCTION:** There is extremely high level of pressure and challenge at in-flight training and may affect sleep quality. AF cadets will undertake aviation physiological training before flying. Is sleep quality of AF cadets worse than general population at the ground training? Aeromedical flight personnel will also join the program about before fulfilling their duty. **MATERIAL AND METHOD:** This was a cross-sectional study conducted in 2015. Seventy subjects were forty AF cadets recruited from Air Force Academy and thirty aeromedical flight personnel volunteered from flight surgeon, flight nurse, and aviation physiologist training program. Pittsburgh Sleep Quality Index (PSQI) was applied to access sleep quality and contained seven aspects including Subjective sleep quality, Sleep latency, Sleep duration, Habitual sleep efficiency, Sleep disturbance, Use of sleeping medications and Daytime dysfunction. Scores of each aspect were between 0-3 and the global scores greater than 5 indicated bad sleep quality. SPSS 20.0 software was applied to analyze data. **RESULTS:** Global PSQI scores were 5.37 and 5.17 in AF cadets and aeromedical flight personnel respectively ( $p = 0.697$ ). The proportion of bad sleep quality (global scores  $> 5$ ) were 42% and 31% in AF cadets and aeromedical flight personnel respectively ( $p = 0.447$ ). The scores of Sleep duration, the third aspect of PSQI, were 1.34 and 0.83 in AF cadets and aeromedical flight personnel respectively ( $p = 0.004$ ) and the distribution of Sleep duration were significant between two groups (Pearson Chi square = 0.02). **DISCUSSION:** AF cadets had worse global PSQI scores than aeromedical flight personnel; besides, AF cadets demonstrated more bad sleep quality than aeromedical flight personnel. However the results were non-significant. But for Sleep duration, AF cadets significantly had less sleep duration than aeromedical flight personnel. General speaking, AF cadets had more bad sleep quality in aviation physiological training. In the future, we will follow up to investigate the trend of AF cadet sleep quality in flight training.

#### Learning Objectives:

1. To investigate the difference of sleep quality between AF cadets and aeromedical flight personnel during aviation physiological training in Taiwan.

**[022] A PILOT STUDY OF FATIGUE AND SITUATION AWARENESS DURING SIMULATED SMALL SATELLITE OPERATIONS**J. Schneider<sup>1</sup>, A. Saenz-Otero<sup>1</sup> and L. Stirling<sup>2</sup><sup>1</sup>Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA; <sup>2</sup>Massachusetts Institute of Technology, Cambridge, MA

**INTRODUCTION:** Fatigue is a concern as it decreases performance, increases operational risk, and generates significant annual costs. Of particular concern with small satellites is the operation of multiple robotic assets. **METHODS:** SPHERES, a small satellite testbed, was used to examine the effects of fatigue and presence of an augmented display with situation awareness aids. All procedures were approved by the MIT Committee on the use of Humans as Experimental Subjects. Subjects (n=6) were trained on the system, then randomized to a sleep protocol order, which included 3 days of rest and 3 days of sleep deprivation. Subjects controlled two satellites in a space debris avoidance scenario. Dependent measures included survival time, fuel usage, secondary task reaction time, and responses to a situation awareness questionnaire. **RESULTS:** An ANOVA found significant interaction effects of sleep protocol order and sleep deprivation state on survival time (p=0.014). For these pilot data, post-hoc tests did not have statistically significant differences between treatments when corrected for multiple tests, although a trend was seen towards improved performance in the sleep deprived state if it occurred on the second day of testing (p=0.060). A separate ANOVA found significant interaction effects of sleep protocol order and sleep deprivation state on fuel usage perception (p=0.012). Subjects that were sleep deprived first significantly improved their perception of fuel consumption on their well-rested day (p=0.047). When pooled on sleep deprivation state, the augmented interface increased correct perceptions of the ending velocities for both satellites compared with the basic interface (p < 0.0005). **DISCUSSION:** The study results suggest that a mental model was harder to develop in the fatigued state since survival time and perception of fuel improved after resting. Here the augmented display may have assisted mental model development as it led to improved situation awareness of the satellite's system states. These initial pilot subjects highlight that training guidelines for operating multiple robotic assets should permit appropriate rest during and after training to assist in mental model development.

**Learning Objectives:**

1. Understand the detrimental effects of partial sleep deprivation on performance and situational awareness in humans controlling multiple robotic assets.
2. Understand the benefits of using augmented reality with situational awareness aids in developing a mental model of a scenario with humans operating multiple robotic assets.

**[023] TYPES OF U.S. CERTIFICATE HOLDER FATIGUE RISK MANAGEMENT SYSTEM (FRMS) PROPOSALS**

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**INTRODUCTION:** Flightcrew Member Duty and Rest requirements in Title 14 CFR Part 117 were designed to improve pilot fatigue management and were implemented in January 2014. Section 117.7, Fatigue Risk Management System (FRMS), contains an optional provision permitting air carriers flexibility for operations outside the rule's limits. An FRMS can be proposed to the FAA with enhanced fatigue management as an alternative method of compliance. The FAA FRMS authorization process requires a systematic and progressive approach, including scientific review and evaluation of proposed alternative methods. Data collection, analysis, and validation must occur to demonstrate an equal level of safety before authorizing the FRMS with an Operation Specification. This presentation describes the number and type of carrier proposals currently submitted for authorization. **METHODS:** A review of FRMS proposals and their status within the five-phase authorization process was conducted with FAA AFS-220 personnel. The phases include: 1) pre-application assessment, 2) formal application, 3) data collection and analysis, 4) demonstration and validation, and 5) authorization, continuous monitoring and reporting. **RESULTS:** Currently, seven air carriers have approached the FAA with 15 FRMS proposals. Two carriers have withdrawn their applications and one is currently not active. There are eight applications in phase 3-data collection;

two in phase 4-equivalence analysis and final report; and one carrier has two, phase 5-completed FRMS authorizations granted. Types of exemptions requested: six, Class 1-equivalent rest facilities; six increased flight duty period (FDP) operations; one augmented crew/flight segment operation; one recovery operation; and one flight engineer augmentation. **DISCUSSION:** With the new regulation, Rest Facility specifications became prerequisite for determining Table C, FDP limitations. Some Class 1 facilities required equivalence testing. Some pre-2014 carrier operations required FRMS authorizations for continued flight. Additionally, extending FDPs for some ultra-long range flights were required due to seasonal jetstream effects on aircraft speeds.

**Learning Objectives:**

1. The reader will learn about how an optional provision in the new Flightcrew Member Duty and Rest regulation permits air carriers with the flexibility for operations conducted outside the rule's limits.
2. The reader will learn about the five-phase authorization process conducted by the FAA for air carrier FRMS proposals to exceed the limitations of the new regulation.
3. The reader will learn about the number and type of FRMS proposals that air carriers have recently submitted in order to conduct flight operations outside of the limitations of the new Flightcrew Member Duty and Rest regulation.

**[024] MEASUREMENT OF FATIGUE INDEX (FI) USING SALIVARY BIOMARKERS**

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**INTRODUCTION:** Fatigue: 1) contributes to misadventure during military operations, 2) is a clinical sign of disease, and 3) reduces quality of life. Scientific understanding of fatigue has been limited by lack of objective measures. The concentration of specific peptides in saliva may reflect fatigue status, enabling development of an objective measure of fatigue. **METHODS:** Human saliva composition before and after a fatiguing physical event was compared. The scope of chemical comparison was limited to peptides of molecular weight less than 10,000 Da. Chemical comparison was facilitated by use of both mass spectrometry and spatial separation on an inert substrate. Various human research protocols have been used to evaluate how putative fatigue biomarkers vary under various fatigue states. **RESULTS:** Chemical analysis revealed that the ratio of two peptides provided the most robust indication of fatigue following physical exertion. The peptides have amino acid sequences of GGHPPPP and ESPSLIA. The ratio of the peptides, the so-called fatigue index, [GGHPPP:ESPSLIA] is high in non-fatigued state and is reduced by several orders of magnitude following fatiguing activity. Concentrations of peptides in non-fatigued states are in nanogram per milliliter. Sleep deprivation induces a similar reduction in levels of the fatigue index as physical exertion. Comparison of peptide sequences to protein databases (GenPept, RefSeq, Swiss-Prot) shows that the peptides are from the family of Proline-Rich Proteins (PRPs) which are produced only by the salivary glands. **DISCUSSION:** The fatigue index offers a promising method for objective measurement of fatigue. Saliva is relatively easy to collect in quantities required for determination. The ratio of the two peptides corrects for changes that occur in saliva as a consequence of hydration state of the individual. Antibodies or other molecules that recognize fatigue index peptides with high specificity enable development of real-time sensors or conventional Point-of-Care type devices. Such devices, currently under development, could prove useful in quickly identifying fatigued individuals and finding methods for reducing fatigue in general.

**Learning Objectives:**

1. Learn how measurement of salivary peptides can be used to objectively measure fatigue in people.

**[025] DEVELOPMENT AND VALIDATION OF FORECASTING METHOD FOR PILOT'S MISSION PERFORMANCE AND FATIGUE LEVEL**H. Koo<sup>2</sup>, B. Choi<sup>2</sup>, S. Yoon<sup>3</sup> and D. Kim<sup>1</sup><sup>1</sup>Basic Science, Korean Air Force Academy, Cheongju, Republic of Korea; <sup>2</sup>Korea Air Force Academy, Cheongju, Rep. of Korea;<sup>3</sup>Chungbuk National University, Cheongju, Rep. of Korea

**INTRODUCTION:** Cumulative psychological stress and physical fatigue influence on situation awareness, alertness level, and combat capability in pilots. Reliable system to evaluate psychological stress and physical fatigue level before aviation mission has not been developed. Aim of this study is development and validation of a system to monitor situation awareness and alertness level of pilots before aviation mission.

**METHODS:** Thirty-two Korean Air Force men pilots participated in this study as volunteers. Heart rate variability (HRV) was obtained from the blood volume pulse of subjects for 5 min through the photoplethysmography (PPG) sensor. Total power (TP) and LF/HF ratio of HRV were analyzed. Reaction time and success rate were measured by the psychomotor cognitive test (PCT), which is an improved performance test. Reliability analysis of the alertness and fatigue level assessment was done. **RESULTS:** TP was decreased with age. The LF/HF ratio was positively correlated with the cortisol level in subjects preferring passive stress coping strategies ( $p < 0.09$ ), whereas it was negatively correlated with cortisol level in subjects preferring active stress coping strategies ( $p < 0.01$ ). Reaction time was correlated positively with fatigue level ( $p < 0.02$ ). Success rate of PCT was associated with fatigue level and LF/HF ratio, an indicator of autonomic balance. Customized alertness and fatigue monitoring system to evaluate alertness and fatigue level based on their cumulative data was constructed by four physiological indices, and characterized by a level of confidence of 85%. **DISCUSSION:** TP of HRV is utilized as an index for physical vitality, LF/HF ratio for physiological stability, reaction time of PCT for alertness level, and success rate of PCT for situation awareness level. However, bio-signal measurement values varied among individuals, thus setting a universal standard to evaluate human performance will be highly unlikely. In order to overcome this drawback, this study proposes a new method to generate a customized physiological standard of an individual and evaluate upon his standard. This customized evaluation method may be effective for aviation safety because increase the reliability in case of high fatigue level.

#### Learning Objectives:

1. analyze fatigue and alertness levels.

#### [026] U-2 12-HOUR FATIGUE ASSESSMENT

D. Bryant<sup>2</sup>, R. Evans<sup>3</sup>, J. Beer<sup>3</sup>, J. Serres<sup>1</sup>, M. Clayton Gallo<sup>3</sup>, T. Dart<sup>3</sup>, B. Wright<sup>2</sup>, M. Wade<sup>2</sup> and D. Burch<sup>2</sup>

<sup>1</sup>U.S. Air Force, Wright-Patterson Air Force Base, OH; <sup>2</sup>Aeromedical Research, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>3</sup>Wyle-Science, Technology & Engineering Group, San Antonio, TX

**INTRODUCTION:** U-2 pilots routinely conduct missions at altitudes above 70,000 ft, requiring pilots to wear a full pressure suit (FPS) and breathe 100% oxygen. Fatigue and cognitive performance are concerns related to the physical and mental stresses of the U-2 environment, breathing 100% oxygen, and wearing an FPS during prolonged mission durations exceeding 9 h. This study examined performance effects resulting from the stresses of the U-2 flight environment, breathing 100% oxygen, and wearing a FPS during a 12-h simulated mission.

**METHODS:** Ten participants (eight male, two female) completed two 12-h runs inside a hypobaric chamber in a simulated U-2 cockpit environment: a control condition at 8,000 ft wearing standard aircrew flight equipment and an experimental condition at 15,000 ft breathing 100% oxygen while wearing an FPS. Cognitive performance, fatigue, and discomfort were measured every 2 h throughout the study using a flight simulator performance task, psychomotor vigilance task, and visual analog scale discomfort assessment task. **RESULTS:** A repeated-measures general linear model analysis on the flight simulator performance data did not show a significant difference between the conditions across the duration of the flight ( $p = 0.099$ ), nor did a Wilcoxon signed-rank test find significance for discomfort scores ( $p = 0.317$ ). **DISCUSSION:** The flight simulator results indicated that while some participants had performance deficits wearing the FPS, no saliency between the two conditions existed. In general, participants found the aircrew flight equipment gear and the FPS to be similarly uncomfortable, as supported by their subjective scoring. Additional analysis is underway for the full data collected. Future studies should address contributing factors of fatigue associated with sustained 12-h flight simulator

performance, mobility differences, and their potential impact to pilot fatigue.

#### Learning Objectives:

1. Understand fatigue and cognitive performance concerns associated with a simulated 12-hour U-2 mission.

#### [027] THE UTILITY OF BIOMARKERS IN IDENTIFYING FATIGUE: CURRENT STATUS AND FUTURE DIRECTION FOR MILITARY AVIATION GUIDELINES

D.A. Boudreaux, K. Salomon and L. Milam  
Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL

**MOTIVATION:** Fatigue has continuously been a problem in the operational environment for aviators. Individual differences in the effects of sleep restriction or disruption of the natural circadian rhythm have led to complex and conflicting, scientific results. Not accounting for these individual differences in fatigue resistance or sleep recovery is one reason for fatigue management policies being overly broad and ineffective. Despite years of research, there are few practical, biologically-based tests for fatigue. Biomarkers have the potential to provide accurate measurements of fatigue specific to the individual that can be used to tailor fatigue management. This presentation aims to identify which biomarkers have shown evidence for detecting fatigue levels along with their applicability for use in fatigue management policies. **OVERVIEW:** Studies have shown fatigue is linked to degraded human performance in a number of cognitive functions related to aviation. A recurring theme in fatigue research is the importance of individual differences; that is, the amount of fatigue can vary extensively amongst individuals exposed to the same amount of sleep restriction. Thus, fatigue management systems that focus on scheduling sleep time are inadequate for ensuring pilots are performing at optimal levels. Recent studies have identified potential biomarkers that can measure the level of fatigue or distinguish fatigue resistant groups. Use of biomarkers can provide an objective, rapid evaluation of fatigue levels. This technology has the potential to be developed for use in real time in an operational environment. This presentation provides a systematic review of the current research to assess known biomarkers for potential in future products and determine what gaps in knowledge exist. **SIGNIFICANCE:** Most current fatigue management practices fail to account for individual differences. Quantifiable measurements of biomarkers have the potential to guide policy or provide additional information in the operational decision-making process. This presentation identifies which biomarkers and methods have been utilized to measure fatigue and determine what lanes of research should be pursued to meet the needs of aeromedicine providers.

#### Learning Objectives:

1. Participants will have an understanding of the current state of biomarker research on fatigue by leaning which biomarkers have been identified, which methods have been used to measure the biomarkers, and how those biomarkers have been linked to fatigue levels.
2. This poster will identify what gaps in knowledge exist in integrating biomarker measurements into fatigue management systems or policies. Recommendations for future research will be proposed.

#### [028] FATIGUE MONITORING IN SCHEDULED AIRLINE OPERATIONS

E. Flynn-Evans<sup>1</sup>, K. Gregory<sup>2</sup> and L. Arsintescu<sup>2</sup>  
<sup>1</sup>NASA Ames Research Center, Moffett Field, CA; <sup>2</sup>San Jose State University Research Foundation, Moffett Field, CA

**INTRODUCTION:** Reporting and monitoring are important facets of a comprehensive Fatigue Risk Management System (FRMS). As part of efforts to reduce fatigue risks, we partnered with an international airline to study volunteer pilots during flight duty and rest days to: (1) identify scheduling factors, physiological measures and cognitive variables that may predict degraded pilot performance; (2) determine recommendations for fatigue mitigation and scheduling modifications that can optimize operational alertness and performance; and (3) identify fatigue-related measures and data sources of individual-performance

effectiveness for inclusion in the FRMS that will enable continuous monitoring and management of operational safety and performance risks. **METHODS:** We gathered sleep and performance measures from 44 (4F) pilots over a 4-week period that included baseline/early/midday/late flight days and rest days off. All pilots received an email invite to participate and those interested attended a briefing session. All study procedures were approved by an IRB and participants provided written informed consent prior to beginning the study. Demographic and background questionnaires were completed at study onset and a wrist-worn MotionWatch collected sleep/wake actigraphy data for the full study period. A sleep diary was completed daily and PVT and Samn-Perelli ratings were done up to 4 times/day. Duty day measures included workload (NASA TLX), hassle factors, and fatigue countermeasures. A subset of pilots provided urine samples for melatonin analysis. **RESULTS:** Reduced sleep duration was associated with both early and late duties. Performance was influenced by duty timing, time of day and time awake. TLX ratings were highest for mental and effort demands while ATC and weather were the most identified hassle factors. Melatonin analysis revealed individual variations in circadian shift over the study period. **DISCUSSION:** The study results highlight the value of FRMS monitoring in airline operations. Ongoing crew education should emphasize individual variation and effective mitigation strategies. Further study could focus on workload and time of day scheduling factors.

#### Learning Objectives:

1. To better understand scheduling and other factors that may engender fatigue-related risks in aviation operations.
2. To identify measures and processes for ongoing fatigue monitoring in aviation operations.

### [029] AN ELECTROPHYSIOLOGICAL TECHNIQUE FOR ASSESSMENT OF THE EFFECT OF ACUTE HYPOXIA ON CONTRAST VISUAL ACUITY

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**INTRODUCTION:** Flight always accompany with hypoxia. And the visual function is the most sensitive sense to hypoxia. For pilots, the ability of distinguishing targets from backgrounds is one of the essential ability to ensure the safety of flight. How to evaluate the effect of acute hypoxia on contrast visual acuity objectively? **METHODS:** 15 volunteers with normal visual acuity were enrolled. Under the condition of photopia, the isolated-check visual evoked potential (ic-VEP) of volunteers were measured when breathing the air (the oxygen density was 20 % in volume) and low oxygen (the oxygen density was about 10 % in volume). In the experiment, the pulse oxygen saturation (SpO<sub>2</sub>) and heart rate were detected. **RESULTS:** After exposure to hypoxia 3 minutes, in the spatial frequency of 1.6 cpd, the SNR values of ic-VEP were decreased in the depth of luminance modulation 2 % ~ 8 % compared with normal (2 %:  $0.74 \pm 0.11$  vs.  $1.36 \pm 0.2$ , 4 %:  $0.56 \pm 0.09$  vs.  $1.34 \pm 0.12$ , 8 %:  $0.35 \pm 0.19$  vs.  $1.58 \pm 0.18$ ), while the SNR values were increased in the depth of luminance modulation 16 % and 32 % compared with normal (16 %:  $2.47 \pm 0.22$  vs.  $1.61 \pm 0.2$ , 32 %:  $2.65 \pm 0.24$  vs.  $1.95 \pm 0.19$ ). **DISCUSSION:** The ic-VEP is an objective visual electrophysiological technique to evaluate the effect of acute hypoxia on contrast visual acuity sensitively. The SNR values of ic-VEP for the lower luminance condition provided additional evidence for the effect that the low luminance contrast visual acuity is more vulnerable to acute hypoxia.

#### Learning Objectives:

1. The participant will be able to understand how to evaluate the effect of acute hypoxia on contrast visual acuity objectively.

### [030] OPERATIONAL BASED VISION ASSESSMENT COLLABORATIVE RESEARCH

M. Winterbottom<sup>4</sup>, L. Williams<sup>4</sup>, J.P. Gaska<sup>1</sup>, S. Hadley<sup>4</sup>, M. Rings<sup>2</sup> and A. Smith<sup>3</sup>

<sup>1</sup>FECO, 711/HPW/USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>2</sup>Ophthalmology, NAMI, Pensacola, FL; <sup>3</sup>RAAF Institute of

Aviation Medicine, Edinburgh, Australia; <sup>4</sup>OBVA Laboratory, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

**INTRODUCTION:** The objectives of the Operational Based Vision Assessment (OBVA) Laboratory are to 1) provide quantitative data defining the visual performance capability that will indeed prove useful during air combat, contribute to success of the mission, and help ensure survivability; 2) provide operationally 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. **METHODS:** The U.S. Air Force School of Aerospace Medicine's OBVA Laboratory has established formal research collaborations across services and multiple countries to accomplish these research objectives, which depend on generating large amounts of clinical and human performance data. Across organizations, normative data are being collected to characterize stereo acuity, contrast sensitivity, and motion perception; reliability and validity of new, computer-based vision tests are being examined, and the relationship between vision tests and operational performance is being examined for several weapons platforms and operational tasks: KC-46 aerial refueling, KC-30 aerial refueling, F-35 head-mounted display performance MRH-90 head-mounted display performance, air-to-air target detection and recognition range, and depth perception requirements for rotary wing call-to-landing. **RESULTS:** Data for approximately 200 human subjects have been collected to establish normative baselines and examine test reliability and validity for tests of color vision, contrast sensitivity, stereo acuity, and motion perception. Additionally, results show that color vision deficiency has a significant impact on color-coded display performance and that quality of vision is important for remote vision system aerial refueling performance. **DISCUSSION:** The relationship between visual performance metrics and operationally relevant performance is reported in detail. Future research plans across these organizations is also described.

#### Learning Objectives:

1. The participant will be able to understand the relationship between operational task performance and clinical vision screening criteria, as well as the need to establish threshold-based vision screening standards and waiver criteria based upon validated operational impacts.

### [031] A NOVEL TESTING PROCEDURE FOR THE DEEP AND SUPERFICIAL NECK MUSCLES FOR THE SWISS AIRFORCE

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Neck pain and cervical injuries are a common medical problem among Air Force pilots worldwide. In the last decade, neck pain cases among Swiss Air Force pilots have increased. Currently, all pilots have to complete a trunk stability test every year. Core strength and stability is measured, analyzed and training recommendations given. Due to the increasing trend of new neck pain cases, a novel stability and strength testing procedure for the neck muscles is necessary. The aim of this study is to integrate a neck testing procedure into the existing testing procedures. In addition, the calculation of reference values enables a pilot's performance to be recorded. In our preliminary study, a pressure-bio feedback test, a neck flexion and a neck extension test have been evaluated as suitable tests to measure neck strength and stability. Two hundred and forty three Swiss Air Force personnel, comprising both jet and helicopter pilots, performed the aforementioned three. In terms of the examination procedures, we first carried out a pressure-bio feedback test, followed by a neck flexion test, and lastly, a neck extension test. For the last two tests, the duration period was measured to record how long they could hold the required position. When carrying out the pressure-bio feedback test, it was necessary to hold 5 levels as steadily as possible for 10 seconds. The averages as well as the standard deviation were recorded. This study recorded an average pressure-bio feedback test of  $4.76 \pm 0.68$ , followed by the flexion test of  $120.97 \pm 40.03$  s and extension test of  $206.43 \pm 77.23$  s. The reference values for a sufficient performance were calculated as

"average – 1 standard deviation". The minimum value for the pressure-bio feedback test is therefore set at level 4. The minimum value for the neck flexion test is defined at 81 seconds and the one for the neck extension test at 130 seconds. All three tests were practicable and provided the examiner with a good estimation of the pilots' neck strength and stability. These testing procedures are now part of a pilots' annual test and training routine. An important finding will be the correlation to clinical findings as well as the comparison to an individual's own progress.

#### Learning Objectives:

1. Neck pain and cervical injuries are increasing health issues among Airforce pilots.
2. Neck strength and stability need to be trained to prevent neck pain.
3. Neck pain prevalence among pilots is higher compared to normal population.

### [032] IMPACT OF VARYING ALTITUDES ON SLEEP QUALITY AND QUANTITY: THE FIRST 48 HOURS

I.V. Sils, S.R. Muza, C.S. Fulco, R.W. Kenefick, A.M. Posch, J. Staab, K.I. Guerriere, S.P. Andrew and B.A. Beidleman  
*Thermal & Mountain Medicine, U.S. Army Research Institute of Environmental Medicine, Natick, MA*

**INTRODUCTION:** Unacclimatized lowlanders ascending directly to altitudes > 2500 m can experience disturbances in sleep quality and quantity. The purpose of this study was to determine the altitude threshold for disturbances in sleep quality and quantity during the first 48 hours of exposure to various altitudes. **METHODS:** Fifty-eight sea-level (SL) residents (39 men and 19 women, mean  $\pm$ SE, 23  $\pm$  1 yr, 174 $\pm$ 1 cm, 74 $\pm$ 2 kg) were randomly assigned to one of four altitude groups: 2500 m (n = 16), 3000 m (n = 18), 3500 m (n = 10), or 4300 m (n = 14). While sleeping for one night at SL and two nights at one of the assigned altitudes, each wore a pulse oximeter to measure percentage arterial oxygen saturation (%SaO<sub>2</sub>) and to count desaturation events per hour (DeSHr) (# of > 6% drops in %SaO<sub>2</sub> for  $\geq$  8 sec) along with a wrist motion detector to estimate sleep awakenings per hour (Awak) and total % sleep duration (%Slp). Awak and %Slp were collected for 34 men and 15 women (2500 m (n = 14); 3000 m (n = 14); 3500 m (n = 10); and 4300 m (n = 11)). The mean of these variables during two nights of sleep at altitude was calculated. **RESULTS:** All groups demonstrated similar sleep quality (%SaO<sub>2</sub>, DeSHr, Awak) and quantity (%Slp) at SL. Mean sleep %SaO<sub>2</sub> decreased (P<0.05) from SL (97 $\pm$ 1) to 2500 m (91 $\pm$ 1), 3000 m (85 $\pm$ 1) 3500 m (83 $\pm$ 1), and 4300 m (77 $\pm$ 1) in a dose-dependent manner. The DeSHr (events/hr) did not change from SL (0 $\pm$ 0) to 2500 m (3 $\pm$ 4), 3000 m (9 $\pm$ 4) or 3500 (11 $\pm$ 5) but increased (P<0.05) from SL to 4300 m (34 $\pm$ 4). Similarly, Awak (awakes/hr) did not change from SL (5 $\pm$ 2) to 2500 m (7 $\pm$ 1), 3000 m (12 $\pm$ 2) or 3500 m (12 $\pm$ 2) but increased (P<0.05) from SL to 4300 m (16 $\pm$ 2). %Slp was decreased at 4300 m (73 $\pm$ 3) compared to SL (96 $\pm$ 3) but unchanged at 2500 m (95 $\pm$ 3), 3000 m (90 $\pm$ 3) and 3500 m (88 $\pm$ 3) compared to SL. **DISCUSSION:** These results suggest that significant disturbances in sleep quality and quantity do not occur at or below 3500 m. This abstract expresses the authors' views; not official U.S. Army or DoD policy.

#### Learning Objectives:

1. Audience will know the initial dose-dependent manner that sleep quality and quantity change at varying terrestrial elevations.

### [033] QUANTITATIVE MODEL OF ALTITUDE ACCLIMATIZATION STATUS FOLLOWING VARIOUS ASCENT PROFILES

B.A. Beidleman, C.S. Fulco, A. Cymerman, S.P. Andrew, J. Staab and S.R. Muza  
*Thermal and Mountain Medicine, U.S. Army Research Institute of Environmental Medicine, Natick, MA*

**INTRODUCTION:** Rapid deployment of unacclimatized Service Members to altitudes above 1200 m causes debilitating effects on Service Member health and performance. Mission planners and leaders need accurate estimates of altitude acclimatization status, defined here as the presence or absence of acute mountain sickness (AMS), induced by various ascent profiles prior to ascent to a higher altitude. **METHODS:** Using multiple logistic regression and a comprehensive database, we analyzed the prevalence of acute mountain sickness (AMS) among 188 volunteers (147 men, 41 women, 25 $\pm$ 3 yr, 71 $\pm$ 4 kg) following 24 hrs of

exposure to 4050 m after they first experienced various ascent profiles. For instance, if an individual stayed at 2000 m for two days prior to ascent to 4050 m, the ascent profile was quantitated by multiplying the elevation of the resident altitude minus 1200 m (e.g., 2000 m minus 1200 m) by the number of days spent at the resident altitude (e.g., 800 m x 2 days) and then adding the additional day of acclimatization at 4050 m (e.g., 4050 m minus 1200 m x 1 day) to reach a final metric (i.e., 4450) of the ascent profile termed "meter-days". Meter-days, along with age, height, weight, sea-level maximal oxygen uptake, smoking status, and body mass index classification (normal weight vs. overweight), was utilized in the model as predictor variables. **RESULTS:** Meter-days was the largest significant factor (P<0.0001) in the prediction of altitude acclimatization status (e.g., the prevalence of AMS). For every 1000 meter-day increase in the ascent profile, the odds of getting sick decreased by 41%. Similarly, for every 1000 meter-day decrease in the ascent profile, the odds of getting sick increased by 69%. The other predictor variables were not significant factors in the model. Discriminative capability of the model was good (c-statistic: 0.82). The model, therefore, has an 82% chance of identifying those that have the event (e.g., AMS) from those that do not have the event if their ascent profiles are known prior to ascending 4050 m. **CONCLUSIONS:** This model provides accurate estimates of altitude acclimatization status at 4050 m resulting from the use of staged ascent profiles between 1200 and 4050 m.

#### Learning Objectives:

1. Participant will obtain information on a mathematical model that predicts altitude acclimatization status (e.g., the prevalence of Acute Mountain Sickness) at 4050 m after first experiencing various ascent profiles.

### [034] IMPACT OF STAGED VERSUS RAPID ASCENT TO 4300 M ON SLEEP QUALITY AND QUANTITY

A.M. Posch, S.R. Muza, C.S. Fulco, I.V. Sils, J. Staab, K.I. Guerriere, S.P. Andrew and B.A. Beidleman  
*Thermal & Mountain Medicine, U.S. Army Research Institute of Environmental Medicine, Natick, MA*

**INTRODUCTION:** Unacclimatized lowlanders ascending directly to high altitude experience disturbances in sleep quality and quantity. Staging at a moderate altitude for several days prior to further ascent is an accepted acclimatization strategy, however its effect on sleep has not been specifically evaluated. The purpose of this study was to determine which of three staging altitudes is most beneficial for improving sleep quality and quantity upon ascent to 4300 m. **METHODS:** Sixty two sea-level (SL) residents (41 men and 21 women, mean  $\pm$ SD, 23  $\pm$  5 yrs.) were randomly assigned to one of four groups: a group that staged for two days at either 2500 m (n = 17), 3000 m (n = 19), or 3500 m (n = 12) before ascending to 4300 m, or a group that ascended directly to 4300 m (n = 14). While sleeping for one night at SL and during the first night at 4300 m, each wore a pulse oximeter to measure percentage arterial oxygen saturation (%SaO<sub>2</sub>) and to count desaturation events per hour (DeSHr) (> 6% drop in %SaO<sub>2</sub> for  $\geq$  8 sec) along with a wrist motion detector to estimate sleep awakenings (Awak), total sleep duration (Dur), and the percentage of time during the night spent actually asleep (%Slp). Awak and Dur were collected for 34 men and 15 women (2500 m (n = 13); 3000 m (n = 14); 3500 m (n = 10); and direct ascent (n = 11)). **RESULTS:** All groups demonstrated similar sleep quality (%SaO<sub>2</sub>, DeSHr, and Awak) and quantity (Dur and %Slp) at SL. At 4300 m, the 3000 m group recorded a higher (P<0.05) %SaO<sub>2</sub> compared to the direct ascent group (79  $\pm$  4 vs 76  $\pm$  4%) and tended (P = 0.06) to have lower DeSHr (26  $\pm$  34 vs 44  $\pm$  34). Compared to the direct ascent group, the 3500 m group had fewer (P<0.05) DeSHr (21  $\pm$  34 vs 44  $\pm$  34), the 2500 m group had a higher (P<0.05) %Slp (79  $\pm$  4% vs 67  $\pm$  5%), and the 3500 m group tended (P = 0.07) to have a higher %Slp (77  $\pm$  5%). Awak and Dur were similar at 4300 m in all groups. **DISCUSSION:** Compared to direct ascent, staging at 3000 m for two days allowed for the greatest improvement in sleep quality at 4300 m. Staging at any altitude did not improve sleep quantity at 4300 m compared to direct ascent.

#### Learning Objectives:

1. The audience will better understand how sleep quality and quantity at 4300 m are affected by staged and rapid ascent.

### [035] TWO DAYS OF STAGING AT 2500-3500 M INDUCES SIMILAR VENTILATORY AND HEMATOLOGIC ACCLIMATIZATION TO 4300 M.

J.E. Staab, B.A. Beidleman, C.S. Fulco, M.L. Jones, U. Bhattarai, S.P. Andrew, K.I. Guerriere and S.R. Muza  
*Thermal & Mountain Medicine, U.S. Army Research Institute of Environmental Medicine, Natick, MA*

**INTRODUCTION:** Six days of staging at 2200 m induces ventilatory and hematologic acclimatization prior to exposure to 4300 m based on end-tidal carbon dioxide (PETCO<sub>2</sub>) and plasma volume (PV) changes. The impact of two days of staging on ventilatory and hematologic acclimatization is unknown. **METHODS:** Three independent groups of unacclimatized men and women were staged for 2 days at either 2500 m (n=19, 23±7 yr, 74±14 kg, mean ± SD), 3000 m (n=20, 24±5 yr, 75±13 kg) or 3500 m (n=15, 24±5 yr, 71±11 kg) prior to ascent to 4300 m and were compared to a control group that directly ascended and lived for 2 days at 4300 m (n=15, 22±2 yr, 72±11 kg). PETCO<sub>2</sub>, hemoglobin [Hb], and hematocrit (Hct) were measured in the morning at sea level (SL) and following 2-3 h at 4300 m in the staged groups and 48 h of continuous residence at 4300 m in the control group. The % decrease in PV from SL to each altitude was calculated using the Dill equation. **RESULTS:** PETCO<sub>2</sub> measured at SL was not different (P<0.05) among the four groups. The change in PETCO<sub>2</sub> from SL to 4300 m in the 2500 m (6.3±1.6 mmHg), 3000 m (7.2±2.7 mmHg) and 3500 m (7.2±3.8 mmHg) groups was not different (P<0.05) compared to the change in the control group (8.2±3.6 mmHg). The % decrease in PV from SL was not different (P<0.05) in the 2500 m (-16±7%), 3000 m (-14±7%) and 3500 m (-13±9%) groups compared to the change in the control group (-19±6%). **DISCUSSION:** These results demonstrate that two days of staging at either 2500 m, 3000 m or 3500 m prior to exposure to 4300 m effectively induced 68-88% of the ventilatory and hematologic acclimatization achieved with 2 days of continuous residence at 4300 m. Funding: USAMRMC. Authors' views; not official U.S. Army or DoD policy.

#### Learning Objectives:

1. Attendee will obtain information on what may be considered an optimal timeline or strategy for ventilatory and hematologic acclimatization to 4300 m.

Monday, April 25

10:30 AM

Avalon 1-3

### S-05: PANEL: SECOND TRANSPORT ROTORCRAFT AIRFRAME CRASH TESTBED STUDY (TRACT 2) – IMPROVED CRASH INJURY MITIGATION TECHNOLOGIES

*Sponsored by Life Sciences and Biomedical Engineering Branch and the AsMA Science and Technology Committee*

Chair: Lindley Bark

*Hollywood, MD*

Chair: Barry Shender

*Patuxent River, MD*

**PANEL OVERVIEW:** This panel presents the results from the second of two full-scale crash tests of transport helicopters conducted at the NASA Langley Research Center (LaRC) Landing and Impact Research Facility (LandIR). A multi-agency effort evaluated multiple protection concepts for occupants and equipment using a variety of fully instrumented anthropomorphic test devices, airframe sensors, video and mechanical data. The TRACT 1 test results served as a basis for protection improvements and experimental modifications for TRACT 2. The panel will also contrast the results from TRACT 2 with TRACT 1. The first presentation, from NASA LaRC, describes the experimental setup, overall study goals and describes the effects of structural modifications for TRACT 2. The second presentation describes prototype crash recorders used during TRACT 2 that can accurately measure the crash pulse in detail, which varies depending upon location within the aircraft. This has obvious implications for crashworthy concept designs. During crash, standing occupants are at greater risk than seated occupants. A

presentation by the Naval Air Systems Command (NAVAIR) describes the performance of a Mobile Aircrew Restraint System when the simulated mobile aircrew are positioned in non-optimal locations and orientations. Perhaps the most vulnerable occupants in a large utility or transport helicopter are patients during evacuation. The U.S. Army Aeromedical Research Laboratory presents an improved patient litter design based on TRACT 1 results. Finally, the study also included measuring the response of civil aviation forward facing passenger seats as well as a comparison of sidewall-mounted troop seats and an investigation of a modification to the FAA Hybrid III ATD conducted by FAA CAMI. The results of the two TRACT crash tests will be contrasted against seat certification testing to identify the ability of certification testing to predict injury potential.

### [036] OCCUPANT RESPONSE IN AN IMPROVED PATIENT LITTER SYSTEM DURING A FULL SCALE CH-46 CRASH TEST

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<sup>1</sup>Injury Biomechanics Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL; <sup>2</sup>Laulima Government Solutions, Fort Rucker, AL

**INTRODUCTION:** Current patient movement items, such as patient litters, are designed to meet static strength requirements. While patient care during medical transportation is critical, the patient movement systems need to structurally withstand the dynamics of turbulent flight and "survivable" crash events. Patient litters and their supporting systems are critical, but often overlooked, infrastructure components of the medical transport environment. The inability to safely restrain patients in harsh environments or properly support patients on a litter during crash impact events could exacerbate existing injuries or potentially lead to additional injuries. **METHODS:** A crash test of a CH-46 helicopter was conducted in September 2014. Design improvements were implemented to strengthen structural components based on analysis from a previous crash test. This included a redesigned litter, additional patient straps, and reinforced stanchions in order to improve crash performance. Space was provided to install three litters stacked above each other with wall stanchions and ceiling hanging straps. The upper and lower litters were loaded with non-instrumented test dummies to produce representative dynamic loads. The center litter was loaded with an anthropometric test device (ATD), instrumented to collect the forces, moments, and accelerations. Additional accelerometers were installed to collect dynamic loads acting on the four support hooks of the middle litter. A high-speed video camera captured the dynamic response of the patient litter systems and occupants. **RESULTS:** All litters collapsed during the event and separated from their support hooks. Review of the on board video revealed test dummies remained restrained on their litters during the test event. Instrumented ATD data were assessed against established injury assessment reference values for automotive testing. **DISCUSSION:** The results suggest the structural integrity of the litter systems used in this test and the CH-46 litter support systems are insufficient to properly secure and restrain litter occupants during severe crash events. Patient safety during this crash loading environment was compromised and could introduce new or exacerbate existing injury.

#### Learning Objectives:

1. The first objective of this paper is to introduce the audience to crash dynamic environments.
2. The second objective of this paper is to reveal some of the hazards present to patient litter occupants when exposed to crash impact conditions.
3. The third objective of this paper is to inform the audience of the limitations of legacy performance requirement of patient litter systems and catastrophic results possible if/when exposed to crash events.

### [037] OVERVIEW OF THE SECOND TRANSPORT ROTORCRAFT AIRFRAME CRASH TESTBED (TRACT 2) CRASH TEST

M. Annett

*NASA Langley Research Center, Hampton, VA*

**INTRODUCTION:** The Transport Rotorcraft Airframe Crash Testbed (TRACT) full scale crash tests were performed at NASA Langley Research Center's Landing and Impact Research Facility in 2013 and 2014. **METHODS:** A CH-46E, categorized as a medium-lift rotorcraft with



fuselage dimensions comparable to a regional jet or business jet, was outfitted with various crashworthy features such as pre-tensioning active restraints and energy absorbing seats. Two CH-46E airframes were impacted at 33 ft/s forward and 25 ft/s vertical combined velocities onto soft soil, which represents a severe, but potentially survivable impact scenario. TRACT 1 provided a baseline set of responses, while TRACT 2 included retrofits with composite subfloors and other crash system improvements based on TRACT 1. For TRACT 2, a total of 18 unique experiments were conducted to evaluate Anthropomorphic Test Devices (ATD) responses, seat and restraint performance, cargo restraint effectiveness, patient litter behavior, and activation of emergency locator transmitters and crash sensors. Combinations of Hybrid II, Hybrid III, and ES-2 ATDs were placed in forward and side facing seats and occupant experiments were compared against injury criteria. **RESULTS:** The response of TRACT 2 was noticeably different in the horizontal direction from TRACT 1 due to changes in the cabin configuration and soil surface, with higher acceleration and damage occurring in the cabin. Loads from ATDs in energy absorbing seats and restraints were below injury limits. Severe injury was likely for ATDs in other seat configurations. **DISCUSSION:** The loads throughout the airframe varied widely from tail to cockpit with just a slight pitch-up attitude. The terrain provided a unique kinematic response that changed the deceleration profiles.

#### Learning Objectives:

1. Assess airframe loads as they relate to seat and occupant loads, and how differences in terrain, attitude, etc. drastically change the seat and occupant response.

### [038] COMPARISON OF SEAT CERTIFICATION WITH CRASH TESTING

J. Pelletiere

*Aviation Safety, Federal Aviation Administration, Dayton, OH*

**INTRODUCTION:** The Federal Aviation Administration has a number of standards and regulations that are designed to protect occupants in the event of a crash. These standards focus primarily on frontal and vertical impact protection and measure the dynamic performance of the seating system and occupant restraint as there is currently no requirement for full-scale crashworthiness testing. The requirements were developed through review of research, existing requirements, modeling and simulation, and accident analysis. **METHODS:** The recent drop test of the TRACT test bed CH-46 airframe provided an opportunity to investigate the performance of an airframe in a simulated crash condition and provide data on the performance of previously approved seating systems. Passenger seats that were previously certified to 14 CFR 25.562 aviation regulations with a 49 CFR 572 Hybrid II ATD were included in the testing. It was expected that the real crash pulse would differ from the certification tests and the performance of the seats would differ as well. The ATDs used in the crash test included the Hybrid II, an FAA Hybrid III, 5% Hybrid III and a 95% Hybrid III. Lumbar loads were collected for all ATDs. **RESULTS:** The Part 25 Passenger seats remained attached to the floor structure and the restraint system held the occupants in place, however the lumbar loads measured were significantly higher than those in typical certification tests and higher than the allowable 1500 lb limit. **DISCUSSION:** Typical certification tests only use the 50% Hybrid II. The main performance requirement during a vertical test is the lumbar load, but structural integrity is also evaluated. This testing demonstrated that seats dynamically qualified for lower impact severities (14 G) were able to maintain structural integrity but were not able to control spinal injury risk at this load level.

#### Learning Objectives:

1. The participant will be able to understand the differences in how seats are certified to airworthiness standards and how they could actually perform in real world events.

### [039] EVALUATION OF MOBILE AIRCREW RESTRAINT SYSTEMS WITH NON-OPTIMAL AIRCREW POSITIONS IN A FULL-SCALE CRASH TEST

L.W. Bark

*Human Systems, Naval Air Warfare Center Aircraft Center Aircraft Division, Hollywood, MD*

**INTRODUCTION:** In a military helicopter, certain aircrew must be mobile in the aircraft. Such aircrew may be mobile for takeoff, landing, and other high risk situations. In a crash, mobile aircrew are at substantial risk of serious or fatal injury as mishap experience indicates. To investigate, a total of four mobile aircrew experiments were included in two Transport Rotorcraft Airframe Crash Testbed (TRACT) tests, the first times mobile aircrew have been included in crash tests. The mobile aircrew experiments in TRACT-2 examined aircrew positioned in non-optimal positions to assess injury potential. **METHODS:** Two 5th percentile male Hybrid III ATD's were each restrained with a mobile aircrew restraint system (MARS) designed to retract the tether between the airframe and mobile aircrew and automatically lock to prevent tether extension upon impact. The two ATD's were symmetrically positioned and secured in a standing position. Upon airframe impact with the terrain, the supports for the ATD's were pyrotechnically severed so the ATD's were free to move. To create the non-optimal aircrew positions, the simulated aircrew on the left side of the aircraft was standing just aft of a bulkhead strike hazard. The ATD on the right side of the aircraft was also standing but facing aft in the aircraft.

**RESULTS:** Test data indicate that the ATD on the left side of the aircraft was prevented from serious flailing contact with the aircraft structure as a result being arrested by the MARS. On the right side, the ATD was rapidly spun around by the MARS webbing, but was prevented from injurious contact with aircraft structure. **DISCUSSION:** The MARS did limit injury potential for mobile aircrew in non-optimal positions. Typical injury criteria will not cover all possible injury modes that are possible for mobile aircrew. The MARS restraint rapidly turns an ATD from aft- to forward- facing. Torso rotation criteria don't exist and the hazardous nature of this motion could be questioned. As systems, such as MARS, are fielded, aeromedical mishap findings may identify areas of needed research relative to appropriate injury criteria or assessment techniques that are appropriate for situations such as testing non-optimal mobile aircrew positions.

#### Learning Objectives:

1. Understand the unique crash-protective challenges related to military helicopter aircrew that may be mobile during all phases of flight.
2. Understand that injury criteria is applicable within the constraints and limitations in place when a specific criterion was developed.

### [040] CAPTURING AIRCRAFT CRASH DATA TO PROVIDE A BASIS FOR SMART CRASH INJURY MITIGATION

L.W. Bark

*Human Systems, Naval Air Warfare Center Aircraft Center Aircraft Division, Hollywood, MD*

**INTRODUCTION:** The TRACT-2 test was a full-scale crash test of a CH-46 airframe conducted by NASA, Navy, FAA, and the Army. TRACT-2 included fuselage mods and experiments based on the TRACT-1 results. The crash impact was moderately severity onto soil. The airframe was instrumented to identify crash pulses relative to location. TRACT-1 demonstrated that vastly different crash pulse results at different locations. TRACT-2 included three prototype crash recorders intended to capture crash accelerations in field mishaps. Ultimately, such data will impact design of crash-protective hardware to reduce injury. **METHODS:** The airframe was impacted with vertical and forward velocity and slight nose up pitch. The three 3-axis crash recorders captured airframe accelerations with a synchronized time zero at 10,000 samples per second in the cockpit, mid-cabin, and aft regions of the airframe. The measured accelerations from the three recorders were compared with hard-mounted lab accelerometers proximal to the recorders. **RESULTS:** The data from the crash recorders in the TRACT-2 test indicate the magnitude and direction of the crash pulse at each location and illustrate the remarkably different characteristics for different longitudinal locations in the airframe. The longitudinal component varies little by location. The vertical component is markedly different at different locations in the airframe with the cockpit experiencing the highest vertical accelerations. The results from the crash recorders mirrored the laboratory instrumentation. **DISCUSSION:** It is proven that proper understanding of field mishap acceleration data can help identify causative factors for previously unexplained occupant injury. The data that will be gleaned from fielded crash recorders will aid in understanding and articulating the causative factors for injuries sustained. This

data will also be used to identify potential design changes may pay large dividends in injury mitigation. Presently, we don't know how close to being saved, injured, or killed a particular occupant was in a given mishap. Developing accurate acceleration profiles will change the way aviation mishaps are investigated and the way crashworthy hardware is designed.

**Learning Objectives:**

1. Develop an understanding that accelerative environment may be substantially different from one end of an aircraft to the other.
2. Develop an awareness that medical personnel may one day have access to acceleration data rather than estimates of acceleration. This should help identify causative factors for injury in aviation mishaps.

**Monday, April 25**

**10:30 AM**

**Avalon 7-9**

**S-06: SLIDE: CLINICAL NEUROPSYCHOLOGY**

**Chair: Ray King**

*Tijeras, NM*

**Chair: David Schroeder**

*Oklahoma City, OK*

**[041] LONGITUDINAL ASSESSMENT OF UNITED STATES AIR FORCE AVIATORS DIAGNOSED WITH POSTTRAUMATIC STRESS DISORDER**

J. Wood and J.E. Heaton

*Aeromedical Consultation Service, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH*

**INTRODUCTION:** Involvement in combat operations is associated with increased risk for posttraumatic stress disorder (PTSD), and United States Air Force (USAF) aviators are commonly deployed to war zones. PTSD has been linked to deficits in attention and concentration, emotional disturbance, and functional impairment at home and at work. However, little is known of the long-term impact of PTSD on high-functioning individuals such as USAF aviators. To gain knowledge regarding the operational impact of PTSD on USAF aviators, a longitudinal study was designed. Aviators who are diagnosed with PTSD are evaluated at the Aeromedical Consultation Service (ACS) and then reassessed at 1, 2, 5, and 10 yr from the date of the original evaluation. **METHODS:** Between 2010 and 2015, twelve USAF aviators diagnosed with PTSD were evaluated on at least two separate occasions at the Aeromedical Consultation Service. Of the twelve, nine (75%) were male and nine (75%) were enlisted. Only one was a pilot. The evaluations consisted of separate clinical interviews by a psychologist and psychiatrist and administration of four neuropsychological measures. These included an intelligence test (MAB-II), a comprehensive neurocognitive screener (MicroCog: Assessment of Cognitive Functioning), a personality measure (NEO-PI-3), and a measure of psychological distress (MMPI-2). Scores on these measures were then compared to the general population and available baseline data. As this study group resembles occupational health practice and is not designed to develop or contribute to generalizable knowledge, these activities do not require Institutional Review Board oversight. **RESULTS:** The majority of aviators (83.3%) reported symptoms of PTSD developed following a deployment. Two (16.7%) reported development of PTSD in response to sexual assault. All twelve were recommended for waiver during their initial evaluation. However, 2/12 (16.7%) were not recommended for waiver during their follow-up evaluation due to recurrence of symptoms. Common lingering symptoms included anxiety/mood issues, insomnia/nightmares, and hypervigilance. **DISCUSSION:** Preliminary results suggest that development of PTSD in aviators is related to exposure to combat, and recurrence of symptoms is relatively common. Further study and monitoring of aviators diagnosed with PTSD are recommended.

**Learning Objectives:**

1. To understand common symptoms found in aviators with post-traumatic stress disorder and the potential for negative operational impact.
2. To understand the role of the Aeromedical Consultation Service in evaluating aviators with posttraumatic stress disorder.

**[042] LONGITUDINAL ASSESSMENT OF UNITED STATES AIR FORCE AVIATORS ON ANTIDEPRESSANT MEDICATION**

J.E. Heaton and J. Wood

*Aeromedical Consultation Service, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH*

**INTRODUCTION:** Previous United States Air Force (USAF) policy restrictions on aviator use of antidepressant medication potentially perpetuated the problem of aircrew flying while symptomatic, minimizing symptoms, or prematurely discontinuing treatment to avoid triggering a waiver requirement. The USAF has changed its policy to allow aviators to operate while on an antidepressant (Zoloft, Celexa, Lexapro, and Wellbutrin) and has designed a longitudinal study to better understand the operational impact among its flying population. Aviators who are on an antidepressant medication are evaluated at the Aeromedical Consultation Service (ACS) and then reassessed at 1, 2, 5, and 10 yr from the date of the original evaluation. **METHODS:** The records of 35 study group participants evaluated at the ACS (May 2013 – September 2015) for an initial waiver due to disqualifying mental health conditions and antidepressant medications were reviewed. Subjects include 21 (60%) officer and 14 (40%) enlisted, 32 (91.43%) males and 3 (8.57%) females, from various aircraft, aircrew, and special duty positions. This study group resembles occupational health practice and is not designed to develop or contribute to generalizable knowledge. This activity does not require Institutional Review Board oversight and therefore is exempt. **RESULTS:** Preliminary results indicate that 32 (91.43%) cases received a waiver to return to flying status upon completion of evaluation. In contrast, 3 (8.57%) cases did not receive a waiver due to continuing symptoms, requiring continued psychotherapy and monitoring. Most prevalent diagnoses of the study group are V-code conditions (i.e., relationship and occupational problems) (40%), adjustment disorders (37.14%), mood disorders (31.43%), anxiety disorders (28.57%), and posttraumatic stress disorder (8.57%). **DISCUSSION:** Preliminary results from the study have determined that aviators with a variety of mental health conditions are being treated with antidepressant medication and have demonstrated stability, regardless of diagnosis. Further study and monitoring of these aviators will occur at 1, 2, 5, and 10 yr from the date of the original evaluation.

**Learning Objectives:**

1. To better understand the operational impact of antidepressant medication use among the Air Force flying population.

**[043] RELEVANCE OF ELEMENTAL COGNITIVE PERFORMANCE TASKS TO OPERATIONAL ENVIRONMENTS**

B. Cheung

*University of Toronto, Toronto, ON, Canada*

**MOTIVATION:** The effects of extreme aerospace environments (for example: high altitude, rapid, intense angular and linear acceleration and degraded external vision) on physiological and cognitive performance are largely understood. However, in the cognitive domain, within less extreme environments, (such as low altitude below 14,000 feet), the effects of hypoxia on cognitive performance remain controversial. **OVERVIEW:** Literature reviews conducted from 1966 to 2011 suggest that in laboratory studies, the presence and significance of mild hypoxia on cognitive impairment below 10,000 feet is dependent on the type of cognitive tests that were used. For example, previous research suggests that exposure to mild hypoxia (at 8,000 ft.) does not affect well-learned cognitive, vigilance and motor performance tasks. Other reports suggest that mild hypoxia can affect the performance of novel, complex cognitive tasks involving multiple demands. Moreover, there were studies which demonstrated that mild hypoxia affects the performance on the Mannikin test for spatial reasoning and spatial transformation, the logical reasoning and vigilance tests, while other studies demonstrated that mild hypoxia does not affect the performance using those identical cognitive tests. One of the most important issues that has not been resolved, is the validation of the usefulness of these elemental cognitive tests with appropriate simulated and real-life flight performance of type-specific aircraft. In other words, how relevant and applicable do these cognitive test batteries resemble cognitive skills that are required for the specific operational environments? **SIGNIFICANCE:** Various cognitive test batteries provide "face value"

feedback. However, without validation in the flight environment, interpretation of such results is difficult. At best, it serves a peripheral role in elucidating the underlying mechanisms and implementation of appropriate training strategies. Performance in the operational environments is highly influenced by the motivation and resiliency of the aircrew. Therefore, in order to provide useful recommendations, validation studies of these cognitive test batteries must be conducted and laboratory studies should be expanded to a simulator and in-flight investigation.

#### Learning Objectives:

1. The audience will learn about the limits of using elemental cognitive test batteries for operational research.
2. A brief review on human performance studies in mild hypoxic environments will be presented.
3. Recommendations on the approach in studying human cognitive performance in operational environments.

#### [044] COGNITIVE RESERVE THEORY – CASE STUDIES OF INFREQUENT NEUROLOGICAL CONDITIONS EXPERIENCED BY AVIATORS SEEKING WAIVER TO RETURN TO FLIGHT DUTIES

G. Ford

Neuropsychiatry Branch, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

**PROBLEM STATEMENT:** As a follow-up to this presenter's 2015 case presentation on Cognitive Reserve Theory, as it relates to neuropsychological evaluation of aviators seeking a waiver following a moderate to severe brain injury, the majority of examinees not only evidenced a return to their cognitive baseline, but in many cases cognitive scores improved. This is a problem when trying to assess improvement or deterioration in cognition in high functioning aviators.

**BACKGROUND/LITERATURE REVIEW:** In this neuropsychologist's civilian practice, patients who complete neuropsychological testing in anticipation of a return to work following a severe neurological insult typically evidence some degree of impairment in the major cognitive domains even when given a positive prognosis by their physician. The civilian patients who have an initial baseline in the average range may evidence a number of cognitive deficits, in part due to the severity of the injuries and possibly due to the lack of cognitive reserve in their recovery process. These are anecdotal observations; however, they are based on examining a large number of clinical cases of aviators and average civilian patients who have experienced moderate to severe brain trauma. **CASE PRESENTATION:** Briefly, 6-10 neurological trauma patients rated in the severe range who have completed a cognitive evaluation at the Aeromedical Consultation Service for waiver consideration will be discussed as they may relate to the Cognitive Reserve Theory. **OPERATIONAL/CLINICAL RELEVANCE:** According to the Cognitive Reserve Hypothesis, as a group, these high functioning aviators with high average to superior intellectual baseline functioning, despite severe brain trauma, appear to have residual capacity to compensate for deficits or the potential for more rapid and complete recovery from severe brain injury. This does not mean that the patient is protected from future decline in cognition or that the next mild insult will not exceed the cognitive reserve.

#### Learning Objectives:

1. Many of the high functioning AF aviators who request a waiver following a moderate to severe brain injury appear to have residual capacity to compensate for any deficits or the potential for more rapid recovery.

#### [045] BILASTINE SHOWS NO PERFORMANCE IMPAIRING EFFECTS DURING 6H AT 8000FT CABIN ALTITUDE

P. Valk<sup>2</sup>, R. Simons<sup>1</sup>, A. Jetten<sup>2</sup>, R. Valiente<sup>3</sup> and L. Labeaga<sup>3</sup>

<sup>1</sup>European Society of Aerospace Medicine, Soesterberg, Netherlands; <sup>2</sup>TNO, Soesterberg, Netherlands; <sup>3</sup>FAES FARMA, Leioa, Spain

**INTRODUCTION:** Determination of performance impairing effects of sedative drugs highly depends on the validity of the testing environment, the performance capabilities addressed, and the type of task used. Since 1995, we apply an 'aviation-dedicated' methodology for assessing possible impairing effects of drugs, such as antihistamines, on performance of pilots under hypobaric conditions that prevail in an airliner.

Using this methodology, we have currently studied bilastine, a new second-generation, non-cardiotoxic antihistamine used in the treatment of allergic rhinoconjunctivitis and urticaria. Bilastine is considered to be non-sedative and might be recommended for use in pilots, pending research on the effects on flying-related performance. **METHODS:** We assessed the effects of bilastine in a hypobaric chamber at 8000 feet cabin altitude. In a randomized, double-blind, crossover study, 24 volunteers received a single dose of bilastine 20 mg, hydroxyzine 50 mg (active control), and placebo. Using the Vigilance and Tracking Task, the Multi-Attribute Task Battery, and the Stanford Sleepiness Scale, assessments were made before (baseline) and up to 6 hours after intake of the study medication. **RESULTS:** Bilastine 20 mg had no impairing effects on sleepiness levels, vigilance, and complex task performance for up to 6 hours post-dose. The active control hydroxyzine 50 mg was associated with significant sleepiness and impaired performance across this time period, confirming the sensitivity of the tests. **CONCLUSION:** The effects of bilastine 20 mg on performance tasks associated with flying ability, such as vigilance, tracking, and complex tasks, did not significantly differ from the effects of placebo. It is anticipated that a single dose of bilastine 20 mg will not affect flying performance. Bilastine may provide a safe therapeutic alternative for pilots suffering from allergic rhinoconjunctivitis or urticaria. The findings of this study confirm the results of our previous studies of second-generation antihistamines, showing that due to their low level of workload and arousal, vigilance and tracking tasks are more sensitive than arousal-increasing complex tasks for demonstrating sedative effects of drugs.

#### Learning Objectives:

1. Participants will learn how to apply an 'aviation-dedicated' methodology when assessing impairing effects of drugs, and will acquire knowledge about the effects on performance of the new second-generation antihistamine bilastine.

#### [046] PSYCHIATRIC AEROMEDICAL EVACUATIONS OF DEPLOYED U.S. MILITARY PERSONNEL DURING OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM 2001-2013

S.F. Dukes<sup>1</sup>, M.T. Baker<sup>7</sup>, J.A. Cigrang<sup>3</sup>, S. Young-McCaughan<sup>5,6</sup>, D. Arant-Daigle<sup>2</sup>, W. Hale<sup>4</sup> and A. Peterson<sup>5,6</sup>

<sup>1</sup>Aeromedical Research Department, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>2</sup>ST, 59th MDW, Lackland AFB, TX; <sup>3</sup>School of Professional Psychology, Wright State University, Dayton, OH; <sup>4</sup>Division of Behavioral Medicine, Strong Star, San Antonio, TX; <sup>5</sup>Department of Psychiatry, School of Medicine, University of Texas Health Science Center at San Antonio, San Antonio, TX; <sup>6</sup>Strong Star Consortium, San Antonio, TX; <sup>7</sup>423rd MDS/SGOW, USAF, RAF Alconbury, United Kingdom

**INTRODUCTION:** The presence of potential risk factors for psychiatric patients could be linked to increased safety risks during aeromedical evacuation (AE). Identifying those risk factors before transport could improve patient safety during flight. Data were collected retrospectively on all U.S. military personnel aeromedically evacuated from the Operation Iraqi Freedom/Operation Enduring Freedom combat theatre for a primary psychiatric condition between 2001-2013.

**METHODS:** The U.S. Transportation Command Regulating and Command & Control Evaluation System, a logistical support system for all active duty patient transport, was used to identify eligible participants (N=10,320) and corresponding baseline demographics. Additional variables obtained from the Defense Manpower Data Center included number of deployments and service component. **RESULTS:** The sample was predominantly white (69.04%), male (83.40%), enlisted (93.16%), active duty (68.20%), members of the U.S. Army (79.24%). Most had an educational status of high school or less (76.28%); about half were married (49.78%). The average age was 27.31 (standard deviation = 7.45); the range of total deployments was 1-10 (mean = 1.79, standard deviation = 1.03). The most prevalent mental health diagnoses were depressive disorder (13.14%), post-traumatic stress disorder (9.22%), and adjustment disorder with anxiety (4.60%). The percentage of service members aeromedically evacuated for suicidal ideation and associated behaviors was 3.12%. The most common psychiatric patient classifications were 1C (moderate psychiatric patient; 49.7%), followed by 1B (intermediate psychiatric patient; 28.5%), 5C (outpatient psychiatric patient going for treatment/

evaluation; 19.2%), and 1A (severe psychiatric patient; 2.6%). **DISCUSSION:** Military service members aeromedically evacuated for psychiatric disorders present challenges that differ from other AE populations and may pose additional safety concerns. Over 30% of this sample required sedation and close observation during AE due to their movement status (1A, 1C), resulting in supplemental demands on the AE team in terms of personnel and resources. Additionally, the referring provider and validating flight surgeon must have comprehensive information available to classify and transport patients under a multitude of conditions. This research will look at specific factors associated with presumed higher risk patients and potential applications to improving current standards of care.

**Learning Objectives:**

1. The participant will be able to identify challenges specific to the aeromedical evacuation of psychiatric patients.

**Monday, April 25**

**10:30 AM**

**Avalon 10-12**

**S-07: SLIDE: HUMAN FACTORS IN MEDICINE**

**Chair: Arthur Formanek**  
Baltimore, MD

**Chair: James Vanderploeg**  
Galveston, TX

**[047] TRANSFERRING AVIATION PRINCIPLES INTO CLINICAL PRACTICE – THE EVOLUTION OF HEALTHCARE SYSTEMS INTO HIGH RELIABILITY ORGANIZATIONS**

N. Powell-Dunford

*Exchange Officer, U.S. Army Aeromedical Research Laboratory, AE*

**INTRODUCTION:** Mishaps were prevalent in early aviation yet are now a rare occurrence because of established safety measures. Modern day aviation is a classic example of a high reliability organization (HRO), defined as an entity in which catastrophic events would normally occur in the absence of successful control measures. CRM, checklists and mishap investigation exemplify HRO principles that have been transferred to the healthcare industry in an attempt to lower unacceptably high medical error rates. The degree of application of aviation practices may predict medical error reduction as well as patient survival. **METHODS:** The implementation of crew resource management (CRM), checklists and mishap investigation techniques into clinical practice were analyzed following a review of health care related HRO journals and academic conference presentations. Characteristics and challenges of successful implementation were identified. Correlations between measures of success and degree of implementation were established. **RESULTS:** Culturally supported, intensely applied, well-funded CRM and checklist practices have resulted in reduction in medical error, with subsequent improvement in survival. Short term reduction in clinical productivity required to effect universal CRM training may be a barrier to implementing this measure. Application of mishap investigation techniques into clinical practice, an emerging and less robust practice, has yet to bear results. Medico-legal concerns may be a pragmatic barrier to using a mishap investigation model. **DISCUSSION:** High rates of medical error currently characterize the healthcare industry. Culturally supported, well-funded and intense application of CRM and checklists have improved medical outcomes. Further research regarding utilization of mishap investigation techniques, an emerging practice, is needed. Time commitment, short term productivity decrements and medico-legal concerns may limit implementation of aviation related measures. Evolution of the healthcare industry into an HRO can be facilitated through adoption of aviation practices but will require cultural support, funding and time investment.

**Learning Objectives:**

1. Define key properties of a high reliability organization (HRO).
2. Recognize aviation based safety measures that have been applied to clinical medicine in an attempt to transition towards high reliability.
3. Recognize features of successful applications of aviation based practices into clinical practice.

**[048] IMPLEMENTING HUMAN FACTORS ON CRITICAL CARE AIR SUPPORT TEAM MISSIONS – A NURSING PERSPECTIVE.**

G. Howarth

*Critical Care Area A, Royal Centre for Defence Medicine, Queen Elizabeth Hospital, Birmingham, United Kingdom*

**PROBLEM STATEMENT:** This case study describes positive changes to teams working within the RAF Critical Care Air Support Team (CCAST) through implementing a combination of simulation and human factors techniques. **BACKGROUND:** Clinical patient transfers are acknowledged as the riskiest part of the critical care patients' journey with incidence of adverse events varying from 3-75%. Furthermore up to 91% of these are preventable. Effective crew skills, teamwork and good interpersonal communication are amongst the documented factors associated with fewer incidents. Research has also demonstrated a positive association between simulated training and team performance. CCAST have been undertaking critical care patient transfers for the last fifteen years. Team manning works on a monthly rota, as such team members may not have met or worked together prior to the on call period. Additionally and comparable to civilian practice the medical officer within the team holds a significantly higher rank than the nursing personnel which may prove a barrier to communication. **CASE PRESENTATION:** In the last four years formalized human factors training has been delivered to CCAST personnel. The last two years has seen a reduction in patient numbers in the post Op Herrick period resulting in the introduction of a monthly Crew Resource Management (CRM) briefing followed by a simulated mission exercise. The simulated missions cover planning and logistical elements alongside troubleshooting and a clinical critical incident. It is run at the beginning of the on call period allowing clinicians to rehearse scenarios and improve team dynamics in a safe controlled environment where feedback can be given and mistakes corrected without compromising patient safety. **OPERATIONAL/CLINICAL RELEVANCE:** This case highlights positive changes made within the CCAST to reduce the risk of preventable incidents during flight. It is felt that through implementing CRM techniques combined with simulated mission training there is improved team cohesion, enhanced communication and a breaking down of the rank barrier and as such the risk to the patient is reduced. This method of practice is reproducible in the wider military and the civilian patient transfer environment.

**Learning Objectives:**

1. The participant will be able to understand the Crew Resource Management techniques and Simulation exercise utilized within the UK Critical Care Air Support Team to improve team cohesion and break down communication barriers.

**[049] SAFE IMPLEMENTATION OF HIGH TECHNOLOGY IN HIGH-CONSEQUENCE SURGICAL SETTINGS: THE ROLE OF AEROSPACE MEDICINE EXPERTISE**

P.S. Bechtle

*Anesthesiology, Mayo Clinic, Ponte Vedra Beach, FL*

**MOTIVATION:** There is a proliferation of medical literature advocating use of aviation-style checklists and procedures in medicine, many so-called 'expert' advocates have no real-world experience in either aviation or high-consequence medicine. The AsMA member typically has significant aviation, industry or operational medicine experience and would benefit from seeing a Mayo Clinic experience in implementation of comprehensive aviation safety paradigms. **OVERVIEW:** Aviation systems have evolved safety conventions that enable them to 'bracket' safety to incredibly low incidence rates. Some of these conventions: checklists, flow-checks, placarding and use of Standard Operating Procedures (SOP's) have appeared in numerous articles and books promoting their application to healthcare safety; this has led to proliferation of use, but not optimal use. The Interventional MRI System (IMRIS) neurosurgical suite represents the highest-consequence surgical setting at Mayo Clinic because of its unique mission and significant physical risks. This safety system consists of detailed SOP's, configuration, normal and emergency checklists, flow-checks, placarding, and structured communication; it was blueprinted from experiences in Naval Aviation, Airshow and Aerospace industries and has now set the standard for IMRIS. Development, testing and implementation will be presented. **SIGNIFICANCE:** Proliferation of

highly capable medical systems, like the IMRI neurosurgical system described here, has generally outstripped the ability of healthcare to 1) take advantage of the “potential safety” that these systems promise 2) effectively deal with the extreme hazards of the systems themselves or 3) implement them efficiently enough to recoup the high capital cost. The skillset and experiences routinely present in AsMA members are both unique and underutilized/underappreciated by hospitals and medical systems that are making significant capital expenditures for these systems; this work concretely highlights the extreme efficiency, safety and value gained by utilizing experienced aerospace medicine staff in conjunction with aviation industry paradigms during initial design and implementation of high-consequence, high cost systems.

#### Learning Objectives:

1. Understand the critical performance limitations in healthcare staff that have not been trained in structured communication.
2. Learn the critical role and limitations that initial configuration, normal and emergency checklists have in ensuring safety in high-consequence settings in healthcare and what competencies are necessary to train healthcare workers in checklist use.
3. Be able to describe the spectrum of skills and insights that Aerospace Medicine, Military Operational Medicine, and others associated with the Aerospace Medical Association possess and why the members represent a valuable and critical resource at this time in healthcare industry evolution.

### [050] APPLYING HUMAN FACTORS PRINCIPLES TO CHECKLIST DESIGN: OPERATIONAL ENVIRONMENT, CULTURE, AND TRAINING

A.L. Clebone

Anesthesiology and Critical Care, University of Chicago School of Medicine, Chicago, IL

**PROBLEM STATEMENT:** Checklists and other cognitive aids are most effective when designed specifically for the operational environment and culture in which they will be used. Personnel should also receive training on when and how to use them. **TOPIC:** Clinical medicine is different from aviation in several ways: In aviation, the work domain is semi-closed and includes the pilots in the cockpit and occasionally air traffic control or technical personnel. Medicine is an open-work domain: personnel in the operating room include a surgeon, an anesthesiologist, a nurse, and a scrub technician, all of whom care for one patient. Each one of these people may come and go for different parts of the surgery. Complementary but distinct goals exist for each person on this team (e.g., physicians of different specialties, nurses, technical support staff). Many more people with varying levels of training may enter the room during a critical event, and few if any of them know which steps have been taken so far, even if a checklist is in use. An appropriately designed checklist can decrease the level of confusion, allowing new members of the team to know what has been accomplished. **APPLICATIONS:** In many institutions, a critical-events checklist is simply placed in the operating room. Personnel receive little if any training on its use. Checklist training should include at a minimum education about its purpose, the goal of each individual item, and how to use it appropriately. Training may also help to ameliorate some of the problems issues with checklist use, including rushing through the checklist, misunderstanding some of the items, and skipping some items altogether because they are thought to be unimportant. Users must also understand its relevance and importance for the goals to be achieved. A successful way is by tailoring checklists to account for unique characteristics of each location. Running checklists during tabletop and high-fidelity simulations, and altering items to fit required workflow can assist greatly in this goal. This talk will review specific examples of and ways to incorporate human factors principles to tailor checklists to the operational environment and to accomplish successful checklist training.

#### Learning Objectives:

1. To learn how the domains of medicine and aviation are different, and how this impacts checklist design.
2. To learn how to create checklists for medicine that take into account the unique aspects of this domain.
3. To see specific ways to implement checklist training within medicine.

### [051] CHECKLIST DEVELOPMENT: OPTIMIZING FOR THE MEDICAL ENVIRONMENT

B. Burian

Human Systems Integration Division, NASA Ames Research Center, Moffett Field, CA

**INTRODUCTION:** Critical event checklists are a potentially invaluable cognitive aid in medicine, but much resistance to their use and implementation still exists. One explanation for this may be related to a mismatch between the checklist's design and content and its possible uses, particularly in the fluid work environment involving many actors that is characteristic of operating rooms. Principles of human factors have yet to be applied to many of the checklist devices in current use.

**METHODS:** Several possible uses of medical critical event checklists were identified. For example, many medical critical events checklists currently in use are written as ‘Do-lists’—analogous to aviation emergency and abnormal checklists—where each item is, in turn, read and accomplished to guide response. In practice, however, they might instead be used to generate ideas of other steps that might be taken after a response has already been initiated without reference to the checklist (i.e., “sampling”). Content and design analyses of popular medical critical event checklists were conducted to identify which possible uses of the devices were best and least supported. **RESULTS:** It was found that the checklists analyzed tended to be most useful for some purposes (e.g., guide step-by-step response) but do less well for others, such as facilitating a differential diagnosis. Optimizing the design of these checklists to meet all possible needs can be challenging—and in some cases, impossible—but areas for improvement to maximize their utility were often identified.

**DISCUSSION:** The acceptance and implementation of medical checklists depends upon a number of factors and optimizing their design and content to ensure greatest utility within medical settings is a critical one. This talk will review possible uses of medical critical event checklists and discuss the application of human factors principles and specific content and design approaches to support those varied uses.

#### Learning Objectives:

1. Attendees will be able to identify the most common uses of medical critical event checklists and cognitive aids.
2. Attendees will be able to identify aspects of some medical critical event checklists and cognitive aids that limit their utility.
3. Attendees will be able to describe human factors principles and approaches to medical critical event checklist design that maximize their use for different purposes.

Monday, April 25

10:30 AM

Avalon 13-14

### S-08: PANEL: BRINGING GRAVITY TO SPACE

Chair: Peter Norsk

Houston, TX

Chair: Mark Shelhamer

Houston, TX

**PANEL OVERVIEW:** This panel will present NASA's plans for ongoing and future research to define the requirements for Artificial Gravity (AG) as a countermeasure against the negative health effects of long-duration weightlessness. AG could mitigate the gravity-sensitive effects of spaceflight across a host of physiological systems. Bringing gravity to space could mitigate the sensorimotor and neuro-vestibular disturbances induced by G-transitions upon reaching a planetary body, and the cardiovascular deconditioning and musculoskeletal weakness induced by weightlessness. Of particular interest for AG during deep-space missions is mitigation of the Visual Impairment Intracranial Pressure (VIIP) syndrome that the majority of astronauts exhibit in space to varying degrees, and which presumably is associated with weightlessness-induced fluid shift from lower to upper body segments. AG could be very effective for reversing the fluid shift and thus help prevent VIIP. The first presentation by Dr. Charles will summarize some of the ground-based and (very little) space-based research that has

been conducted on AG by the various space programs. Dr. Paloski will address the use of AG during deep-space exploration-class missions and describe the different AG scenarios such as intra-vehicular, part-of-vehicle, or whole-vehicle centrifugations. Dr. Clément will discuss currently planned NASA research as well as how to coordinate future activities among NASA's international partners. Dr. Barr will describe some possible future plans for using space- and ground-based partial-G analogs to define the relationship between physiological responses and G levels between 0 and 1. Finally, Dr. Stenger will summarize how the human cardiovascular system could benefit from intermittent short-radius centrifugations during long-duration missions.

### [052] ARTIFICIAL GRAVITY: HISTORICAL PERSPECTIVES

J.B. Charles

*NASA Human Research Program, Houston, TX*

**MOTIVATION:** The condition of weightlessness during ballistic spaceflight has well-known associated physiological concomitant effects on the neurosensory, cardiovascular and musculoskeletal systems. Given the deleterious nature of those concomitant effects, an obvious question is, "why has artificial gravity (AG) not routinely been provided on piloted spacecraft using rotation of small or large habitable components of the vehicle structure?" This presentation will review the in-flight and ground-based history of AG proposals as a foundation for future prospective investigations. **OVERVIEW:** Even the earliest proposals for space travel considered the benefit to astronauts' health and performance of rotating all or part of the space vehicle to provide AG. Practically every piloted spacecraft concept has been evaluated repeatedly for its ability to accommodate some form of AG. However, in-space demonstrations of even rudimentary AG have been rare, and those at a scale adequate for human occupancy almost nonexistent. More work at every scale has been performed on Earth, but applicability to spaceflight is always confounded by the presence of Earth gravity in the orthogonal direction, requiring careful interpretation. **SIGNIFICANCE:** Ambitious plans for multi-year piloted space exploration missions beyond low Earth orbit will inevitably require extended periods of unpowered flight and associated free fall during transits between planets for all but a few minutes at planetary departure and arrival. Any decision to provide AG must consider both the benefits and the costs of implementation. The historical record presented here can help inform such a decision.

#### **Learning Objectives:**

1. The participant will be able to demonstrate knowledge of the history of artificial gravity exposures in spaceflight and on Earth.

### [053] ARTIFICIAL GRAVITY OPTIONS FOR SPACE EXPLORATION MISSIONS

W.H. Paloski

*Human Research Program, NASA Johnson Space Center, Houston, TX*

**MOTIVATION:** Human space exploration missions currently being planned by NASA would expose crews to microgravity for up to 1000 days. While we can protect crews from the effects of sustained exposure to microgravity for up to six months aboard ISS using aggressive exercise countermeasure protocols, it is not clear whether this approach would be effective during missions of five times that duration. Also, recent emergence of a high incidence of visual impairment in ISS crewmembers putatively linked to prolonged microgravity exposure leads us to reconsider the need to replacing gravitational loading aboard these exploration missions through inertial means. **OVERVIEW:** Key considerations to be addressed before deciding to deploy artificial gravity countermeasures aboard exploration missions come from both the medical requirement side and the engineering implementation side. While the requirement has not yet been firmly established, options for implementation are beginning to evanesce. Three potential approaches include: spinning the entire vehicle, spinning a portion of the vehicle, and spinning a crewmember within the vehicle. The cost and complexity of implementing any of these solutions must be traded-off against the effectiveness and efficiency of the protection provided. Uncertainties currently exist on both sides of the trade; however, it may take 3-5 more years to

establish the need for a medical requirement, and during that time more implementation options are likely to disappear. Thus, it behooves us now to begin looking carefully at the potential options so as to be prepared for action should the need arise. **SIGNIFICANCE:** The microgravity environment of spaceflight drives adaptive responses of multiple physiological systems, causing risks to crew health and performance. The question of whether the exercise countermeasure approaches that have effectively protected crewmembers from these responses during six-month ISS missions will continue to be effective on much longer exploration missions is of high importance today, as the alternate approach of gravity replacement through inertial means will prove increasingly costly to implement as we approach engineering decision points for these missions.

#### **Learning Objectives:**

1. This presentation will aid the audience in understanding the considerations driving the renewed interest in employing artificial gravity as a countermeasure to offset the human health and performance risks associated with sustained microgravity exposures during exploration missions currently under consideration by NASA.

### [054] INTERNATIONAL ROADMAP FOR ARTIFICIAL GRAVITY RESEARCH

G.R. Clément

*Science, Technology and Engineering, Wyle, Houston, TX*

**MOTIVATION:** Artificial gravity (AG) is an alternative health protective countermeasure for mitigating the deconditioning effects of weightlessness on humans during long-duration space missions. Research on AG is an integrative approach including physiological, behavioral, and human factor aspects. It is also a multidisciplinary effort where space physiologists, crew surgeons, astronauts, vehicle designers, and mission planners need to review, evaluate, and discuss the issues for incorporating AG technologies into the vehicle design. Commitments by spacecraft designers to implement AG will only come following acceptance of a well-argued requirement from the aerospace medicine community. **OVERVIEW:** AG during centrifugation can be adjusted by varying the rotation rate of the spacecraft/centrifuge or the distance of the habitat/crewmember relative to the axis or rotation. These AG parameters have an impact on vehicle design and on operations. Questions that will need answers are: (a) what evidence do we have to support the requirement for AG on board a spacecraft for a long-duration mission; (b) what design parameters would we levy upon the engineers; and (c) what prescriptions (G level, duration, frequency) would we recommend to the crewmembers? Recommendations must also be provided regarding the additional complementary countermeasures to ensure human health and performance of long-duration crewmembers. These questions must be answered before the design of the spacecraft and mission is completed. **SIGNIFICANCE:** Representatives of NASA, ESA, and the space agencies of Canada, France, Japan, Germany, and Russia have developed and periodically update an international AG research plan. This roadmap contains a common set of goals, objectives, and milestones from the current research plans of each of the participating agencies. It includes both current and future activities in AG research, and provides a framework that facilitates the opportunities for collaboration using the full range of available AG facilities worldwide.

#### **Learning Objectives:**

1. Understand the issues for incorporating artificial gravity into the vehicle design for a human Mars mission.

### [055] PARTIAL GRAVITY ANALOGS – SUMMARY OF A NASA WORKSHOP AND ITS RECOMMENDATIONS

Y. Barr<sup>1</sup>, P. Norsk<sup>2</sup> and G.R. Clément<sup>3</sup>

<sup>1</sup>UTMB/Wyle/NASA, Friendswood, TX; <sup>2</sup>NASA Human Research Program, Universities Space Research Association, Houston, TX;

<sup>3</sup>Science, Technology and Engineering, Wyle, Houston, TX

**MOTIVATION:** Little is known about the physiologic responses to partial gravity (a G-level between 0 and 1). Understanding the effects of partial-G exposure is critical for determining the most effective G level for in-flight artificial gravity (AG) weightlessness mitigation and for defining

whether additional countermeasures are required for long-term planetary operations. Analogs that simulate the effects of partial-G environments are therefore needed and are one of the gaps addressed by NASA's Human Research Program (HRP). **OVERVIEW:** To determine which partial-G analogs (PGAs) should be pursued, scientists and managers from NASA's HRP convened at a workshop in February 2015. Thirteen ground-based, four space-based, and one in-silico PGAs were discussed and ranked according to their suitability to address knowledge gaps in each research discipline. Analogs that provide acute intermittent partial-G as well as those that provide chronic continuous exposure were considered. The PGA that was deemed the most informative by the workshop's attendees is chronic space-based long-radius human centrifugation, as this would be the most accurate simulation of planetary surface partial G and would allow integrated investigations of numerous physiologic systems. In the absence of a space-based capability for chronic human centrifugation, other suggested PGAs include chronic space-based centrifugation of animals using a rodent centrifuge and centrifugation of cell cultures. Among the ground-based PGAs, chronic centrifugation of head-down-tilted humans in rotating rooms was rated highly, as well as low-angle, head-up-tilt bed rest, different degrees of head-out water immersion (dry and wet) and parabolic flight. **SIGNIFICANCE:** The use of PGAs will assist in answering two main questions: What are the protective effects of lunar and Martian gravity against physiologic deconditioning, and what range of G levels is protective during space transit missions? PGAs can also be used to validate potential AG prescriptions for space missions. This knowledge will be used to inform vehicle designers on whether AG is needed and, if so, the technical requirements.

#### Learning Objectives:

1. To understand the variety of potential partial-G analogs and their prioritization.

#### [056] CARDIOVASCULAR BENEFITS OF ARTIFICIAL GRAVITY – SUMMARY OF RECENT NASA RESEARCH STUDIES ON INTERMITTENT CENTRIFUGATION

M.B. Stenger

*Cardiovascular and Vision Laboratory, Wyle ST&E, Houston, TX*

**MOTIVATION:** Whole-vehicle centrifugation is a complex engineering task, and therefore development of a small-radius centrifuge that would fit inside a spacecraft for periodic exposures to artificial gravity (AG) has been proposed. However, the ideal combination of AG magnitude, frequency, and duration needed to protect against cardiovascular deconditioning during spaceflight has yet to be defined.

**OVERVIEW:** The National Aeronautics and Space Administration has implemented several research studies to investigate short-radius centrifugation as a method to reproduce the Gz gravity-like stress and determine its effects on the cardiovascular system in ambulatory and bed rest subjects. These studies investigated differences in short vs long radius centrifugation, ambulatory vs deconditioned subjects, oscillatory vs constant acceleration, men versus women, and centrifugation with and without exercise. Three weeks of oscillating AG (1 to 2.5 Gz, measured at the feet) for 45 min/d improved orthostatic tolerance in ambulatory men and women. Improvement was greater in men than women and greater in exercisers (cycle ergometry at ~50%  $\dot{V}O_2$ max) than in passive subjects (without exercise). In a separate study, men who were exposed to daily centrifugation (constant 1 Gz at the heart, ~2.5 Gz at the feet) during 21 d of bed rest had greater post-bed rest orthostatic tolerance than control subjects. This constant Gz protocol was too provocative for women, who as a result were excluded from this bed rest study. Thus, in a subsequent investigation, ambulatory men and women were exposed to Gz profiles based on individual Gz tolerance. A single oscillatory AG exposure that ramped up to 0.2 Gz below individual Gz tolerance improved orthostatic tolerance in men and women compared to a control condition in which they did not receive AG exposure. **SIGNIFICANCE:** The ideal type, magnitude, duration and frequency of an AG countermeasure will need to be studied systematically. Individual tolerances to Gz stress may influence the AG prescription developed for future spaceflight missions.

#### Learning Objectives:

1. To provide an overview of artificial gravity as a countermeasure to cardiovascular deconditioning in space flight.

**Monday, April 25**

**10:30 AM**

**Avalon 15-16**

#### S-09: PANEL: ENABLING HUMAN PERFORMANCE SCIENCES AT THE AIR FORCE RESEARCH LABORATORY

**Chair: Rajesh Naik**

*Wright-Patterson AFB, OH*

**PANEL OVERVIEW:** This panel will highlight activities at Air Force Research Laboratory (AFRL), including the 711<sup>th</sup> Human Performance Wing and in collaboration with our international and academic partners on developing innovative technical solutions for human performance. First, we will present an overview of AFRL and the research activities in support of human performance. This will be followed by a presentation on the Human Effectiveness Directorate (711 HPW/RH) which is the research arm for the 711th Human Performance Wing to exploit biological and cognitive science and technology to optimize and protect the Airman's capabilities. This will be followed by talks highlighting our international and academic collaborations on human health and performance research. The international collaboration will highlight the SHORESH aerospace working group established to further international aeromedical collaborations to leverage expertise, increase data sets, and more economically execute accomplish research. The final presentation will be our academic collaborator from Northwestern University discussing novel technologies to rapidly detect, identify and quantify biomolecules in easily accessible human samples to monitor and quickly diagnose human physiological responses to environmental factors, harmful agents, or stress. The panel will conclude with a question-and-answer session with the panel members.

#### [057] AIR FORCE RESEARCH LABORATORY OVERVIEW

M. Stone

*Air Force Research Laboratory, Wright-Patterson AFB, OH*

AFRL is the Air Force's only organization wholly dedicated to leading the discovery, development, and integration of warfighting technologies for air, space and cyberspace forces. The Laboratory was formed at Wright-Patterson Air Force Base, Ohio as a consolidation of four Air Force laboratory facilities (Wright, Phillips, Rome, and Armstrong) and the Air Force Office of Scientific Research under a unified command. The Laboratory is composed of seven technical directorates, one wing, and the Office of Scientific Research. Each technical directorate emphasizes a particular area of research within the AFRL mission. In my talk I will present an overview of AFRL's research activities and highlight activities within the lab that impact human performance.

#### Learning Objectives:

1. To create greater awareness of the Air Force Research Laboratory capabilities.

#### [058] HUMAN EFFECTIVENESS DIRECTORATE OVERVIEW

K. Geiss

*Air Force Research Laboratory, Wright-Patterson AFB, OH*

The Human Effectiveness Directorate (711 HPW/RH) is the research arm for the 711 Human Performance Wing which is a part the Air Force Research Laboratory. 711 HPW/RH vision is to lead the Air Force in Airman-Centered Research. Our mission is to exploit biological and cognitive science and technology to optimize and protect the Airman's capabilities to fly, fight, and win in air, space, and cyberspace. 711HPW/RH is leading the way to deliver what the AF needs in Airman-centered science and technology across the spectrums of Autonomy, Human Augmentation, as well as other strategically aligned with Department of Defense Air Force leadership priorities. 711 HPW/RH have a successful record of technical accomplishments directly supporting the warfighter. In order to optimize human performance, our scientists and engineers are developing human-related technologies with effective interface between humans and systems. 711 HPW/RH is creating revolutionary technologies to augment Airman-Weapon System Teaming which include ways to measure and assess Airman's state.

**Learning Objectives:**

1. To outline the capabilities of the 711HPW Human Effectiveness Directorate.

**[059] THE SHORESH AEROSPACE MEDICINE WORKING GROUP - USAF/USN/USARMY/ISRAELI AIR FORCE - A PROCESS FOR INTERNATIONAL COLLABORATION**

W. Nelson<sup>1</sup> and Y. Erlich<sup>2</sup>

<sup>1</sup>711th Human Performance Wing, Wright-Patterson AFB, OH; <sup>2</sup>Aeromedical Center, Israeli Air Force, Ramat Gan, Tel Hashomer, Israel

Given the ever increasing complexity of aeromedical questions, specialization of expertise and equipment as well as rising cost to execute the research needed to answer these questions, collaboration among aeromedical research centers is increasingly relevant. The Shores Meeting is a biennial meeting of United States and Israeli military medicine subject matter experts to exchange medical research, development, test and evaluation data. Prior meetings focused on areas primarily of interest to ground forces. U.S. and Israeli General Officers leading Shores identified the need to integrate aerospace medicine into the Shores Meeting. Consequently The U.S. Army Medical Research and Materiel Command Commanding General invited the USAF Surgeon General to integrate aeromedical topics within the 2015 Shores Meeting. Subsequently the Shores Aerospace Medicine Working Group was constituted, including members from the USAF 711 Human Performance Wing, .Na.vy Naval Medical Research Unit Dayton, U.S. Army Aeromedical Research Laboratory, and Israeli Air Force Aeromedical Center. This presentation will describe the process used to form the Working Group, identify topics selected for discussion, and discuss the outcome of the inaugural meeting of the Group; including the eleven Action Items for ensuing international collaboration. This process could be emulated to establish further international aeromedical collaborations to leverage expertise, increase data sets, and more economically execute accomplish research.

**Learning Objectives:**

1. The participant will be aware of a process that can be used to implement international aeromedical collaboration to address aeromedical research efforts.
2. The participant will have increased awareness of aeromedical research capabilities contained within the USAF 711 Human Performance Wing, U.S. Navy Medical Research Unit-Dayton, U.S. Army Aeromedical Research Laboratory, and the Israeli Air Force Aeromedical Center.
3. The participant will know the aeromedical research topics that the Shores Aerospace Medicine Working Group is addressing.

**[060] BIOMARKER DETECTION USING SPHERICAL NUCLEIC ACIDS**

C.A. Mirkin

International Institute for Nanotechnology, Northwestern University, Evanston, IL

**INTRODUCTION:** Many biomolecules function as highly specific indicators of important health factors. Current biomarker detection methods lack the necessary specificity to function without high false responses, the simplicity to operate non-invasively in field conditions, and the sensitivity to detect trace concentrations. The rapid identification and quantification of biomolecules in easily accessible human samples would therefore allow one to monitor and quickly diagnose human physiological response to environmental factors, harmful agents, or stress. **METHODS:** Spherical nucleic acids (SNAs) represent a fundamentally new form of nucleic acids that have been successfully used for detection and therapeutics in a wide range of diseases. SNAs are comprised of a functional core material (e.g. metal, semiconductor, protein) surrounded by a shell of densely packed, highly oriented nucleic acids with programmable sequences. These materials readily enter cells without the need for transfection agents, and can thus be used to selectively target and bind to biomarkers or to deliver core materials. **RESULTS:** Two specific platforms have been explored for biomarker detection. The first, termed the nanoflare, consists of a SNA probe with a gold core and nucleic acid "capture" sequences. Detection relies upon the

release of a fluorescent reporter when in the presence of a biomarker target. This has been shown to work in biological fluids, such as whole blood and saliva. The second, termed Scanometric microRNA array profiling, uses the sequence-specific binding properties of SNAs to bind these constructs to precise locations on gene chip arrays. This has allowed for us to identify unique biomarkers associated with a disease or physiological response, and to quantify their concentrations with minimal false negatives. **DISCUSSION:** SNAs can function as the ultimate programmable building block for the high-sensitivity detection of biomarkers in settings pertinent to the field. In this research, many unique biomarkers can be targeted and identified to characterize both immediate physiological response, as well as long-term effects that develop over time through quantification.

**Learning Objectives:**

1. Understand biomarker detection methods utilizing the spherical nucleic acid platform.

**Monday, April 25**  
**Avalon 17**

**10:30 AM**

**S-10: PANEL: MAINTENANCE OF CERTIFICATION: HUMAN FACTORS, EGRESS, AND DISASTER MANAGEMENT**

**Chair: Cheryl Lowry**  
Alexandria, VA

**Chair: Kimberly Toone**  
Alexandria, VA

**[061] MAINTENANCE OF CERTIFICATION: HUMAN FACTORS, EGRESS, AND DISASTER MANAGEMENT**

K. Toone<sup>2,1</sup>

<sup>1</sup>U.S. Navy, Virginia Beach, VA; <sup>2</sup>ASAMS, Alexandria, VA

**PROBLEM STATEMENT:** The American Board of Preventive Medicine (ABPM) has four distinct requirements for maintenance of certification (MOC): **Part 1: Professional Standing** - Diplomates must hold an active, valid and unrestricted medical license in all States, U.S. territories, or Canadian Provinces in which the diplomate is licensed to practice medicine. **Part 2: Lifelong Learning and Self-assessment (LLSA)** - A total of 250 hours of Continuing Medical Education (CME) over the 10-year span of certification is required. **Part 3: Assessment of Cognitive Expertise** - Diplomates holding time-limited certificates will be required to take and pass a cognitive exam. **Part 4: Assessment of Practice Performance** - Diplomates are required to complete two practice performance assessments during their 10 year certification cycle. **TOPIC:** This panel, sponsored by the American Society of Aerospace Medicine Specialists (ASAMS), will address Part 2 of the MOC requirements by providing a lecture series on topics within the core competencies of Aerospace Medicine. This panel will discuss Human Factors, specifically fatigue, circadian rhythm and shiftwork issues, Escape Mechanisms and Egress, as well as Disaster Management and Man-Made Threats. **APPLICATIONS:** As stated by the ABPM, "Aerospace medicine focuses on the clinical care, research, and operational support of the health, safety, and performance of crewmembers and passengers of air and space vehicles, together with the support personnel who assist operation of such vehicles." In order to provide care to such a diverse and complicated population, continuing education is a vital tool that must be addressed throughout the 10 year certification period and not simply relegated to a few weeks prior to the examination. This series is intended to supplement other continuing education procedures and should not be used as "stand alone" course for MOC. **RESOURCES:** Additional information on MOC can be found at <https://www.theabpm.org/moc/requirements.cfm>, <https://www.theabpm.org/public/studyguide.pdf>. Information about ASAMS can be found at <http://www.asma.org/about-asma/constituents/american-society-of-aerospace-medicine-specialists>.

**Learning Objectives:**

1. The objective of this session is to provide information pertinent to maintenance of certification for Aerospace Medicine Specialists.



**Monday, April 25****10:30 AM****Avalon 6****S-11: SLIDE: BODIES AND MOVEMENTS****Chair: Jeb Pickard***San Antonio, TX***Chair: David Salisbury***Ottawa, ON, Canada***[062] THE RELATIONSHIP BETWEEN IN FLIGHT LEANS ILLUSION AND OPTO-KINETIC CERVICAL REFLEX RESPONSES**F. Patterson, H. Williams, R.V. Folga and R. Arnold*Aeromedical, Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH;*

**INTRODUCTION:** In-flight Leans sensations can introduce a significant distraction into what may already be a high workload environment and in rare cases, may provoke a pilot into entering an unintended roll that will induce a false sensation of level flight. During sustained visual meteorological conditions (VMC) banked turns, previous research has demonstrated the Opto-Kinetic Cervical Reflex (OKCR) causes pilot head tilt away from the cockpit vertical (Z) axis, toward the horizon; as opposed to instrument meteorological conditions (IMC) where absence of OKCR stimulus and the need to use head down displays results in pilot head alignment with the cockpit vertical (Z) axis.

**METHODS:** In a non-motion based simulator, 26 experienced pilots completed a series of simulated solo and formation flight scenarios that involved 30 sec cycling between VMC and IMC. During VMC, OKCR was expected to cause head alignment toward the outside horizon. In contrast, removal of the outside horizon cue during IMC was expected to cause realignment of the head with the cockpit vertical axis. Head and eye tracking data were recorded, and participants verbally rated any Leans sensations, 15 sec into each 30 sec VMC and IMC cycle. **RESULTS:** With formation flight trials, 22 of the 26 subjects (85%) reported Leans sensations ranging from very slight to very strong during VMC and IMC transitions. Subjects experience very little (16%) Leans sensations during the VMC periods; however, during IMC, subjects reported a high incidence (33%) of moderate to very strong Leans. Solo flight trials produced a Leans Illusion affect similar to the formation trials; although the magnitude of the effect appeared to be attenuated. For both formation and solo trials, head tracking data indicated a significant ( $p < 0.01$ ) positive relationship between OKCR head tilt response and reported incidences of the Leans. **CONCLUSION:** In a non-motion based simulator, alternating VMC and IMC conditions result in OKCR head tilt cycling that appears to increase the frequency and severity of Leans illusion.

**Learning Objectives:**

1. Participants will appreciate the ability to elicit the opto-kinetic cervical reflex response during non-motion simulated flight and the relationship between the reflexive head tilt response and the leans illusion in subjects.

**[063] SPATIAL DISORIENTATION COUNTERMEASURES DEVELOPMENT ACROSS SIMULATED ENVIRONMENT PLATFORMS**D. Huber, F. Patterson, H. Williams and R.V. Folga*Aeromedical, Naval Medical Research Unit Dayton, Dayton, OH*

**MOTIVATION:** A continuing challenge for aerospace medicine is to develop valid training systems that address aviation hazards in virtual environments and flight simulations. Ground-based training technology continues to improve the quality and diversity of flight environments, while continually decreasing equipment footprint. However, there remains a critical capability gap in how these improvements can be utilized to facilitate enhanced Spatial Disorientation (SD) training. Of particular interest to the Navy Aviation Enterprise are versatile, passive training systems that address SD while also accurately depicting the night environment in which it most often occurs. **OVERVIEW:** The continuing cost of SD in terms of both lives and assets demands a continuing effort

to improve man and machine. Improved sensors and interfaces play an important role in reducing the risk of spatial disorientation, but aviators continue to rely on training techniques to alleviate the human factor. Research and development currently conducted at the Naval Medical Research Unit Dayton (NAMRU-D) is designed to improve this training in three ways. First, NAMRU-D is partnering with Naval Air Systems Command to develop reconfigurable simulation systems in order to induce and study the effect of SD within ground-based simulators with different displays. This will help understand the limitations of current non-motion simulations and provide potential data for implementation into next generation training devices. Second, the system has the capability of incorporating Night Vision Devices (NVDs) and stimulating illusions common to aviators at night, when a significant number of SD events occur. Third, the data gleaned from this research will be adapted into courseware, with the caveat that the visual display of information can be streamlined across a wide spectrum of displays, to include virtual reality visors, simulators and flat screen monitors for classroom presentation. **SIGNIFICANCE:** We intend to provide details on the display systems, data and environmental features needed to stimulate SD in various environments that warfighters will find themselves facing. The long range goal of these projects is to develop specific SD countermeasure training superior to existing efforts in efficacy, efficiency and digital interoperability.

**Learning Objectives:**

1. The learner will understand the aeromedical applications of flight simulation for research and advanced spatial disorientation training.

**[064] SIMULATOR SICKNESS IN AIRFOX® DISORIENTATION SIMULATOR**P. Renjhen*Medical, Indian Air Force, Delhi, India*

A simulator is defined as a machine with a similar set of controls designed to provide a realistic imitation of the operation of a vehicle, aircraft, or other systems. The use of flight simulator for training aircrew (both military and commercial) has increased since World War II. Aircrew training involves use of sophisticated ground-based flight simulators. The simulators enable experience of a broad range of flight conditions and emergency procedures without jeopardizing flight safety. However, as the use of flight simulators has consistently increased over the years, a phenomenon known as simulator sickness (a subset of a larger entity of motion sickness syndrome) upon simulator exposure (SE) has come to light. It is also known as visually-induced motion sickness (MS). This Simulator Sickness (SS) has been largely considered to be a persistent limiting factor in continuing flying training. Simulator sickness (SS) is classically characterized by nausea, dizziness, postural instability, fatigue and general malaise. On cessation of simulator exposure, few symptoms may persist up to several hours; these symptoms are called after-effects. These after-effects may have adverse impact on post-simulator training activities. AirFox® DISO, a disorientation simulator, is widely used in Indian Air Force to train aircrew of all streams (fighters, transport and helicopters) on spatial disorientation. Currently, no data is available in respect of the incidence of simulator sickness on AirFox® DISO and also on incidence of simulator sickness in Indian aircrew. The paper presents a study carried out to determine the incidence of simulator sickness in Indian aircrew after a simulator exposure using the AirFox® DISO using a Simulator Sickness Questionnaire (SSQ). The study also highlights the different symptoms experienced by aircrew post simulator exposure.

**Learning Objectives:**

1. The paper presents the effects of simulator exposure in terms of simulator sickness.
2. The paper highlights the different symptoms experienced by aircrew post simulator exposure.

**[065] ASSESSMENT OF SIMULATED BLOOD POOLING IN FOREARM OF AN AIRCRAFT PILOT**B.B. Sharma<sup>1</sup>, M. Khan<sup>1</sup> and S. Vashisth<sup>2</sup><sup>1</sup>*Electrical Engineering, Jamia Millia Islamia, New Delhi, India;*<sup>2</sup>*Electronics and Communication Engineering, ITM University, Gurgaon, India*

**INTRODUCTION:** Gravity-induced loss of consciousness (G-LOC) is due to reduced blood flow to the nervous system because of blood pooling in the body of the aircraft pilot. A number of studies reveal that blood pooling induces arm pain especially when Extended Coverage Anti Gravity (G) Suit is worn along with positive pressure breathing. Onset of arm pain terminates high G centrifuge test runs and reduces aircraft pilot's ability to function effectively during high G maneuvers. **METHODS:** Physiologically blood pooling has been induced in the forearm by placing a blood pressure cuff around the upper arm of human volunteers. When the cuff was inflated to pressures beyond venous pressure but below arterial pressure, blood pooling in the lower arm below the cuff was recorded. Electrical Impedance Plethysmography (EIP) with tetra polar electrode system was used to drive a constant current of 3mA at 20 KHz into forearm. The electrical impedance changes from base value were observed on digital display of Impedance Plethysmograph. Two aluminum foil current electrodes ( $I_1$ ,  $I_2$ ) and two aluminum foil voltage electrodes ( $E_1$ ,  $E_2$ ) were made and placed on the wrist and above elbow joint respectively. The EIP was then connected to the electrodes via connecting leads. The electrical impedance of the forearm was then recorded without inflation and with inflations of cuff. Blood pooling was calculated from base and lowered values of forearm electrical impedance. Blood pooling assessed by EIP was compared by oil filled Plethysmograph (OFP). For OFP measurements, capillary fitted on the plastic container directly indicated blood pooling of forearm. **RESULTS:** Various graphs are plotted for five sets of experimental data of blood pooling assessed by EIP and OFP techniques for applied pressures from 0 to 100 mm Hg. Maximum blood pooling found as approximately 10 ml in the forearm corresponding to maximum cuff pressure of 100 mmHg. Both EIP and OFP techniques resulted correlation factor of 0.99. Results obtained for assessment of blood pooling in the forearm clearly establishes that the EIP provides assessment of blood pooling noninvasively with no discomfort to the body. **CONCLUSION:** The correlation curve may be useful to design and develop a biofeedback controller for anti G-suit of aircraft pilot during high G maneuvers.

**Learning Objectives:**

1. Assessment of blood pooling could be used to study arm pain of aircraft pilot during high G maneuvers.

**[066] USING WAIST-TO-HEIGHT RATIO AS THE METRIC FOR BODY FAT ASSESSMENT IN THE U.S. ARMY**

M. Lo and S.A. Bernstein

Laulima Government Solutions LLC, Enterprise, AL

**BACKGROUND:** Army Regulation (AR) 600-9 defines weight-for-height and body fat standards to maintain physical readiness and optimize performance, establishing by gender and age the maximum allowable weight for a given height and the maximum allowable percentage body fat. Soldiers exceeding the weight standard undergo body fat assessment using circumference-based tape measurements of the neck, waist, and hip (females only). This assessment process is both time- and labor-intensive. To simplify this process, proposed is using waist circumference and height as the only metrics to calculate the waist-to-height ratio as the metric for body fat assessment with 55% as the standard for all. **METHODS:** During combat deployment, 42 Soldiers (34 male, 8 female; age range, 20–38) failing their pre-deployment body fat assessments were followed by battalion medical staff for weight and body fat loss. Each Soldier was evaluated with a full history and physical; lab assessment; and anthropometric measurements. Physician-based counseling and management was provided monthly for the first three months and then quarterly until the end of deployment with focus on proper intake and trimming appropriately. During each visit, measurements and vitals were recorded. **RESULTS:** Prior to deployment, mean body mass index (BMI) was 33.9 (moderately obese) for the 34 males (3 overweight, 17 mildly obese, 12 moderately obese, 2 morbidly obese). Mean BMI was 30.5 (mildly obese) for the 8 females (4 overweight, 4 mildly obese). By the end, 28 (68 percent) of the 41 Soldiers met AR 600-9 standards, although none had a normal BMI. Mean BMI at the end of deployment was 32.0 (mildly obese) for males and 28.1 (overweight) for females. All Soldiers had a waist circumference of over 55 percent of their height at the start, and all who had a waist-to-height ratio below 55% met AR 600-9 taping assessment standards and presented a professional military appearance. **CONCLUSION:** Waist circumference is a key

component of body-fat taping assessment. Attaining a waist circumference of less than one half's height plus 10 percent (55 percent) serves as a simpler marker for meeting AR 600-9 standards and achieving a professional military appearance, a secondary objective of these standards. Measuring one's waist-to-height ratio to monitor weight and body-fat loss is easier for clinicians to explain, patients to understand and track, and promotes health and wellness, and for unit leaders to monitor and enforce.

**Learning Objectives:**

1. Identify two factors for successful weight control in a deployed setting (answer: medical-based counseling and personal management).
2. Identify two anthropometric measures, the ratio of which serves as a valid metric for body fat assessment (answer: waist circumference and height).
3. Identify the threshold waist-to-height ratio below which Army body fat standards are met (answer: waist circumference of less than half one's height plus 10 percent, or 55 percent).

**Monday, April 25**  
**Avalon 1-3**

**2:00 PM**

**S-12: SLIDE: ACCIDENT INVESTIGATION/INJURY ANALYSIS**

**Chair: Douglas Boyd**  
Houston, TX

**Chair: Eduard Ricaurte**  
Edmond, OK

**[067] MIDAIR COLLISIONS IN ALASKA, 1983 - 2014**

K.M. Moller<sup>2</sup> and M.B. O'Connor<sup>1</sup>

<sup>1</sup>National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Anchorage, AK; <sup>2</sup>Tulane University, New Orleans, LA

**INTRODUCTION:** During 2011, there were three midair collisions in Alaska, resulting in five fatalities. Increasing popularity of mobile handheld computing devices, avionics, and other technologies led pilots to believe that midair collisions were occurring more frequently than in previous years due to inexperienced pilots using these devices while flying. The purpose of this study was to analyze findings from reports of midair collisions and determine trends and areas for focused education efforts. **METHODS:** Reports from the National Transportation Safety Board database were searched for midair collisions in Alaska during 1983-2014. The database was searched using key words "midair", "mid air", "mid-air", "collided", and "collision". Reports were then analyzed for pilot and flight data, factors and causes. **RESULTS:** There were 29 midair collisions over this time period, resulting in 47 deaths; 17 (59%) of the collisions involved at least one fatality. Of the 58 aircraft involved, 40 were operating under FAR Part 91, 14 were under Part 135, and four were Part 135 carriers operating under Part 91. Analysis using Poisson regression showed a 73% decrease in the rate of midair collisions per active aircraft in Alaska over this time period. All collisions occurred during visual meteorological conditions. The median number of hours for pilots was 3285 hours; 22 (38%) of the pilots had commercial certificates, 18 (31%) had private pilot certificates, 16 (28%) held airline transport pilot certificates and two (3%) were student pilots. The most commonly cited cause of the midair collisions was the failure of one or both pilots to properly perform visual lookout procedures. **DISCUSSION:** Although there was a decrease in the rate of midair collisions, results suggest that see and avoid techniques could be used more effectively to minimize midair collisions. Procedures to improve visual lookout procedures should be emphasized during student training, flight reviews, check rides, and recurrent training. In addition, appropriate communications, traffic collision avoidance systems, and other avionics systems may be useful in avoiding midair collisions.

**Learning Objectives:**

1. Describe the characteristics of pilots and flights involved in midair collisions in Alaska.

### [068] A COMPARISON OF PERSONAL FLYING ACCIDENT RATES BETWEEN SELECTED LIGHT SPORT AIRCRAFT AND GENERAL AVIATION AIRCRAFT

W.D. Mills and C.A. DeJohn

Medical Research Division, FAA Civil Aerospace Medical Institute, Oklahoma City, OK

**BACKGROUND:** The safety impact of expanding flight privileges that do not require medical oversight is currently an important topic, especially in the U.S. Accident rates per 100,000 flight hours for sport pilots are a desirable measure of safety but are unavailable. We compared personal flying accident rates in aircraft with Special Light Sport Aircraft (SLSA) and Experimental Light Sport Aircraft (ELSA) airworthiness certificates to accident rates for personal flying in other general aviation (GA) aircraft. **METHODS:** To calculate accident rates, personal flying hours were obtained from the annual FAA "General Aviation and Part 135 Activity Surveys." Numbers of personal flying accidents were obtained from the National Transportation Safety Board's accident database. Overall and fatal personal flying accident rates for the SLSA and ELSA groups and other GA aircraft were calculated and accident rates were compared. **RESULTS:** The overall personal flying accident rate for SLSA and ELSA was found to be 29.8 per 100,000 flight hours and the fatal accident rate was 5.2 per 100,000 flying hours. These are both significantly greater than the overall personal flying rate of 12.7 per 100,000 hours and fatal rate of 2.6 per 100,000 hours for other GA aircraft. **DISCUSSION:** Although this study has several limitations which will be discussed, the significantly higher accident rates in the sport pilot aircraft suggests caution when expanding sport pilot privileges to include larger more complex aircraft. Other approaches and challenges regarding calculation of accident rates for specific pilot groups will be discussed.

#### Learning Objectives:

1. To appreciate the challenges of comparing accident risk in specific pilot groups of interest with currently available U.S. data.
2. To learn of information that is needed to enable calculation of pilot specific accident rates in the future.

### [069] CHARACTERISTICS OF PILOTS WHO ATTEMPTED OR COMMITTED SUICIDE AND HOMICIDE WHILE OPERATING AN AIRCRAFT, 1991-2015

E.M. Ricaurte, C.A. DeJohn, W.D. Mills and J. Larcher

Medical Research Division, FAA Civil Aerospace Medical Institute, Oklahoma City, OK

**INTRODUCTION:** On March 24<sup>th</sup> 2015, Germanwings flight 9525 with 150 people onboard, crashed into the French Alps. The preliminary investigation concluded that the co-pilot intentionally crashed the aircraft. Aeromedical aspects of the flight crew, including a better understanding of the psychiatric, psychological and behavioral issues which could lead pilots to commit suicide and take the lives of the aircraft's occupants, are currently under scrutiny by regulatory agencies and stakeholders. The purpose of this study was to compare characteristics of U.S. suicidal pilots who take the lives of others when committing suicide (suicidal/homicidal) with those who do not (suicidal). **METHODS:** Cases were selected from the FAA Incapacitation registry where medical incapacitations were determined to be caused or related to mental disorders during the period 1991-2015. Pilots' aeromedical history and accident information were obtained from the FAA medical database, the Document Imaging Workflow System (DIWS), and the National Transportation Safety Board (NTSB) accident database respectively. For comparison purposes, cases were divided in two groups: suicidal only and suicidal/homicidal pilots respectively. **RESULTS:** Out of 29 cases, six suicide cases (21%) involved the death or serious injuries of 22 innocent victims (suicidal/homicidal). In two out of the six suicidal/homicidal events, three occupants died; one person on the ground died and 13 people sustained injuries, two of which were serious. Half suicidal/homicidal pilots showed abnormal behavior and left a suicide "note." Toxicological findings revealed higher use of alcohol and antidepressants in the group of suicidal as compared to suicidal/homicidal pilots. No

prescribed psychotropic medications were found in the suicidal/homicidal pilots and one pre-existing psychiatric condition was reported as compared to over half in the suicidal group. **DISCUSSION:** Pilots' mental health care programs may help to reduce the use of drugs and alcohol as well as domestic and legal problems in suicidal/homicidal pilots.

#### Learning Objectives:

1. To understand the prevalence of pre-existing mental conditions - such as depression, bipolar disorder and psychotic episodes in pilots who Attempted or Committed Suicide and Homicide while Operating an Aircraft.
2. To understand the proportion of suicidal pilots with a history of alcohol/substance dependence/illicit drugs.
3. To learn the prevalence of prescribed psychotropic medications in pilots who Attempted or Committed Suicide and Homicide while Operating an Aircraft.

### [070] AIRCRAFT ACCIDENT INVESTIGATION IN GENERAL AVIATION: MORPHOLOGICAL EVIDENCE OF THE PILOT'S VITALITY AT THE MOMENT OF IMPACT

M.J. Schwerer<sup>1,2</sup> and M. Graw<sup>2</sup>

<sup>1</sup>German Air Force Center for Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>2</sup>Forensic Medicine, Ludwig-Maximilians-University, Munich, Germany

**INTRODUCTION:** Aircraft accidents in general aviation rely on human factors in a significant proportion. The question of vitality of the responsible pilot must be answered unquestionably when investigating these mishaps. **METHODS:** The victims of 23 accidents, among them 24 pilots and 14 passengers were assessed. The autopsy reports were evaluated for the following criteria: Inspiration of soot or blood to the lungs, subendocardial bleeding in the left ventricle, and rupture of the aorta with bleeding in surrounding tissues. Evaluation was carried out after anonymization of the victims in accordance with the faculty's ethical requirements. **RESULTS:** In 4 accidents the aircraft caught fire after impact. Six of 7 victims from these events showed an inhalation of soot to the lungs as a sign of vitality when the fire started. Inhalation of blood to the lungs was seen in 14 of 20 pilots and in 8 of 11 passengers in accidents without fire. Among the burnt victims only 2 bodies showed an inhalation of blood. Subendocardial bleeding was present in 8 pilots and 6 passengers in accidents without fire and in none of the burnt victims. A rupture of the aorta was found in 13 pilots and 9 passengers, all of them from events without fire. Overall, confirmation of vitality in unburnt victims involved one of these criteria in 7 pilots and 1 passenger, a combination of two of these criteria in 8 pilots and 5 passengers, and the presence of all these criteria in 4 pilots and 4 passengers. In 2 victims none of these criteria was observed. Further assessment of these bodies showed hemorrhage around rib and spine fractures. **DISCUSSION:** Demonstration of the vitality of a pilot at the time of an aircraft accident without fire can be established from several criteria including the inhalation of blood to the lungs, subendocardial bleeding, the rupture of the aorta, or a combination of these. In burnt bodies, soot in the distant airways is frequently the only available sign of vitality at the moment of impact. In exceptional cases, vitality of a victim at time of the accident can only be discussed on the basis of less significant signs of unimpaired circulation such as hemorrhage around rib and spine fractures. However, these can also result from blunt force on the dead body. Additional evidence for the vitality of a pilot in such cases might be obtained from histological or molecular biological assessment of fat or bone marrow embolism to the lung vessels.

#### Learning Objectives:

1. Knowing signs of blunt trauma which indicate that a pilot was alive at the time of an aircraft crash.
2. Knowing that hematomas e.g. in the soft tissues of the arms and legs are no evidence of vitality of a pilot at the time of impact.
3. Knowing that the inhalation of soot to the lungs is frequently the only proof of vitality in a severely burnt body.

### [071] RECENT TRENDS IN U.S. ARMY HELICOPTER CRASH INJURY PATTERNS, 2012-2014

J. Crowley<sup>1</sup>, J. Bishop<sup>2</sup>, S. Bernstein<sup>2</sup>, D. Wise<sup>2</sup> and S. Van Horn<sup>1</sup>

<sup>1</sup>U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL;

<sup>2</sup>USAARL-SAD, Laulima Government Solutions LLC, Fort Rucker, AL

**INTRODUCTION:** Helicopter aircrew involved in crash impacts depend on aircraft crashworthy design features and effective aviation life support equipment (ALSE) for their survival. Military helicopter aircrews also require protection from combat-related injury, which may occur during flight or during subsequent egress, escape, or evasion. The purpose of this study was to review the patterns of injury in recent U.S. Army helicopter crashes to help determine the adequacy of injury-preventing ALSE and aircraft design features in the current helicopter fleet.

**METHODS:** The U.S. Army Combat Readiness Center accident database was queried for Class A helicopter accidents occurring 2012-2014. Data were extracted regarding kinematics, injury patterns, helmet and seat performance, and egress/post-crash factors. **RESULTS:** There were 40 aircraft involved in Class A accidents during the study period. Forty-nine of the 63 occupants sustained 108 recorded injuries; 20 of these occupants were fatally injured. The most frequently injured body region was the head (31%), followed by lower extremities (17%), back (14%), upper extremities (11%) and "body in general" (11%). Restricting the analysis to survivable events with complete investigations yielded a series of 24 Class A accidents, in which 24 occupants were injured and five were killed. Correlations of injury patterns with survival equipment performance and kinematics were documented. **DISCUSSION:** Despite successful performance of modern flight helmets, the head and brain remains the most frequently-injured body region. Equipment damage confirms that serious head and back injuries would be much more common if helmets and energy-attenuating seats were not employed. In two accidents, post-crash fire caused injury and could have affected post-crash egress. One of these was a non-survivable accident, and in the other, only first degree burns resulted. These events point out the continuing need for fire protective clothing, despite the success of crashworthy fuel systems in reducing fire-related injury. The relevance of helicopter crash injury data to the design of military helicopters and ALSE will be discussed.

**Learning Objectives:**

1. Review the patterns of injury in recent U.S. Army helicopter crashes to help determine the adequacy of injury-preventing ALSE and aircraft design features in the current helicopter fleet.
2. Discuss the performance of aviation life support equipment and their role in reducing injury.
3. Describe and discuss the body regions at risk in helicopter crashes and how ALSE and aircraft design features are necessary to reduce injury.

**[072] SPORT PILOT INJURIES ASSOCIATED WITH POWERED PARACHUTES: A CROSS-SECTIONAL ANALYSIS**

N.W. Skelley<sup>1,2</sup>

<sup>1</sup>Orthopaedic Surgery, Washington University, St. Louis, MO; <sup>2</sup>Orthopaedic Surgery, Massachusetts General Hospital, Boston, MA

**INTRODUCTION:** Powered parachutes have become one of the most popular forms of flying. This is largely due to their low level of regulation and significantly lower cost compared to other aircraft. No previous study has reviewed the mechanisms and characteristics of injuries sustained in this sport. The purpose of this study was to describe the mechanism of injury and injuries associated with powered parachute flying. **METHODS:** This study was a retrospective cross-sectional analysis of sport pilot injuries associated with powered parachutes. National Transportation and Safety Board incident reports between 2004-2015 involving powered parachutes were reviewed. Using report data, internet searches were performed to find further information related to the incident by contacting involved pilots. **RESULTS:** There were 71 reports filed between 2004-2015 involving 116 people. The reports included 10 incidents that resulted in 14 fatalities (12%). The average pilot age was 52 and 98% of pilots were male. Pilot error was the most common explanation for an incident and the most common pilot error was misjudging the necessary distance required for take-off and landing. This accounted for 37 of the 71 incidents (52.1%). Orthopaedic injuries involving the lower extremities were the most common severe injuries reported. Over 40% of injuries required surgery with approximately half involving fractures. No correlation was found between pilot experience and the likelihood of sustaining an injury. **DISCUSSION:** To the author's knowledge, this is the first cross-sectional analysis of injuries associated with powered parachutes. Powered parachute pilots sustain unique injuries associated

with the sport compared to other forms of flight. Reviewing the mechanism of injury demonstrates that pilot error is the most common cause for injury. These results provide evidence for design changes in the aircraft and support the need for proper pilot training to avoid future injuries. This information will help improve aircraft design and pilot awareness to improve the safety and well-being of participants in this sport. Furthermore, the information will help physicians council and care for patients participating in this sport.

**Learning Objectives:**

1. Understand the mechanisms of injury associated with powered parachute flying.
2. Understand the most common severe injuries associated with powered parachute flying.

**Monday, April 25**

**Avalon 7-9**

**2:00 PM**

**S-13: SLIDE: AVIATION VISION**

**Chair: Harriet Lester**

*New York, NY*

**Chair: Warren Silberman**

*Oklahoma City, OK*

**[073] DEVELOPMENT OF A NEW DIGITAL AUTOMATED VISION TESTER (AVT)**

S.C. Hadley

*Ophthalmology, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH*

**PROBLEM STATEMENT:** Current military vision standards and test apparatus were established by the Armed Forces National Research Council on Vision Committee in the 1940s and 1950s. The testing equipment consisting of glass slides and near/far optics in a box has not been updated in 65 years. The military testing equipment (OVT 2300) only tests three major vision functions (visual acuity, ocular alignment, and stereovision) and must be augmented by numerous other vision testing equipment to select aircrew or ensure the applicant meets occupation vision standards. The OVT is not a reliable test due for the following reasons: 1) a low number of data points are sampled, resulting in poor test-retest reliability; 2) the product manual and answer key are available online and can be memorized; 3) all testing equipment including military versions can be purchased by anyone online; and 4) there is potential for administrator error in transcription and bias. **TOPIC:** USAFSAM OBVA development of digital automated vision tester (AVT) equipment that is capable of administering all Department of Defense vision tests will be discussed. The AVT may assist in future development of a single set of accepted aircrew vision standards across the Department of Defense. **APPLICATIONS:** The digital AVT equipment will be applicable to all military and civilian vision testing organizations to include all military services, the Federal Aviation Administration Aviation Medical Examiner, and state occupational/driver's license organizations to accurately and reliably exam the visual performance and abilities of all applicants to ensure they meet applicable standards. **RESOURCES:** Barbur J. Minimum colour vision requirements for professional flight crew: recommendations for new colour vision standards. West Sussex (UK): Civil Aviation Authority; 2009. CAA Paper 2009/04.

**Learning Objectives:**

1. Describe the reliability problems with the current equipment used for testing occupational visual standards.
2. Discuss the advantages of an automated visual tester (AVT) over current manual testing equipment.
3. Describe the engineering challenges of producing an automated visual tester (AVT).

**[074] OPERATIONAL BASED VISION ASSESSMENT: VISUAL MOTION SENSITIVITY AND OPERATIONAL PERFORMANCE**

J.P. Gaska<sup>1</sup>, M. Winterbottom<sup>1</sup>, R. Gray<sup>2</sup> and S. Hadley<sup>1</sup>

<sup>1</sup>USAFSAM/FHO, Wright-Patterson AFB, OH; <sup>2</sup>Arizona State University Polytechnic, Mesa, AZ

**INTRODUCTION:** Visual motion analysis provides mission-critical information including detecting and tracking friend / foe aircraft, navigation through the environment and constructing a 3-dimensional world from 2-dimensional retinal images. This research is aimed at providing estimates of the distribution of motion sensitivity in the normal population and determining if an individual's motion sensitivity is correlated with their operational performance. **METHODS:** A monitor-based test of coherent motion sensitivity was developed in the OBVA lab and distributed to our research partners to establish normative data. Additionally, the OBVA lab examined whether test scores are related to operational performance. **RESULTS:** Normative data from approximately 200 human subjects demonstrates that there is greater than a 4 to 1 range in motion sensitivity. There was a significant correlation between motion sensitivity and performance in a simulated KC-46 refueling task and an emergency braking driving simulation task. Importantly, there was little to no correlation between motion sensitivity and visual acuity. **DISCUSSION:** The research shows that there is a relatively large range of motion sensitivity in normal adults that is most likely not measured in the current battery of standards tests. The finding that an individual's sensitivity is predictive of operational performance suggests that measuring an individual's motion sensitivity may prove useful in ensuring that the visual capabilities of air crew meet or exceed those required for mission success. This research contributes to the identification of a set of non-redundant, quickly administered, automated vision tests that fully characterize the visual capability of individual aircrew most relevant to operational performance.

**Learning Objectives:**

1. To better understand the relationship between motion sensitivity and operational performance.

**[075] OPERATIONAL BASED VISION ASSESSMENT: DEPTH PERCEPTION IN ROTARY WING CALL-TO-LANDING TASK**

M. Winterbottom<sup>2</sup>, J.P. Gaska<sup>1</sup>, L. Williams<sup>2</sup>, C. Lloyd<sup>3</sup>, E. Shoda<sup>2</sup> and S. Hadley<sup>2</sup>

<sup>1</sup>FECO, 711/HPW/USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>2</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>3</sup>Visual Performance, LLC, Ellisville, MO

**INTRODUCTION:** The U.S. Air Force and U.S. Navy maintain a depth perception standard for non-pilot aircrew, such as flight engineers and tail gunners, while most other services do not. For the Air Force, more stringent Flying Class III (FCIII) with scanner duty vision screening standards were motivated in part by an accident in 1998 where two HH-60G aircraft collided in mid-air and poor depth perception of two FCIII aircrew was identified as a contributing factor. Because additional screening and tracking of aircrew granted waivers are costly, labor intensive, and time consuming, a research effort was launched to quantify the importance of depth perception for FCIII aircrew for critical operational tasks such as rotary wing call-to-landing. **METHODS:** X-Plane, an SA Photonics SA-55 head-mounted display, and a NaturalPoint OptiTrack head-tracking system were used to generate an immersive, stereoscopic simulation of a rotary wing landing scenario. In the experiment reported here, participants were asked to identify when the tail wheel of the simulated MH-60 aircraft was closest in depth to a landing zone obstacle (in this case a windsock pole). Height above the obstacle was varied between 10 cm and 200 cm. Visibility (contrast) was also varied. The effect of stereo display (stereo on/off) was also examined. Finally, the relationship between ocular health (stereo acuity, contrast sensitivity, motion perception) and operational performance was also examined. **RESULTS:** Preliminary data show that without stereo, depth accuracy was limited to 178 cm at the greatest height and 141 cm for the smallest height above the obstacle. With stereo, depth accuracy improved to 100 and 32 cm, respectively (i.e., approximately 2x to 4.5x improvement with stereo). Based on the vision test results, better stereo acuity and motion perception were both related to improved depth estimation performance. **DISCUSSION:** The relationship between visual performance metrics and operationally relevant call-to-landing task performance is reported in detail. Future research plans concerning FCIII depth perception standards are also described.

**Learning Objectives:**

1. Describe current USAF depth perception standards for FCIII aircrew with scanner duty.
2. Describe methods of testing depth perception and ocular alignment.
3. Introduce evaluation of how well current vision standards actually predict performance on operationally-relevant flight tasks.

**[076] NIGHT VISION GOGGLE PERFORMANCE EVALUATED AS VISUAL ACUITY**

H. Goto

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**INTRODUCTION:** Night vision aids have been widely used in aviation, however, the discrepancy of viewing images of day or mesopic vision with natural human eyes and displayed vision through night vision aids can cause visual conflicts and may cause mishaps. So it is critical for aviators to understand the basics of night vision aid and possible pitfalls. The specifications of night vision devices stated by the manufactures or researchers as spectral performance curve may not be well accepted by everyone. The aim of this study was to facilitate the instruction for the aviators on the night vision goggle performance by using metrics in visual acuity testing. **METHODS:** CSV-1000 ETDRS (Early Treatment of Diabetic Retinopathy Study) contrast sensitivity chart was used in this study to measure Visual acuity in logMAR. Subjects were seven eyes of 7 healthy young active duty service members in Japan Ground Self Defense Force who do not have any ocular diseases except refractive errors. Day vision with habitual correction, night vision with and without night vision goggle under red LED (620nm) and green LED (520nm) illumination conditions were measured. (Day: 1500lux, Night 0.7cd/m<sup>2</sup>). **RESULTS:** In the night condition, the visual acuity in logMAR was not significantly different under both red and green LED illuminations (0.47±0.10 / 0.53±0.10). The night vision aid enhanced the visual acuity under red LED (0.27±0.10), while the green LED condition significantly decreased visual acuity in logMAR (0.82±0.14)(p<0.01). This result could be imposed to the curve of the 3rd generation night vision goggle spectral performance curve in wavelength and light sensitivity. **DISCUSSION:** This result explains the theoretical features of the 3rd generation night vision goggle spectral performance as the changes of visual acuity, which is familiar to general population. For service members who may not have strong scientific background, the night vision specification described as visual acuity that are familiar to them can be more intuitive on the performance and possible pitfalls of night vision devices.

**Learning Objectives:**

1. Understand the basics of night vision goggles.
2. Select appropriate wavelength of lights for night vision aids under various night operational settings.

**[077] ACUTE SEQUENTIAL MONOCULAR VISUAL FIELD LOSS IN A STUDENT PILOT: A CASE REPORT**

H. Lester<sup>1</sup> and C. Salicrup<sup>2</sup>

<sup>1</sup>Regional Flight Surgeon Eastern Region, FAA, Jamaica, NY; <sup>2</sup>Flight Surgeon-Pilot, IFALPA, Mexico City, Mexico

**PROBLEM STATEMENT:** Civil student pilot applicant with sequential monocular visual loss. Background/Literature Review: It is important to consider visual field as well as nuances of visual acuity and perception. Standard of care medical testing is not the same as functional testing. When central visual acuity is preserved, but visual field is lost, it is necessary to make a functional determination of whether the aviator is safe to fly. Challenges here include: not typical "monocular"; no flying experience; congenital strabismus, and risk in good eye due to NAION (non-arteritic ischemic optic neuropathy). **CASE PRESENTATION:** A 47-yr-old Australian engineer, whose work brought him to USA and Mexico, acutely lost left eye superior right quadrant visual field in March 2015. USA specialist noted left disc edema, workup and history were negative other than 4 congenital strabismus surgeries. 4 days later, Mexican neuro-ophthalmologist started high dose steroids, followed by aspirin. Several weeks later, he acutely lost inferior right quadrant field in the same eye, emergently treated with 5 days hyperbaric oxygen and anti-coagulation. Findings

included crowded "discs at risk," left disc edema, slight right eye abduction limitation from strabismus surgeries. Second opinion in Texas reached same conclusions. Inferior field loss and color vision improved. Considered for genetic testing and therapy. October 2015, FAA Aviation Medical Examiner exam, Class 3 Student Pilot Medical Certificate. Acuity 20/20 right eye, 20/30 left eye with nerve pallor and abnormal field. He wants to fly. **OPERATIONAL/CLINICAL RELEVANCE:** This case highlights some civil aviation regulatory challenges in evaluating a student pilot applicant with vision abnormalities and some risk of progression. NAION caused devastating monocular sequential visual field loss which, fortunately, improved somewhat following aggressive treatment. Multiple elements need to be assessed, and safeguards applied, to minimize risk to the pilot and the safety of the national air space. This pilot is highly attentive to detail, and very cooperative, which makes the situation more manageable from a safety perspective.

#### Learning Objectives:

1. Recognize basic challenges of assessing visual function for the aviator.
2. Learn fundamental clinical features of non-arteritic ischemic optic neuropathy (NAION).
3. Identify some regulatory approaches that mitigate risk in the context of NAION.

### [078] TREATMENT AND MONITORING OF CENTRAL SEROUS CHORIORETINOPATHY IN AVIATORS

A. Shinojima, R. Mori, K. Fujita and M. Yuzawa

Ophthalmology, Nihon University School of Medicine, Tokyo, Japan

**PROBLEM STATEMENT:** Faster visual recovery and prevention of recurrent or prolonged visual impairment due to Central Serous Chorioretinopathy (CSC) in aviators. **BACKGROUND / LITERATURE REVIEW:** Central Serous Chorioretinopathy (CSC), which has the characteristics of a serous retinal detachment (SRD) in the macular area, affects mostly males in the 30-50 age group. The symptoms of CSC are gradual vision loss and/or metamorphopsia. SRD remission reportedly occurs in approximately 30% of CSC cases within 6 months, though nearly 70% of patients with CSC suffer symptoms. Symptoms of CSC are a concern for some active aviators as they can result in flight status disqualification, often for months. Recurrence is also a possibility. Furthermore, some patients have persistent SRD, which may cause retinal thinning and subretinal neovascularization followed by age-related macular degeneration. Thus, the treatment and observation of CSC are both critical for maintaining aviation eligibility, especially in chronic or recurrent cases. The Federal Aviation Administration requires minimal visual acuity over 20/20 as distance vision for aviators. Multimodal imaging allows early detection of CSC. Moreover, half-dose verteporfin photodynamic therapy (PDT) is a remedy for CSC when applied in the early stage. **CASE PRESENTATION:** Four CSC cases, all Japanese commercial airline pilots, will be presented. Half-dose verteporfin PDT was performed on these patients. Spectral domain optical coherence tomography (SD-OCT) images, the findings obtained with other newly-developed retinal imaging devices and best corrected visual acuity were also analyzed. **OPERATIONAL / CLINICAL RELEVANCE:** Half-dose verteporfin PDT can rapidly reduce serous subretinal fluid in CSC eyes. Recurrent and/or chronic CSC is, however, seen in clinical cases. Therefore, continuous observation by SD-OCT after half-dose PDT is necessary, even if the patient's vision shows recovery. Early treatment, i.e. before visual acuity decreases, is recommended.

#### Learning Objectives:

1. For aviators with central serous chorioretinopathy, early treatment, i.e. before visual acuity decreases, is recommended.

Monday, April 25

Avalon 10-12

2:00 PM

## S-14: SLIDE: HOT AND HIGH

Chair: Vivienne Lee

Farnborough, Hampshire, United Kingdom

Chair: Thomas Sodeman

Toledo, OH

### [079] VENOUS GAS EMBOLI AND AMBULATION AT 4.3 PSIA

J. Conkin<sup>1</sup>, N.W. Pollock<sup>2</sup>, M.J. Natoli<sup>2</sup>, S.D. Martina<sup>2</sup>, J.H. Wessel<sup>3</sup> and M.L. Gernhardt<sup>4</sup>

<sup>1</sup>Universities Space Research Association, Houston, TX; <sup>2</sup>Center for Hyperbaric Medicine and Environmental Medicine, Duke University Medical Center, Durham, NC; <sup>3</sup>EVA Physiology, Wyle Science, Technology and Engineering Group, Houston, TX; <sup>4</sup>Johnson Space Center, National Aeronautics and Space Administration, Houston, TX

**INTRODUCTION:** Ambulation imparts compressive and decompressive forces into the lower body, potentially creating quasi-stable micronuclei that influence the outcome of hypobaric depressurizations. Hypotheses: ambulation before the conclusion of a denitrogenation (prebreathe) protocol at 14.7 psia is not sufficient to increase the incidence of venous gas emboli (VGE) at 4.3 psia but is sufficient if performed after tissues become supersaturated with nitrogen at 4.3 psia. **METHODS:** VGE results from 45 subjects that performed exercise prebreathe without ambulation before or during a 4-hour exposure to 4.3 psia (Phase II control) are compared to 21 subjects that performed the same prebreathe but ambulated before and during the hypobaric exposure (Phase II-1) and to 35 subjects that only ambulated before the hypobaric exposure (Phase II-3). VGE in the pulmonary artery were detected at about 16-minute intervals using precordial Doppler ultrasound (2.5 mHz) and assigned a Spencer 0 – IV grade. The highest grade assigned during the exposure is one metric, and Grade III or IV were combined as "high VGE grade". We used Fisher's exact directional chi-square for VGE counts, evaluated survival curves for onset of high VGE grade using non-parametric Kaplan-Meier, and used logistic regression (LR). **RESULTS:** The incidence of high VGE grade for Phase II-1 (57%) was greater than Phase II (17%,  $P = 0.001$ ) and Phase II-3 (17%,  $P = 0.001$ ). Mean onset times for high VGE grade were similar for control ( $105 \pm 72$  min SD), II-1 ( $104 \pm 55$ ), and II-3 ( $102 \pm 22$ ) conditions. Differences among the three Kaplan-Meier survival curves were significant from log-rank tests ( $P \leq 0.001$ ), but not just between II and II-3 ( $P > 0.88$ ). Age and ambulation status from LR were needed to describe the probability of high VGE grade. **DISCUSSION:** VGE are increased by mild ambulation conducted under a supersaturated state (Phase II-1 vs II-3); however, no increase in VGE was observed with mild ambulation during the undersaturated state alone (Phase II control vs II-3).

#### Learning Objectives:

1. Lower body exercise is a consideration for hypobaric decompression sickness and bubble formation.

### [080] DECOMPRESSION SICKNESS DURING SIMULATED LOW PRESSURE EXPOSURE IS INCREASED WITH MILD AMBULATION EXERCISE

N.W. Pollock<sup>1,3</sup>, M.J. Natoli<sup>1</sup>, S.D. Martina<sup>3,1</sup>, J. Conkin<sup>2</sup>, J.H. Wessel<sup>5</sup> and M.L. Gernhardt<sup>4</sup>

<sup>1</sup>Anesthesiology, Duke University, Durham, NC; <sup>2</sup>Universities Space Research Association, Houston, TX; <sup>3</sup>Divers Alert Network, Durham, NC; <sup>4</sup>NASA, Houston, TX; <sup>5</sup>Wyle, Houston, TX

**INTRODUCTION:** Musculoskeletal activity accelerates inert gas elimination during oxygen breathing prior to decompression (prebreathe), but may also promote bubble formation (nucleation) and increase the risk of decompression sickness (DCS). The timing, pattern and intensity of musculoskeletal activity are likely critical to the net effect. The NASA Prebreathe Reduction Program (PRP) combined oxygen prebreathe and exercise preceding a 4.3 psia exposure in non-ambulatory subjects (a microgravity analog) to produce two protocols now used by astronauts preparing for extravehicular activity - one employing cycling and non-cycling exercise (CEVIS: 'cycle ergometer vibration isolation system') and one relying on non-cycling exercise only (ISLE: 'in-suit light exercise'). Current efforts investigate whether light exercise normal to 1 G environments increases the risk of DCS over microgravity simulation. **METHODS:** The current studies replicate the CEVIS protocol, each with a single exception, all matched for total metabolic output. Experiment 1 (E1) added intermittent, controlled ambulation (stepping in place: 4 min at 80 steps/min x 7 cycles) at ground level immediately preceding prebreathe (saturated inert gas state) and at 4.3 psia (spacesuit pressure, oxygen

breathing, supersaturated state) instead of remaining non-ambulatory throughout. Experiment 3 (E3) restricted ambulation to the ground level period only. Study endpoints included symptomatic DCS. Fisher Exact Tests were used to compare groups (significance accepted at  $p < 0.05$ ).

**RESULTS:** E1 (21 person-trials [16 male, 5 female]) yielded 4/20 (20%) DCS, significantly more than CEVIS (0/45 DCS [0%]) trials ( $p = 0.004$ ). E3 (35 person-trials [26 male, 9 female]) yielded 2/35 (6%) DCS, not significantly different from CEVIS ( $p = 0.094$ ), but trending towards being significantly lower than E1 ( $p = 0.070$ ). **CONCLUSION:** The risk of DCS at spacesuit pressure is increased by mild ambulation conducted sequentially at ground level in a saturated state and a subsequent supersaturated state, but it appears that exercise in a supersaturated state has the greater impact.

#### Learning Objectives:

1. To understand how exercise can accelerate inert gas elimination during oxygen breathing.
2. To appreciate how exercise may promote bubble formation and increase decompression stress.
3. To comprehend how inert gas saturation may play a role in exercise-induced bubble formation.

### [081] LOCALIZED HEAT URTICARIA FROM 95-GHZ MILLIMETER WAVES

J.A. Gibbons

Bioeffects Division, Air Force Research Laboratory, San Antonio, TX

**PROBLEM STATEMENT:** This case report describes the development of urticaria (hives) after exposure to 95-GHz millimeter wave energy. **BACKGROUND/LITERATURE REVIEW:** Local heat urticaria is a physical urticaria caused by the environmental stimulus of heat. Typically the resultant lesion, a wheal, is pruritic (itches) and sometimes accompanied by a burning sensation. It is a self-limited phenomenon that resolves after 1.5-2 hours. The prevalence of local heat urticaria in the general population has been estimated as 1 in 200,000 persons. **CASE PRESENTATION:** The patient, a 39-year old active duty male participated in a test of a 95-GHz energy beam designed to heat the skin. He had delayed presentation of raised erythematous, non-pruritic, non-painful areas at five of the exposure sites where the skin temperature exceeded 54 degrees C. All wheals resolved within two hours of the exposures.

**OPERATIONAL/CLINICAL RELEVANCE:** This is the second report of a previously asymptomatic individual developing local heat urticaria after a 95 GHz energy beam exposure, an incidence of  $< 0.02\%$ . The duration of exposure is too short to produce systemic symptoms, based upon existing local heat urticaria clinical case reports. To date, 95 GHz energy has a low incidence of local heat urticaria, consistent with the incidence of local heat urticaria within the general population. Research also shows 95 GHz energy has no systemic effects or long term sequelae.

#### Learning Objectives:

1. The participant will be able to identify local heat urticaria.

### [082] PASSENGERS UNDER PRESSURE? SYMPTOM EVALUATION/TREATMENT FOLLOWING CABIN PRESSURE LOSS IN CIVILIAN AVIATION

M.A. Garber<sup>1</sup> and P.M. Alves<sup>2</sup>

<sup>1</sup>Engineering Systems, Inc., Norcross, GA; <sup>2</sup>MedAire Inc., Tempe, AZ

**PROBLEM STATEMENT:** This case report describes a decompression event in a civilian fixed-wing aircraft in which one passenger received hyperbaric treatment for altitude related symptoms. **BACKGROUND/LITERATURE REVIEW:** At least 60-70 decompression events occur on average each year in civil aviation. There are no data routinely gathered regarding occupants exposed to hypobaric environments, and there are no published civilian protocols to ensure follow-up for commercial passengers potentially at risk for immediate or delayed decompression symptoms following a loss of cabin pressure. **CASE PRESENTATION:** A business jet experienced a rapid decompression event at FL 340. The cabin climb rate exceeded 40,000 feet per minute, and the cabin altitude reached approximately 30,000 feet. The 2 pilots immediately donned their oxygen masks, and the 4 passengers donned the standard commercial passenger masks (not aviator masks) that dropped in the passenger compartment. During the subsequent emergency descent procedure, the aircraft was required to level off at FL250 for

several minutes because of traffic in the area. The aircraft landed safely, but two of the passengers experienced symptoms consistent with altitude exposure, including paresthesia and ear barotrauma. The operator identified a local resource with a hyperbaric chamber, and one passenger was given hyperbaric oxygen treatment as prescribed in U.S. Navy dive table six. **OPERATIONAL/CLINICAL RELEVANCE:** Though not contacted immediately, the operator's in-flight medical services company later participated in a review of the incident, and developed response plans with specific guidance for decompression events, including procedures for rapidly locating nearby hyperbaric chambers. The operator has also developed an emergency response plan for future events of this type. The authors are unaware of any similar protocols utilized by passenger airlines, and suggest that policies governing these rare but foreseeable incidents be created where they are applicable.

#### Learning Objectives:

1. The participant will be able to identify the risk of hypobaric symptoms and appropriate treatment/followup for civil aviation passengers exposed to in-flight decompression events.

### [083] HEAT STRAIN IN A HELICOPTER DURING A SIMULATED DESERT MISSION

M. Gronkvist<sup>1</sup>, U. Ciuha<sup>2</sup>, I. Mekjavic<sup>2</sup> and O. Eiken<sup>1</sup>

<sup>1</sup>Environmental Physiology, Royal Institute of Technology, Stockholm, Sweden; <sup>2</sup>Dept. of Automation, Biocybernetics and Robotics, Ljubljana, Slovenia

**BACKGROUND:** It has been reported that helicopter personnel commonly experience high heat strain whilst wearing body armor during flight missions in warm or hot climates. The present study investigated the level of heat strain to be expected in personnel operating in the rear cabin of the helicopter during desert-climate missions, and to what extent the strain can be mitigated by use of battery-driven ventilation vests. **METHODS:** 8 male subjects undertook three-hour simulated flight missions at an ambient temperature of 45°C (113°F), relative humidity of 10% and with simulated solar radiation. Each subject wore the Swedish Airforce helicopter flight equipment, including body armor. Each subject conducted the mission under three test conditions, wearing: (1) T-shirt; (2) ventilation vest with a 3-dimensional mesh (Mesh); and (3) ventilation vest with foam-cast plastic ducts (Ducts). Each mission started with a 10-min walk on a treadmill followed by sitting for 30 min, kneeling on a vibration platform (5 Hz vibration) for 2 hours, and concluded with 30 min of sitting. Rectal temperature, heart rate, skin temperature and heat flux, oxygen uptake ( $\text{VO}_2$ ), and sweating rate were measured. Evaporative resistance of the garments was determined using a thermal manikin. **RESULTS:** In the T-shirt and Mesh conditions, all 8 subjects managed to complete the simulated mission, whereas in the Ducts condition, one subject had to finish prematurely at the end of the second hour of kneeling, due to heat exhaustion. Rectal temperature increased on average by 0.93°C in the T-shirt condition, 0.61°C in the Mesh condition, and 0.88°C in the Ducts condition. Reductions in body weight were more pronounced in the T-shirt (1.97 kg) and Ducts (1.87 kg) compared to Mesh (1.63 kg) trials. There were no differences in  $\text{VO}_2$  between the three conditions. The moisture vapor transmission rate for the three garment ensembles measured with a sweating thermal manikin was 4.1 g/min for the T-shirt, 7.8 g/min for the Mesh, and 4.4 g/min for the Ducts ensembles. **DISCUSSION:** Helicopter personnel may be at risk of heat exhaustion during flight missions in hot climates. The risk can be substantially reduced by blowing ambient air on the torso by means of a battery-driven ventilation vest. However, the cooling efficacy differs substantially between different vest concepts available on the market.

#### Learning Objectives:

1. Potential risks for heat exhaustion during a helicopter mission and the possibility to reduce the risk for heat exhaustion by use of a ventilated vest.

### [084] HEMI-DIAPHRAGM PARALYSIS IN TWO NAVAL FLIGHT SURGEONS: RECOVERY AND OBSERVATIONS

D.B. Gillis<sup>1</sup>, D. Hohman<sup>2</sup> and L. Savoia-McHugh<sup>3</sup>

<sup>1</sup>Retired, Nassau Bay, TX; <sup>2</sup>377 Med Group, Kirtland Air Force Base, NM; <sup>3</sup>Medical, Naval School of Aviation Medicine, Pensacola, FL

**PROBLEM STATEMENT:** Two cases of hemi-diaphragmatic paralysis, one prolonged presented. **BACKGROUND:** Two Naval Flight Surgeons developed hemi-diaphragmatic paralysis, received limited waivers. Course and outcome varies widely but both recovered, one at 6 mo., one at 2 years. **Case Presentations: Case 1:** A 59 yr male RAM Resident with significant dyspnea running. Elevated Rt diaphragm, negative viral panel, unilateral Rt diaphragm elevation, condition stable. Workup included positive sniff test and reduced pulmonary functions. He continued strenuous running, swimming with abrupt return of function 6 months later. No recurrence. **Case 2:** 34 yr RAM Flight Surgeon with fever, Feb 2002, dyspnea evacuated Mar 2002 to USA after worsening. Workup: Lt. hemi-diaphragm paralysis, mycoplasma pneumonia & regurgitation, waived for CVN duty. Initial symptomatic recovery in March 2003 when he could stop sleeping in seated position and reflex treatment. **OPERATIONAL/CLINICAL RELEVANCE:** While complete recovery varies, new evidence points to upregulation of neurotrophins, neural cell adhesion molecules and cytokines in nerve recovery, and adaptations in respiratory muscles compensating for hemi-diaphragmatic symptoms in some patients. Exercise stimulates respiratory center neurons for the phrenic nerve and increase trophic factors and remyelination. There is beneficial effect of exercise in neuronal and long nerve recover from disease and injury and in multiple sclerosis, improving cognition and memory while benefiting heart, muscle and lung function. Acute moderate exercise improves cognitive performance. Flight Status may be resumed in some cases after complete accelerated recovery in as little as 6 mo.

**Learning Objectives:**

1. To assist in diagnosis, management, recognition of adequate recovery, and likely performance outcomes of bilateral and hemi-diaphragmatic paralysis due to phrenic neuropathies.
2. To be able to predictively conceptualize the various likely clinical paths that may occur to enable and support the patient and the assessments and treatments necessary to optimize the final outcome of these disorders.
3. To learn and understand the advancing status of neuroscience and microbiology in improving outcomes of these disorders.

**Monday, April 25**

**2:00 PM**

**Avalon 13-14**

**S-15: PANEL: MARS EXPLORATION:  
EVIDENCE-BASED RECOMMENDATIONS FOR  
TEAM AND SOCIAL SUPPORT**

**Chair: Lawrence Palinkas**  
*Los Angeles, CA*

**Chair: William Vessey**  
*League City, TX*

**PANEL OVERVIEW:** As NASA spaceflight missions move beyond low-Earth orbit, the methods used to support teams and individuals will need to be adapted to these new mission profiles. This panel consists of presentations detailing operational recommendations for team and social support generated from both new research and reviews of available evidence related to the spaceflight context. These recommendations apply not only to spaceflight, but to many other settings where teams and individuals are deployed away from home for long periods of time. First, the panel will include a summary of the findings of a recent study of communication delay effects on team functioning aboard the International Space Station and associated operational recommendations. Second, this panel will include a presentation detailing operational recommendations for the related topic of family support for lengthy deployments under conditions of limited or no-real time communication. Drawing on a related environment to spaceflight, the third presentation will be a summary of recent research into team resilience on U.S. Navy submarines and recommendations for analogous spaceflight teams will be provided. The fourth presentation will address the potential impact of peer social support interventions delivered pre-flight on deployed teams. In the fifth and final presentation, also addressing the before and during mission periods, an overview of team training best practices and recommendations for long-duration exploration teams will be provided.

**[085] THE IMPACT OF EXPERIMENTAL DELAYS IN  
COMMUNICATION TO AND FROM THE INTERNATIONAL SPACE  
STATION ON SUBJECTIVE ASSESSMENTS OF PERFORMANCE  
AND WELL-BEING**

*L.A. Palinkas and N. Kintz*

*School of Social Work, University of Southern California, Los Angeles, CA*

**INTRODUCTION:** The NASA Human Research Program Behavioral Health and Performance Element (BHP) examined the impact of an experimental communication delay to and from the International Space Station on performance, well-being and perceptions of autonomy. This presentation describes preliminary results relating to the impact of delays in communication on subjective assessments of communication quality, individual and team performance and well-being. Secondary analyses investigated whether task-related communication levels moderated these effects. **METHODS:** During a recent increment, 3 astronauts and 18 ground support personnel performed 6 tasks under conditions of no communications delay and 4 tasks under conditions of a 50-second one-way delay in communications to and from the ISS. After each task, participants answered questions about ability to communicate with one another, individual and team performance, perceptions of crew morale, perceived affect, how much autonomy was exercised, and how much support was received in completing the task under conditions of delay or no delay. Audiovisual records of the tasks were used to determine task-related communication levels (high or low). **RESULTS:** Communication quality was inversely associated with individual ( $p < 0.01$ ) and team ( $p < 0.001$ ) and team well-being ( $P < 0.001$ ) Delays in communication were inversely related to communication quality ( $p < 0.01$ ), and this effect was stronger for high compared to low communication tasks. Communication delays were also significantly inversely related to team performance for high ( $p < 0.05$ ), but not low communication tasks. In addition, there was a strong positive relationship between delays in communication and perceived stress/frustration for high ( $p < 0.01$ ) but not low communication tasks. On the other hand, delays in communication were not significantly related to crew morale or individual performance. **DISCUSSION:** Understanding the relationship between experimental delays in communication on the ISS and subjective assessments of performance and well-being provide important insights into challenges space teams may experience during long-duration space explorations and potential countermeasures to prevent or mitigate adverse impacts.

**Learning Objectives:**

1. Understand the impact of delays in communication during long-duration space missions on individual and team performance.
2. Understand the moderating role of extent of communication required for task completion on the association between communication delays and performance.
3. Understand that delays in communication adversely impact perceived stress/frustration and team performance selectively in tasks involving high levels of communication with ground support personnel.

**[086] SUBMARINE TEAM RESILIENCE IN ISOLATED CONFINED  
AND EXTREME (ICE) ENVIRONMENTS**

*J.C. Lamb<sup>1</sup>, R. Armbruster<sup>1,2</sup> and S. Chabal<sup>1,3</sup>*

*<sup>1</sup>Naval Submarine Medical Research Laboratory, Groton, CT; <sup>2</sup>CGI, Inc., Norfolk, VA; <sup>3</sup>Leidos, Groton, CT*

**INTRODUCTION:** Since the 1950s, USN nuclear submarines have been operating in ICE environments with limited/delayed communications and a limited capability for evacuation. These conditions mirror the conditions of NASA's currently envisioned Long Duration Exploratory Missions (LDEM). While submarine crews are much larger, the teams that actually operate the boat are a set of small teams (4-5 members) and whose composition remains basically stable throughout the mission, whose duration range from 70 days continuous operation to 6 months deployments with multiple, shorter missions. To measure the resilience of these teams, NSMRL has developed a behavioral observation tool, the Submarine Team Behaviors Tool (STBT). The tool consists of five practices, Dialogue, Critical Thinking, Problem Solving Capacity, Decision Making and Bench Strength. Each has two or more threads (sub-practices). The combination of observed and not observed behaviors characterize a level of team resilience, Unstressed Team, Leader-Dependent, and Resilient



Team. Recent research was conducted to investigate the effectiveness of the STBT in characterizing team resilience and if the STBT, in conjunction with good learning practices could improve team performance.

**METHODS:** The STBT was compared to a validated measure of team performance using observer-based inputs. In another phase, the teams' instructors and supervisors were trained in the use of the STBT and how to intervene in the various phases of operational scenarios. Observations were conducted on 160 operational teams at four different training sites.

**RESULTS:** The STBT was shown to correlate significantly ( $r_{rb}=0.41, p<0.05$ ) with the validated measure but not with measures of technical skills.

Training improved when the STBT was combined with training interventions. Changes in performance on individual threads went from equal improvement/decline (14/14) to greater improvement (17/4).

**DISCUSSION:** The STBT is a valid measure of team resilience for submarine operational teams. NSMRL is currently applying the STBT behaviors to the NASA long-term Human Experimental Research Analog (HERA) studies to see if the STBT components can be used as leading indicators of team performance degradation.

**Learning Objectives:**

1. The participant will be able to understand the impacts of behavioral factors on team performance.

**[087] APPLICATION OF WORKPLACE SOCIAL SUPPORT TO ENHANCE BEHAVIORAL HEALTH PRIOR TO LONG-DURATION SPACEFLIGHT: RECOMMENDATIONS FROM AN EVIDENCE REVIEW**

J.J. Vasterling<sup>1</sup> and C. Deming<sup>2</sup>

<sup>1</sup>Psychology/Psychiatry, VA Boston Healthcare System/Boston University School of Medicine, Boston, MA; <sup>2</sup>Psychology, Harvard University, Cambridge, MA

**INTRODUCTION:** Long-duration spaceflight brings with it psychosocial stressors potentially affecting the well-being and performance of astronaut crew members, including potential social isolation, communication failures, and stressful team dynamics. Preparation for such a mission likewise includes challenges such as extensive travel and demanding training, and astronauts have reported greater stress pre-mission than during or post-mission. Workplace social support may form the basis of countermeasures to mitigate behavioral health concerns arising pre-flight and enhance resiliency before and during extended missions. We reviewed relevant scientific evidence, including our own work within the U.S. military, with the objective of integrating findings from related literatures into the context of extended spaceflight.

**METHODS:** We conducted a literature review of observational and interventional studies examining social support in professional contexts sharing one or more characteristics with astronauts and spaceflight. Key words pertaining to populations of interest, social support constructs, and behavioral health outcomes were entered; abstracts were subsequently reviewed for relevance. **RESULTS:** The review identified 4 social support subtypes (instrumental, emotional, informational, appraisal) and 2 broad intervention categories (direct provision of support; training to optimize skills in both provision and receipt of social support). Observational studies documented clear associations between workplace support and favorable behavioral health outcomes following exposure to stress, and especially to extreme stress. Intervention findings suggest that mentoring and coaching techniques have high acceptability to professionals and may be effective in mitigating occupational stress. Further, social resiliency training based on positive psychology principles may confer enhanced skills relevant to social support. **DISCUSSION:** Social support interventions may have high applicability to pre-mission phases of long-duration spaceflight, although such interventions may require tailoring to context. We will also discuss the extent to which the effects of pre-flight social support would be expected to continue during spaceflight.

**Learning Objectives:**

1. To identify different types of social support that may help enhance resiliency.
2. To become familiar with workplace interventions that can potentially enhance social support.
3. To become familiar with workplace interventions that can potentially build or reinforce existing skills in the provision and receipt of social support to and from others.

**[088] SPACEFLIGHT TEAM TRAINING: SUPPORTING PERFORMANCE THROUGHOUT LONG-DURATION EXPLORATION MISSIONS**

L.B. Landon

Behavioral Health and Performance Element, Wyle-NASA, Houston, TX

**MOTIVATION:** Team training has matured to a set of common, evidence-based best practices for traditional organizations, which have been applied in both medical and aerospace settings to improve team performance. This presentation will review the most recent lessons learned and identify research gaps related to team training, specifically in the context of supporting team functioning and performance throughout a long-duration space exploration mission (e.g., Mars mission).

**OVERVIEW:** A review of team training as related to spaceflight, spaceflight analogs, and analogous populations was conducted as part of a larger update of the Evidence Book for the NASA Human Research Program's Behavioral Health and Performance Element – Team Risk. Current team skills training for astronauts is focused on International Space Station missions of 6 months. Crews are increasingly trained in team skills, in addition to skills that support team performance such as communication, specific team tasks (e.g., spacewalks), and common languages. Astronaut candidates now take Spaceflight Resources Management classes, which focus on team skills and grew from Crew Resource Management from the aviation industry. However, current team skills training is a secondary concern to technical training related to working in space. For future missions, researchers and operations personnel have recognized the greater importance of team skills training for teams on exploration missions. This review will describe current efforts to add team skills training to astronaut training and new research efforts in the Team Risk to create robust team skills training for future long-duration, isolated, and autonomous teams. Six team skill areas addressed as recommendations for operations are: cooperation, conflict management, coordination, communication, coaching/leadership, and cognition. **SIGNIFICANCE:** Evidence-based team training is effective and is particularly important for the future Mars mission team. This renewed focus on team skills training in spaceflight holds lessons for all team operations researchers and practitioners, offers operational recommendations, and highlights gaps to direct future research and development efforts.

**Learning Objectives:**

1. Understand current efforts to add team skills training to astronaut training and new research efforts in the Team Risk to create robust team skills training for future long-duration, isolated, and autonomous teams.

**[089] FAMILY SUPPORT AND COMMUNICATION FOR LONG-DURATION EXPLORATION MISSIONS**

W. Brim and M. Weinstock

Center for Deployment Psychology, Bethesda, MD

**INTRODUCTION:** Future long-distance space exploration (LDSE) missions will differ substantially from current low-Earth-orbit International Space Station missions. One of the salient issues in LDSE is the importance of the contact with family during the pre-mission training phase. Pre-mission family-based support may provide a useful countermeasure against inflight behavioral health problems. Military deployments and military family support programs may serve as an analogue to LDSE pre-mission preparation. Lessons learned and programs developed by the military may serve as models for future NASA missions. **METHODS:** To better understand the role of pre-flight family support and how to utilize the role of the family in the promotion of astronaut behavioral health, a literature review of evidence-based, family support strategies during the pre-mission phase for long duration spaceflight and analogous settings was conducted. Literature was first identified via keyword search and then evaluated for degree of relevance to family support. Interviews were conducted with 10 individuals who are involved with NASA family programs, human space flight, astronauts and their family members. Additional interviews were conducted with DoD Family Services subject matter experts (SMEs) and SMEs with experience working with and conducting research on military family members and programs. **RESULTS:** The analog literature is sparse with the exception of

the military deployment literature, which has been growing and maturing over the past few decades as the military culture has evolved in its view of the role of family members and the military's responsibility in caring for them. Deployments do appear to create a higher incident rate of emotional and behavioral problems for the families and longer separations may be harder than shorter ones. Little empirical evidence exists evaluating the effectiveness of military pre-deployment programs. Recommendations can be made for future research and programs for LDSE. **DISCUSSION:** Recommendations for future research, cultural change and assessment of family needs will be presented.

**Learning Objectives:**

1. Understand the state of the literature regarding long-duration separations and their impact on family members.

**Monday, April 25**

**2:00 PM**

**Avalon 15-16**

**S-16: PANEL: IMPROVING HUMAN PERFORMANCE FROM THE CLINIC PLATFORM**

*Sponsored by the Society of USAF Flight Surgeons*

**Chair: Richard Baker**

*Helotes, TX*

**PANEL OVERVIEW:** The Military Health Service has appropriately espoused the necessity of an increasing focus on the optimization of Human Performance (HP). This panel presents ongoing transformational efforts by USAF medical platforms to improve war fighter human performance. The first presentation, from the Air Force Medical Operations Agency, outlines the overarching concept of operations developed to deliberately develop and structure the service around such an increasing HP focus. Building on the precepts of the Patient Centered Medical Home, current efforts incorporate mission-specific activities designed to optimize Service-member availability through an Air Force Medical Home model. Subsequent presentations provide case examples of these mission-specific activities working to optimize performance. A presentation by the AF Surgeon General's Branch Chief for Aerospace and Operational Physiology, describes the career field's storied efforts in human performance optimization and their on-going role as key integrator of AFMS HP efforts. Lt Col Steve Ward will then present Fairchild Air Force Base's (FAFB) HP successes working with SERE instructors and the Security Forces squadron. FAFB HP programs represent a model for commanders to proactively address the human performance of Airmen with minimal investment in personnel and resources. Finally, LCDR Timothy Welsh, an Assistant Professor at the Uniformed Services University of the Health Sciences, will speak to ongoing Consortium for Health and Military Performance (CHAMP) efforts. The consortium is working to establish a "one-stop shop" for DoD Human Performance Optimization Solutions.

**[090] AIR FORCE MEDICAL HOME: BRINGING THE PRACTICE OF HUMAN PERFORMANCE TO THE CLINIC**

R. Baker

*AFMOA, USAF, Helotes, TX*

**MOTIVATION:** Aerospace medicine and physiology are intimately involved in the optimization of human performance in aircrew training; the same constructs can be applied from the medical clinic platform to improve performance of other Service members, workers, and other clinic patients. **OVERVIEW:** The Air Force mission to fly, fight, and win remains unchanged since the Air Force's inception in 1949, however the domains in which this mission is executed have expanded from air, to space, and now cyberspace. Expansion of this mission into these new domains demands a re-imagining of the practice of Air Force medicine. Building on the precepts of the Patient Centered Medical Home the Air Force Medical Home incorporates mission-specific activities designed to optimize Service-member availability. The human performance practitioner working with a robust clinical support mechanism ensures that Service members are healthy enough to perform their assigned mission and that their cognitive, physical, and emotional states allow optimal performance while

deployed and in garrison. **SIGNIFICANCE:** The human is a component in every weapon system and optimizing the performance of the human who is operating or supporting the system maximizes the system's ability to provide a competitive advantage over our adversaries. The Military Health Service has appropriately espoused a shift from a focus solely on healthcare to health; the logical extension of this is to identify opportunities to improve performance, and health as a necessary but insufficient precondition for performance. Embracing the ability of a patient to perform, or meet a goal as a valuable outcome of provision of medical care is not only consistent with meeting Service missions, but also with patient-centeredness and outcomes-accountable care.

**Learning Objectives:**

1. Outline the overarching concept of operations developed to deliberately develop and structure the Air Force Medical Service around an increasing Human Performance focus.

**[091] HUMAN PERFORMANCE OPTIMIZATION: THE AEROSPACE & OPERATIONAL PHYSIOLOGY LINK**

E. Phillips and E.M. Hendrickson

*USAF, Springfield, VA*

**MOTIVATION:** In 2015, the USAF AF Surgeon General succinctly observed that, "... to serve our Airmen, we must move from episodic care to population health, and from population health to human performance." In support of the overarching panel theme of improving Human Performance (HP) from the Clinic Platform, this presentation describes how the Aerospace and Operational Physiology (AOP) career field has been optimizing human performance directly within the operational Line community for decades and is at the forefront of the AFMS HP transformation. **OVERVIEW:** Approximately 15 years ago, the AFMS began formal integration of AOP professionals into various wing operations to expand the human performance support provided by AOP beyond just aircrew. This effort, which began as an AFMS imbedded outreach initiative, has now grown into a recognized necessity by senior leaders across the Air Force. Therefore, the AFMS is now expanding and refining AOP's role to be a critical operational link and member of the Human Performance Integration Team that is being developed within the AFMS. **SIGNIFICANCE:** As AFMS continues its human performance optimization trajectory, AOP is well-positioned to be further leveraged as a vital link to operationalizing AFMS human performance across the AF.

**Learning Objectives:**

1. Comprehend Aerospace and Operational Physiology's role in optimizing human performance in operational environments and how it links to the greater Air Force Medical Service HP transformation effort.

**[092] FAIRCHILD AFB HUMAN PERFORMANCE PROGRAM**

S.R. Ward

*USAF, 92 AMDS, Fairchild AFB, WA*

**MOTIVATION:** Airmen are our greatest asset—we must invest in maximizing the performance of this human weapon system. Most base programs are often passive or reactive in nature, focusing on struggling/broken Airmen. Our project motivation was focused on moving from health "care" of struggling/broken Airmen to creating cultures of health within squadrons for all Airmen. **OVERVIEW:** FAFB Human Performance Program is a test concept to provide a model solution to improve the human performance of all Airmen. This goal directly aligns with the USAF/SG's Human Performance CONOPs, and the SG's vision is that our supported population is the healthiest and highest performing segment of the U.S. by 2025. The FAFB HP program encompassed two pilot programs. In 2014 it focused on increasing SERE Instructor graduation rates, which had fallen due to training program injury rates. Through a Squadron embedded "Smart PT" program graduation rates were increased by 40% after a four-month intervention. In 2015 we focused on the 92 Security Forces Squadron through an expanded program called "Cop Fit." This program began with an injury rehab and movement correction "pre-hab month" to get all Airmen ready to participate in the program. The formal program included "Smart PT," advanced PTL training, nutrition, sleep hygiene for shift workers, and Military Family Life Consultant programs. The initial test flight saw 4 of 6 SF Airmen come off profile and return to full duty during the "tune-up" month. In the first six weeks of Smart PT Airmen

saw an average of 1:39 improvement on the 1.5 mile run, average 4-to-8 pull-ups, and an average 3 lb fat loss and 2 lb muscle gain. More important, PTL skill sets were massively improved allowing the Squadron to maintain its gains, and we saw increased flight camaraderie and peer-to-peer accountability to maintain these gains. **SIGNIFICANCE:** We must break from the tradition viewing these as medical issues, and we must break from our tradition focusing solely on struggling/broken Airmen. Although not resource neutral, we believe the FAFB HP programs represent a model to proactively address the human performance of Airmen with minimal investment in personnel and resources.

**Learning Objectives:**

1. Provide the Fairchild AFB case example of improving human performance from the clinic platform.

**[093] THE CONSORTIUM FOR HEALTH AND MILITARY PERFORMANCE: HUMAN PERFORMANCE OPTIMIZATION SOLUTIONS**

T. Welsh

*Dept. of Preventive Medicine and Biostatistics, Uniformed Services University of the Health Sciences, Bethesda, MD*

The Consortium for Health and Military Performance (CHAMP) — in agreement with the recent Force Health Protection Concept of Operations DOTmLPF-P Change Recommendation has identified a major capability gap: Lack of a centralized human performance optimization knowledge management function across all elements of the Department of Defense (DoD). Such a function would support DoD efforts to eliminate redundant and stove-piped human performance optimization (HPO) research, analytic and educational efforts; facilitate the exchange of information within and across separate Military and Military Health Services, Joint Staff, Health Affairs and other components of the Office of the Secretary of Defense; promote joint and inter-/intra-service collaborative research, and promulgate evidence-based HPO practice recommendations based on Military Service requirements. CHAMP proposes establishing a Human Performance Optimization Solutions functional effort to collect, catalogue, compare, contrast and otherwise analyze DoD HPO research, clinical, educational, and programmatic activities related to HPO through a “one-stop shop” to assist in the coordination, synchronization and integration of these activities and to provide current, concise and state of the science advice for policy-makers. The content will reflect Military Service-specific requirements, encourage and promote intra- and inter-service collaborations, identify evidence-based HPO practices for clinicians and HPO practitioners, and assist in determining HPO research and programming efforts within and across each Military Service.

**Learning Objectives:**

1. Describe the function of Consortium for Health and Military Performance.
2. Describe the function of Human Performance Optimization Solutions.
3. Explain the Force Health Protection Concept of Operations DOTmLPF-PChange Recommendation human performance optimization major capability gap.

**Monday, April 25**

**2:00 PM**

**Avalon 17**

**S-17: PANEL: SUPERMAN READINESS SKILLS VERIFICATION (RSV) FOR FLIGHT SURGEONS**

**Chair: Douglas Files**

*Fairborn, OH*

**Chair: Ann Hoyniak-Becker**

*Beavercreek, OH*

**Chair: Dale Tidaback**

*Fairborn, OH*

**Chair: Russell Turner**

*Fairborn, OH*

**PANEL OVERVIEW: INTRODUCTION:** This panel will update flight surgeons on issues that affect the safety, health, and well-being of the aviator or passengers on the flight. It includes individual aircrew issues: physiologic events, human factors, human performance enhancement. The first topic will address human performance enhancement and sustainment. The second presentation is on aeromedical evacuation, such as how to mitigate physiologic stressors on the patient. The third presentation is on physiologic incident response and the reporting that needs to accompany it. The final program is about Mishap/HAZMAT response, that is, how to respond like Superman when your local area suffers a disaster. Each session will be interactive and informative. Aerospace medicine professionals will participate in all aerospace medicine scenarios as well as to explore the links between them. This panel affords aerospace medicine professionals the opportunity to make aerospace medicine decisions which affect the mission and aircrews. Airmen will leave the panel better prepared to ensure the safety of the airfield.

**[094] HUMAN PERFORMANCE ENHANCEMENT**

R. York

*USAF School of Aerospace Medicine, San Antonio, TX*

**MOTIVATION:** Aerospace medicine professionals sustain top-notch aviator performance. One of those high risk special interest items involves the use of medication. Flight surgeons prescribe hypnotics to help aviators sleep prior to a sortie and in special circumstances prescribe alertness medication to improve performance during critical phases of flight. This presentation will instruct aerospace medicine professionals in the proper use and documentation of performance enhancing medication to aviators. **OVERVIEW:** Aerospace medicine professionals understand the physiologic effects and risks of flight. In order to ensure mission completion, flying safety, and individual health and well-being, flight surgeons will sometimes prescribe medication for use. Hypnotics are used to assist aircrew in getting a good night sleep prior to a mission while alertness medications improve pilot performance during critical phases of flight. Flight surgeon experience and comfort with using these medications is variable. This program will update flight surgeons on the use of performance sustainment and enhancement medication. **SIGNIFICANCE:** The U. S. Air Force has determined that currency in the use of performance enhancing and sustaining medication should be performed annually. However, many other services use performance enhancing medication. This program will incorporate some of the latest techniques and will be beneficial to all AsMA attendees participating in the session.

**[095] AEROMEDICAL EVACUATION CLEARANCES**

R. York

*USAF School of Aerospace Medicine, San Antonio, TX*

**MOTIVATION:** Aerospace medicine professionals are tasked with oversight of the medical safety, health, and well-being of passengers on an aircraft. As such they regulate clearance for patients being transported by the aeromedical evacuation system. This presentation will assist professionals to maintain currency by performing medical clearances for virtual aeromedical evacuation patients. **OVERVIEW:** Aerospace medicine professionals study the physiologic effects of flight at altitude. Medical care can be especially dangerous when an injured patient with compromised physiology must be flown. This program will reinforce techniques to ensure flight surgeons are successful in planning and protecting patients being transported in the aeromedical evacuation system. **SIGNIFICANCE:** The U. S. Air Force is a world leader in aeromedical evacuation. They have determined that currency in regulating patients for aeromedical evacuation should be performed 2-3 times annually. Many of the flight surgeons who attend AsMA have never participated in a single aeromedical evacuation. Further, other Services that attend AsMA interface with the Air Force' aeromedical evacuation system making lessons learned widely applicable. This program will give professionals an opportunity to participate in the medical clearance of patients traversing the aerevac system. It will cover the latest trends and techniques and will be beneficial to all AsMA attendees participating in the session.

**[096] PHYSIOLOGIC INCIDENT RESPONSE AND ANALYSIS**

R. York

USAF School of Aerospace Medicine, San Antonio, TX

**MOTIVATION:** Aerospace medicine professionals are required to recognize when an inflight incident is related to human physiology and to know how to respond to it. This presentation will allow professionals to maintain physiologic incident currency by participating in a response exercise. **OVERVIEW:** Aerospace medicine professionals study the effects of normal physiology in abnormal environments. Aircrew consult them for medical problems. However, opportunities for individual flight surgeons to respond to inflight incidents can be infrequent, or if it does occur, it is often repetitive in that particular types of aircraft (fighters, heavy, rotary wing) are prone to the same type of physiologic incident. This program will update aeromedical professionals on response to a physiologic incident by providing an opportunity for individuals to participate in a physiologic incident response exercise. **SIGNIFICANCE:** The U.S. Air Force has determined that currency in physiologic incident response whether tabletop or actual response, should be performed annually. Flight surgeons listen to aircrew issues at plane side, understand the physiologic causes, and then express it coherently to the aircrew. Further, these issues can be a harbinger of larger problems. For instance, a sinus block in an experienced aviator who has never had sinus issues can point to an underlying pathologic process. This physiologic response presentation will give flight surgeons an opportunity to learn about responses, incorporating the latest physiologic response information.

**[097] DISASTER RESPONSE EXERCISE**

R. York

USAF School of Aerospace Medicine, San Antonio, TX

**MOTIVATION:** Aerospace medicine professionals are required to understand mishap response including for aircraft crashes, HAZMAT spills, and mass casualty scenarios. This presentation will allow professionals to maintain currency by participating in a response exercise. **OVERVIEW:** Aerospace medicine professionals are first in and last out for disaster relief operations. They are concerned with the medical aspects of toxic and hazardous materials used on an airfield and consult on hazardous spills. They are asked to respond to aircraft mishaps, caring for the initial responders as well as those directly injured. However, the actual opportunity for any individual to do this is infrequent. This program will update aeromedical professionals on response issues by providing an opportunity for individuals to participate in a mishap exercise. **SIGNIFICANCE:** The U.S. Air Force has determined that currency in Disaster Response, whether tabletop or actual response, should be performed twice a year. However, all AsMA attendees will benefit. Aerospace medicine professionals will improve their understanding of the nuances of dealing with other airfield organizations (i.e. - fire dept, civil engineering, etc), with federal authorities, and with local facilities that interact with the airfield during a disaster response. International professionals will gain insight into how disaster response flows in the United States and can export lessons learned to their own countries. Thus, all services and all countries will have an opportunity to experience a mishap response that incorporates the latest disaster response information

**Monday, April 25****2:00 PM****Avalon 6**

**S-18: PANEL: IN-COCKPIT SPATIAL  
DISORIENTATION EXPERIENCE: LESSONS AND  
STATE OF THE ART COUNTERMEASURES**

Sponsored by the Associate Fellows Group

**Chair: Steven Gaydos**

Ft. Rucker, AL

**Chair: Philippe Souvestre**

Vancouver, BC, Canada

**PANEL OVERVIEW:** Spatial disorientation (SD) has been a contributing factor in aviation mishaps since the origins of aviation. In-flight space and motion perception deterioration and subsequent loss of situational awareness are among the top origins of serious incident and fatal aircraft accidents. Abundant international scientific literature on SD's aftermaths generally concurs on that "SD contributes to at least 25-33% of all aircraft mishaps and it results in the highest number of fatalities. [Gibb R, Ercoline B, Scharff L. Spatial Disorientation: Decades of Pilot Fatalities. Aviat Space Environ Med 2011; 82:717-24] The Associate Fellows Group Panel features military and civilian pilot-physicians and expert aerospace scientists who respectively present on either a peculiar personal in-flight SD experience or how to specifically model reported SD related fundamental phenomenology. To reflect the complex dimension of this distinctive unresolved in-flight issue and the magnitude of its impact on flight safety, a broad range of SD occurrences and countermeasures are demonstrated through combining all presenters' invaluable in-flight SD experiences. Pilot-physicians recount a specific circumstantial in-flight SD experience reported live by themselves along with their own biomedical analysis and interpretation of their SD-induced physiological mishap, and share on what they did at that time in their cockpit to countermeasure it, and on what they now think should have been done to better mitigate or even prevent it. Scientists present on how to model SD occurrence patterns and quantify, mitigate, and prevent SD related dysfunctional momentum in the light of state of the art Aerospace Medicine related sciences.

**[098] LESSONS LEARNED: A FATAL SPATIAL DISORIENTATION MISHAP IN A UNITED STATES AIR FORCE F-16C**

M.M. Metzler

Aerospace &amp; Operational Physiology, United States Air Force, Tyndall AFB, FL

**INTRODUCTION:** Spatial Disorientation (SD) has plagued both civilian and military aviators since the beginning of aircraft flight. The United States Air Force has had significant losses from this deadly human factor. In the last ten years, 12% of all class A USAF aviation mishaps were due to SD. While this may seem like a low number, over 60% of these mishaps were fatal. Also of note, 100% of all fighter aircraft involved in spatial disorientation mishaps were destroyed. This presentation will focus on one such fighter mishap, which occurred on 28 January 2013. A four-ship formation of F-16Cs launched at night from Aviano Air Base Italy, on a training sortie over the Adriatic Sea. Weather was a factor, as it precluded their briefed mission, and the formation broke into two 2-ship formations to simulate bomb attacks. The third engagement included a threat reaction against a simulated surface-to-air missile, which forced the mishap pilot to execute an abrupt maneuver which resulted in SD. The mishap pilot radioed that he was spatially disoriented, and attempted to recover. Unable to successfully recover to wings-level flight, the mishap pilot initiated an ejection at approximately 7,000 feet Mean Sea Level, at 570 knots. The pilot was killed in the ejection sequence and the aircraft was destroyed. Many corrective actions were applied as a result of this mishap, including the installation of an Automatic Ground Collision Avoidance System (Auto-GCAS) in all Aviano F-16s, as well as efforts currently underway to improve ejection seat safety.

**Learning Objectives:**

1. Understand the sequence of events that led to a fatal spatial disorientation mishap in the F-16C.
2. Recognize the SD countermeasures applied during this mishap sequence.
3. Comprehend current technological advances to prevent fatalities from spatial disorientation.

**[099] THE OCULOGRVIC ILLUSION REVISITED**

J.R. Stott

Aerospace Physiology, King's College London, Alton, United Kingdom

**INTRODUCTION:** The textbook description of the oculogravic illusion, an apparent upward displacement of objects in the visual scene during acceleration in the line of flight, takes a different form in rotary wing aircraft. Two accident case histories illustrate the severity of this visual illusion in helicopter operations. **METHODS:** The investigation used flight data records and cockpit voice recordings. The circumstances of the

accidents were derived from the reports of the UK Air Accident Investigation Branch. The misperception of the pilots was obtained from debriefing statements from the surviving aircrew. **RESULTS:** In both accidents, on the basis of external visual information, the aircraft were flown into in inadvertent attitudes, in one case a nose-up attitude of 22 degrees, in the other an attitude of 36 degrees nose-down and 36 degrees right wing low. **DISCUSSION:** The conventional description of the somatogravic and oculogravic illusions does not apply in helicopters since in these aircraft there is no source of accelerative force in the longitudinal axis of the fuselage. Rather, the weight vector generated by the upward force of the rotor remains predominantly vertical with respect to the aircraft whatever its attitude with respect to the gravitational vertical. The oculogravic illusion needs to be redefined to take account of the circumstances unique to helicopter operations.

#### Learning Objectives:

1. The somatogravic and oculogravic illusions take a different form in helicopters from the convention description relating to powered fixed wing aircraft.
2. The oculogravic illusion needs to be considered as a disorientation hazard in its own right and should be defined more broadly to take account of its potentially fatal presentation in helicopter operations.
3. This form of the oculogravic illusion should be given greater prominence in the training of helicopter aircrew and also in textbook descriptions.

#### [100] CASE REPORT: U.S. ARMY ROTARY WING SPATIAL DISORIENTATION IN A DEGRADED VISUAL ENVIRONMENT

M. McPherson

*U.S. Army School of Aviation Medicine, Enterprise, AL*

**INTRODUCTION:** In the U.S. Army 31% of helicopter fatalities in the past 10 years spatial disorientation was a factor. The Combat Readiness Center and the Chief of Staff U.S. Army consider spatial disorientation the number one problem in U.S. Army helicopter aviation today. **CASE STUDY:** UH-60 Helicopter flying in Degraded Visual Environment that resulted in significant spatial disorientation.

**METHODOLOGY:** This event was evaluated using aircraft data and presented in animation format. This animation presents an excellent example of UH-60 crew reaction to a spatial disorientation event.

**DISCUSSION:** The specific response by the pilots, air crew coordination and the use of technology to define the extent of spatial disorientation as well as opportunities to address solutions in the force through training while technology solutions are improving will be discussed.

#### Learning Objectives:

1. Describe Spatial Disorientation Event as it related to Military Rotary Wing Aviation with brief discussion of DVE/SD in rotary wing aircraft.
2. Discuss training opportunities related to crew coordination and spatial disorientation.

#### [101] NOVEL AND INTENSE ORIENTATION ILLUSIONS

G.W. McCarthy

*AvMedSafe, Portland, OR*

**METHODS:** 1. A personal experience of severe somatographic illusion will be described. It will be supported by results from an in-flight experiment that verified the Inversion Illusion. 2. The unique acceleration profile of a horizontal launch, vertically ascending rocket plane will be depicted, and the predicted illusion described. The illusion will be intensified, or minimized, by the cockpit window configuration. 3. The operator of an unmanned aircraft system may be subject to an orientation illusion, even though not moving him/herself. As a function of the UAS design, the orientation of the vehicle may be misinterpreted, its velocity vector may be incorrectly perceived, and the situational awareness may be further confused by an on-board video camera, the axis of which can vary in elevation and azimuth. 4. The newest tactical aircraft, the F-35, presents a picture of the terrain to the pilot, on the Helmet-Mounted Display, that may be viewed "through" the floor of the aircraft. Thus, the velocity vector of the aircraft, and the pilot's attentional focus, are uncoupled. This novel system may induce subtle, unnoticed SD if the pilot's attention is channelized on the synthetic tactical terrain depiction. Recommendations for minimizing

SD in these situations include observers for UAS, a Malcolm horizon for spacecraft, and autopilot and/or automatic ground collision avoidance for the F-35.

#### Learning Objectives:

1. Attendees will refine their knowledge of the forces necessary to induce SDO, and the suppressive effect of visual dominance.
2. Attendees will consider the novel orientation problems imposed on pilots of UAS.
3. Attendees will learn the challenges of controlling a horizontal to vertical spacecraft.

#### [102] MODELING IN-FLIGHT HUMAN PERFORMANCE: A NOVEL APPROACH TO EXPLAIN SPATIAL DISORIENTATION

I. Cinelli<sup>1</sup> and P. Souvestre<sup>2</sup>

<sup>1</sup>*Biomedical Engineering, NUI of Galway, Galway, Ireland;*

<sup>2</sup>*NeuroKinetics Health Services, Inc., Vancouver, BC, Canada*

**PROBLEM STATEMENT:** For all Aerospace Specialists, Spatial Disorientation [SD] remains the utmost unresolved in-flight incapacitation to date still neither reliably predictable nor accessible to mitigation. Modeling methodologies developed so far towards unravelling SD genesis are essentially anatomic-physiological restricted to vestibular system based networks dysfunction leading to undependably efficient training-based countermeasures. **BACKGROUND / LITERATURE REVIEW:** In peer-reviewed international bioengineering literature demonstrates that bioengineering modeling is a multidisciplinary approach which requires a multifactorial functional system to optimally simulate a given physical phenomenon. It has been successfully applied to influencing and changing cognitive neurodynamics in human performance. Simulation environment is a well-recognized research tool to better understand complex phenomena, reproducing their physics and estimating behaviour under different conditions. **CASE PRESENTATION:** We propose a novel model to analyse demonstrated neurophysiological and biomedical systemic models such as Fine Postural System and Postural Deficiency Syndrome routinely used in advanced biomedical neuro-traumatology and performance recovery optimization. **OPERATIONAL / CLINICAL RELEVANCE:** Our hypothesis is to redefine in its core SD pathogenesis notwithstanding flight patterns and aircraft types. State of the art neurophysics of human behavior identifies novel cognitive paradigm that allows accounting for an innovative modeling designed to address and resolve conflicts between shared cognitive processing mechanisms, hence allows identifying potential for universal SD countermeasure. Neural networking can be investigated by computational modeling with focus on neural interaction patterns. Complex interactions of sensory-motor, ocular-vestibular and cognitive controls are investigated as perturbations of a neural network from steady condition. Such instrumental approach can effectively contribute to SD research. General mathematical validity of such model aims at reproducing clinical evidence as published in peer-reviewed international bioengineering literature.

#### Learning Objectives:

1. Understand role and nature of interfering chronological sequences in the causation of both sensory-motor and sensory-cognitive dysfunctional patterns in SD.
2. Because in-flight SD patterns are symptomatically versatile and diverse in origin, their underlying and co-morbid factors can be indicated by modeling principles.
3. Using innovative neurophysical modeling in SD research includes flight safety enhancement and incidents and fatalities reduction in all current types of flight operations

#### [103] UK MILITARY SPATIAL DISORIENTATION (SD) TRAINING - HAVE WE GOT IT RIGHT?

I.A. Mollan and C. Barker

*Aviation Medicine Training Wing, RAF Centre of Aviation Medicine, CARTERTON, United Kingdom*

**INTRODUCTION:** One-in-five fatal civil [i], and UK military accidents [ii] are due to spatial disorientation (SD). Over a third of U.S. Army accidents resulting in injury or fatality are caused by SD [iii]. Whilst

the overall accident rate has decreased in the last 30 years, the SD-accident rate is a significant contributory cause of accidents in aviation. The SD accident-rate has remained stubbornly static despite enhancements in cockpit instruments and training efforts<sup>2</sup> [iv]. Theoretical and practical SD training for all UK military aircrew make use of Disorientation Trainers (DISOs) and is delivered under internationally agreed practice at RAFCAM [v]. Notwithstanding this, aircrews with an input into aircraft control and orientation should have the best available training to enhance recognition of disorientation and disorientating situations in order to reduce the risk to life of SD-related accidents. **METHODS:** An examination of current UK military SD training was undertaken. Areas for quality improvement were listed, prioritized and undertaken. Current aircrew across the range of platform types were consulted for advice on the fidelity of technical simulation and enhancement of the disorientation scenarios; air safety occurrence reports were examined for lessons to be learned from risky situations. Communication with the DISO manufacturer was maintained and development improvement work was undertaken. **RESULTS:** The organization of training was changed and some technical limitations resolved. Rotary-wing simulation technical aspects were improved, enhancing fidelity for handling aircrews. Improved platform-specific scenarios were fielded and standardised between instructors. Simple technological enhancements of the visual displays and audio enhanced learning for observing aircrew students. **DISCUSSION:** Continuing refinement of the technological aspects of simulation could be undertaken to match the fidelity and flight characteristics of real aircraft, but is this really required? Accident and near-miss reports remain a key source of information which can be exploited to update learning and enhance aviation safety. Ongoing dialogue with aircrew trainees allows scenario refinement and augments the learning potentials.

#### Learning Objectives:

1. The participant will be able to identify that the all cause accident rate has decreased in the last 3 decades, but that the SD-related accident rate is static.
2. The participant will be able to analyze the steps undertaken in the UK to evaluate modalities and quality of training.
3. The participant will be able to appraise the options and rationale for the further development of these trainings and formulate options for measurement of its success.

**Monday, April 25**  
**Avalon 18-19**

**2:30 PM**

### **S-19: POSTER: A. TRAVEL/TRANSPORT; B. SPACE; C. PUBLIC HEALTH**

**Chair: Craig Kutz**  
*Johns Island, SC*

**Chair: Anita Mantri**  
*Bryan, TX*

#### **[104] QUANTIFYING C-130 OPERATIONAL VIBRATION PATTERNS AND EFFECTS ON PATIENTS**

**D.S. Burch<sup>2</sup>, S.D. Smith<sup>1</sup>, B. Fouts<sup>2</sup> and J.L. Serres<sup>2</sup>**

<sup>1</sup>711 Human Performance Wing, Knowledge Preservation Program (ORISE), USAF, Miamisburg, OH; <sup>2</sup>Aeromedical Research, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

**INTRODUCTION:** The U.S. Air Force aeromedical evacuation (AE) environment includes patient exposures to operational vibration during flight. Such exposures may seriously influence patient comfort, injury management, and recovery. While studies have been conducted to assess vibration effects on military aircrew, research characterizing Air Force AE patient exposures is nonexistent. This study seeks to characterize and assess patient vibration exposure during simulated AE aboard the C-130H Hercules. **METHODS:** During each of six flights, three portable systems will collect acceleration data at the litter and seat interfaces, head, chest, and leg of three volunteer participants (375<sup>th</sup> Aeromedical Evacuation Squadron). Twelve litter locations and six seated locations are targeted for data collection (multiple tiers, left and right sides, forward, mid, and aft cabin areas). The multi-axis spectral

characteristics will identify and compare location, frequencies, and directions of concern. Military and international vibration exposure guidelines will be applied to assess patient comfort and health risk. The study has been approved by the Wright Site Institutional Review Board for human use. Flight tests will commence in December 2015. **RESULTS:** It is expected that the highest vibration will occur at the forward cabin area for both litter and seated patients. Vibration is also expected to be different on the left and right sides of the aircraft for both configurations. The significance of these differences and any effects of tier level will be presented and discussed. **DISCUSSION:** Knowledge gained from this project will improve the ability of the AE community to configure the C-130 airframe to minimize in-flight motion and vibration that may place patients at risk for increased complications related to their condition. The results of this study will be leveraged to inform current practices, expand exposure criteria, enhance patient comfort, optimize health, and improve medical device designs throughout the en route care system. A compendium of the C-130 patient vibration characteristics will enable future laboratory testing with animal-wound models, new litter platforms, and medical devices.

#### Learning Objectives:

1. Participant will learn about the methods being used to characterize litter and seated patient vibration during simulated aeromedical evacuation.
2. Participant will learn about the differences in the multi-axis patient vibration exposure at different locations in the C-130 aircraft.

#### **[105] STUDENT CHARACTERISTICS IN ADVANCED CRITICAL CARE AIR TRANSPORT TEAM VALIDATION BY SERVICE COMPONENT**

**C. Novak<sup>1</sup>, S. Bertsch<sup>4</sup>, T.A. Losekamp<sup>2</sup>, S.F. Dukes<sup>3</sup>, K.N. Eaton<sup>3</sup> and D. Bevington<sup>1</sup>**

<sup>1</sup>C-STARs, USAF, Cincinnati, OH; <sup>2</sup>Aeromedical Research Department, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>3</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; <sup>4</sup>C-STARs, United States Air Force, Hebron, KY

**INTRODUCTION:** Critical Care Air Transport Teams (CCATTs) provide air transportation of critically ill patients. Despite doctrinal directives to ensure qualified candidate selection, a concerning number are unable to successfully achieve validation. This study was developed to identify and describe characteristics of CCATT Advanced Course successful and unsuccessful outcomes. Literature review revealed no research into the CCATT Advanced Course outcomes or educational techniques applied in the CCATT environment. This research builds foundational knowledge for targeted educational interventions that may maximize success. Successful completion of CCATT Advanced Course prevents wasted cost and man-hours of training, time away from home unit, and inability to deploy. **METHODS:** Five years of CCATT Advanced Course demographic records were analyzed. This included, but were not limited to: position, rank, unit, years in practice, and hospital beds. Descriptive statistics identified successful and unsuccessful completion of the CCATT Advanced Course. **RESULTS:** After inclusion criteria were applied, sample size was 762. Eighty-five percent of those individuals successfully validated. There is a 14% overall non-validation rate over the 5-yr period. There was no evidence of differing non-validation rates among the three professional groups: 11% doctors, 16% nurses, 17% respiratory therapists. Small hospitals (<20 beds) had the highest non-validation rate (17.14%). Medium-sized hospitals (100-200 beds) had the highest validation rate (91.25%). Individuals with more experience are more likely to non-validate (experience non-validation: 1 yr = 9.76%, 11-15 yr = 25%). This was statistically significant. Individuals caring for critically ill patients have a statistically significant lower failure rate (12.04% non-validation) compared to individuals who do not (18.46% non-validation). **DISCUSSION:** The results of this study suggest factors that appeared to contribute to non-validation had, in fact, no statistical relevance. These factors may have been mitigation by external events or individual learning styles. Findings may be used to provide the starting point for educational intervention research within the CCATT Advanced Course.

**Learning Objectives:**

1. Routine practice of critical care skills leads to successful completion of the CCAT Advanced Course.
2. No significant difference in CCAT Advanced Course Validation exists between the Active Duty, Air Force Reserves and Air National Guard.

**[106] STUDENT CHARACTERISTICS IN ADVANCED CRITICAL CARE AIR TRANSPORT TEAM TRAINING SUCCESS BY PROFESSION**

S. Bertsch<sup>2</sup>, T.A. Losekamp<sup>1</sup>, K.N. Eaton<sup>3</sup>, C. Novak<sup>2</sup> and S.F. Dukes<sup>3</sup>  
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**INTRODUCTION:** Despite clear tactical doctrine directives and leadership efforts to ensure only the most qualified candidates are selected for the Critical Care Air Transport (CCAT) Advanced Course, a concerning number of students do not successfully validate. Data were gathered to gain insight into the characteristics related to successful validation allowing for the development of targeted recommendations to increase the validation rate. In targeting the appropriate characteristics for team members it helps to optimize the Air Force resources used to provide sustainment training. **METHODS:** A 5-yr (2010-2014) retrospective review of training records maintained by the CCAT Advanced Course was conducted. Demographic data collected consisted of CCAT position, hospital bed size, years in practice, CCAT deployments, access to current allowance standard, current practice setting, time working in an intensive care unit setting, and critical care unit experience. Descriptive statistics helped to identify the characteristics with successful (validation) or unsuccessful (nonvalidation) completion of the CCAT Advanced Training Course. **RESULTS:** Demographic data were compiled by profession into the categories of Medical Doctor (MD), Registered Nurse (RN), and Respiratory Therapist (RT) and then compared. Listed are the greatest percentages and pertinent characteristics for each cohort: 44% of MDs, 38% of RNs, and 50.7% of RTs came from hospitals with less than 100 beds; 51.7% of MDs and 60.6% of RTs had 1-5 yr of experience, while 38% of RNs had 6-10 years of experience; MDs (80.4%), RNs (84.9%), and, RTs (60.5%) care for the critically ill in their current job practice. **DISCUSSION:** Looking at successful validation characteristics for each profession allows for recommendations on how to best prepare each profession for the CCAT Advanced Course. Multiple findings demonstrate unique challenges for students participating in the course; these include limited experience with critical care, newer to their profession, and limited hospital size. The findings from this study may be used to help provide targeted feedback for the course leading to implementations for more successful validation rates and utilization of Air Force resources.

**Learning Objectives:**

1. Recognize the impact on CCAT Advanced Course expectations that a majority of CCAT Advanced Course students are practicing medical care at facilities with less than 100 beds.
2. Understand the impact of CCAT Advanced Course students having recently graduated from their respective training platforms with limited time experience and its impact on course outcomes.
3. Discuss the impact of Respiratory Therapists attending the CCAT Advanced Course without providing significant medical care for the critically ill patient in their current practice and the impact on student outcomes for validation.

**[107] EFFECTIVENESS OF REGIONAL ANESTHESIA FOR EN ROUTE PAIN CONTROL IN PATIENTS WITH TRAUMATIC AMPUTATIONS**

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**INTRODUCTION:** Regional anesthesia (RA) is a component of effective pain management in patients who have experienced acute traumatic injuries. Limited data exist regarding the appropriate analgesic management of military service members undergoing medical evacuation following combat trauma. Our objective was to examine the effectiveness of RA throughout the medical evacuation

process in combat-related trauma. **METHODS:** A retrospective case and control cohort study was completed whereby acutely injured amputee patients were identified through the use of the United States Transportation Command's patient movement database. The Theater Medical Data Store was then cross referenced for additional patient care data to include demographics, opioid consumption, duration of regional technique, pain scores, and rates of intubation. **RESULTS:** All 84 subjects (42 cases and 42 controls) were men with traumatic amputations from improvised explosive device detonation ranging in age from 19-40 yr. Patients were transported from Kandahar Air Field or Camp Bastion, Afghanistan, to the United States by Critical Care Air Transport Teams. Ninety-one percent of the RA interventions remained in place during the 12.5 average days of total transport time. A statistically significant difference was found between opioid consumption between both subject groups during each leg of the air evacuation process ( $p < 0.01$ ). Pain scores were frequently not found in documentation and therefore made statistical comparison inconclusive. Higher rates of intubation were identified in the non-RA group where higher rates of non-documented pain scores were found. Ketamine administration progressively decreased in the control group throughout the evacuation process. A statistically significant difference in the frequency of sedation between case and control subjects was noted. **DISCUSSION:** Our analysis described the utility of RA as a pain management strategy in combat-wounded trauma patients throughout stages of aeromedical evacuation within en route care. Less sedation and less opioid consumption, thereby foregoing the need for intubation in traumatically injured military service members, are just a few of the benefits supported by the data in this study.

**Learning Objectives:**

1. Identify indications for the use of regional anesthesia in wounded military members.
2. Describe characteristics of patients with traumatic amputation being transported within the en route military air evacuation system with regional anesthesia.
3. Name the differences in patients with traumatic amputation transported with a regional anesthesia compared to similar patients transported without regional anesthesia.

**[108] INVESTIGATING THE USEFULNESS OF NOISE IMMUNE STETHOSCOPE TECHNOLOGY IN THE EN ROUTE CARE ENVIRONMENT**

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**INTRODUCTION:** Within healthcare, physical assessments are often conducted in civilian and military environments using conventional stethoscopes. Alternatively, these devices are not efficacious in most military environments due to high ambient noise. Technological advancements have led to the development of devices specifically for auscultation in these high noise environments. Unfortunately, no research has been conducted to investigate the use of a noise immune stethoscope (NIS) in fixed-wing en route care (ERC) environments. Therefore, this project aimed to investigate the use of a NIS for patient care in a simulated ERC environment. **METHODS:** The study was an exploratory descriptive design that included a standardized training session, hands on practice, and utilization on a simulated C-130 fuselage. Ten active duty aeromedical evacuation providers evaluated the NIS device with a subjective questionnaire and provided responses to open-ended questions. Providers conducted pulmonary and cardiac auscultation in each of the device modes on two human subjects in a simulated C-130 high-noise environment. Independent samples tests were conducted to compare the scores between modes, auscultation locations, and the two human subjects. A typology methodology was utilized to analyze open-ended responses. **RESULTS:** The Doppler mode was rated significantly higher than the acoustic mode for cardiac auscultation for both subjects,  $p = 0.014$ ,  $p < 0.0001$ , respectively. During cardiac auscultation, four spots were identified as optimal auscultation points in the female subject and one spot was rated higher in the male subject. Overall, the device received "good" ratings for portability and durability. The qualitative analysis identified five main categories from responses: acoustics, usefulness, mechanics, training, and current

practice. **DISCUSSION:** This study served as a foundation for implementing a stethoscope capable of providing reliable auscultation in high ambient noise environments. To ensure optimal patient outcomes in these environments, it is critical for healthcare providers to have this basic and effective assessment tool to facilitate improved quality of patient care.

**Learning Objectives:**

1. Identify the usefulness of conventional stethoscopes in the en route care environment.
2. Recognize potential technologies to mitigate the effects of noise during auscultation in the en route care environment.
3. Describe indications for the noise-immune stethoscope device during en route care.

**[109] APPLICATION DEVELOPMENT FOR OPTIMIZING PATIENT PLACEMENT IN THE EN ROUTE CARE ENVIRONMENT**

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**INTRODUCTION:** Patient load plan development is a challenging and yet critical element of aeromedical evacuation (AE) missions. AE members designing the load plan must consider a multitude of factors: patient type, injury/illness, acuity, and destination. AE load planners create position assignments for all patients, flight crew, AE crew, non-medical attendees, and additional passengers. This process is completed manually and oftentimes is repeated multiple times due to changes in the load plan. A user-friendly, interactive tool to aid AE personnel in the development of patient load plans would streamline the process by allowing electronic transmission of current load plans to pertinent personnel and improve patient outcomes by ensuring patients are placed in an optimal position based on their condition.

**METHODS:** A proof-of-concept patient load application for optimizing patient placement on AE airframes was developed and implemented on the iOS platform. Phase I of the effort involved the knowledge elicitation of current patient placement practices on frequently used AE airframes. Subject matter experts with expertise in patient load development provided feedback on regulatory guidelines, soft rules, and constraints. Phase II utilized knowledge gained from Phase I and involved the development of a graphical prototype in Microsoft Excel. The initial prototype developed in Phase II was then used to create an electronic application for the Apple iPad using Objective-C. **RESULTS:** A proof-of-concept application was developed and demonstrated on an iPad device. Users select from three AE airframes (C-130, C-17, and KC-135) and may choose the desired airframe layout to arrange patients and equipment accordingly. Currently, input data are pre-loaded and output data are not generated. **DISCUSSION:** By optimizing patient placement practices, patient safety and pain management in AE will likely improve as AE crews will be able to seamlessly determine the optimal patient placement configuration at a moment's notice. Further design optimization is needed to include human factors testing, integration with other AE airframes, and algorithm development to provide placement recommendations to the user.

**Learning Objectives:**

1. Recognize the issues associated with the current process of developing patient load plans within the aeromedical evacuation domain.
2. Identify at least two benefits that implementing an electronic patient load plan application would have on the aeromedical evacuation community.
3. Identify three future research projects that could stem from the development of a patient load planning app within en route care.

**[110] DEVELOPMENT OF A PATIENT LITTER INTEGRATED WARMING AND COOLING SYSTEM**

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**INTRODUCTION:** The treatment of thermal exposure is currently not consistent across medical evacuation platforms. Warfighters deployed to forward operating sites are most vulnerable to complications associated with thermal injury. A patient litter integrated warming/cooling system that can treat and move with the patient through all

phases of medical evacuation, from CASEVAC on the ground to intertheater evacuation is one approach to this problem. **METHOD:** Eight active duty subjects, ages 18 to 30 yrs. participated in the manned assessment of a patient litter cooling/warming system. Human use review and approval was obtained prior to the initiation of this study. Participants lay supine on the modified litter were exposed to maximum and minimum temperatures for 15 min. This device provided 300 W of cooling and 225 W of heating to the participant via a circulating fluid which passes through a mat on a patient litter. Thermocouples measured temperature at the head, mid-torso and foot sections of the mat. The testing environment was maintained at a constant 72°F. **RESULTS:** The cooling and warming patient litter achieved and maintained an average minimum and maximum temperature of  $41 \pm 4$  and  $108 \pm 3$  degrees F, respectively. Additional analysis demonstrated stable once temperature reached asymptote. The system reached maximum and minimum heating and cooling target temperatures within five minutes from commanding a temperature to reaching the target temperature.

**DISCUSSION:** The patient litter the system produced stable warming and cooling within 1 degree Fahrenheit and produced warming and cooling temperatures levels that may prove useful in treating hypo- hyperthermia complications during enroute care.

**Learning Objectives:**

1. Describes an alternative enroute treatment of hypo- and hyperthermia.

**[111] CALCULATED TISSUE OXYGEN DELIVERY WITH AND WITHOUT CABIN ALTITUDE RESTRICTION**

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**INTRODUCTION:** Altitude can impede tissue oxygen delivery (DO<sub>2</sub>) via hypoxia and hypobaria. Cabin altitude restriction (CAR) below 8,000 ft can potentially mitigate the drop in DO<sub>2</sub> during aeromedical evacuation. Despite much discussion, there is little data. **METHODS:** A retrospective review of 100 patients was conducted; 50 were flown with a CAR and 50 without. They were matched with International Classification of Diseases-Ninth Revision codes and, to some extent, aircraft. Patient demographics, inflight status, and overall outcomes were recorded. Using a calculator designed to compute DO<sub>2</sub> (based on well-accepted physiological parameters to include arterial blood gases), preflight values were determined and analyzed with respect to CAR versus non-CAR.

**RESULTS:** Patient demographics and inflight status were not significantly different between CAR and non-CAR groups, nor length of stay, days in intensive care unit, and discharge status; however, CAR patients required significantly fewer postflight procedures (CAR = 4.98, non-CAR = 6.08;  $p = 0.032$ ). Preflight evaluation with calculated DO<sub>2</sub> detected no significant difference between groups. When inflight CAR was factored into the calculation, again no significant difference was identified. However, post hoc effect size computation (*Cohen's q*) strongly suggested an under-powered analysis. Interestingly, calculated arterial/alveolar difference (aka A-a gradient) was inversely related to arterial oxygen partial pressure/fraction inspired oxygen ratio (aka pulmonary shunt ratio;  $\text{PaO}_2/\text{FiO}_2$ ) ( $R = -0.59$ ). **DISCUSSION:** Although this first look at the predictive usefulness of DO<sub>2</sub> in aeromedical evacuation was under-powered, it does not discourage further research. Indeed, it offers a good jumping point for future efforts. In addition, impetus for further investigation into the relationship between A-a gradient and  $\text{PaO}_2/\text{FiO}_2$  ratio is supported by these findings.

**Learning Objectives:**

1. To understand the importance of DO<sub>2</sub> during the aeromedical transport of patients.
2. To understand the physiological underpinning for calculating DO<sub>2</sub>.
3. To understand how DO<sub>2</sub> calculators may be useful in determining the use of cabin altitude restriction during aeromedical transport.

**[112] REAL-TIME PATIENT-PROVIDER COMMUNICATION SYSTEM FOR EN ROUTE PATIENT CARE**

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**MOTIVATION:** Communication with patients is often difficult during flight due to noise, low light and large numbers of patients. Additionally, the communication is not point-to-point (i.e., between a patient and his/her AE crewmember); rather, multiple people can 'listen in' on the conversation. The goal of this study is to identify and test available COTS technology that can: 1) increase effective point-to-point communication between the patient and the provider; 2) provide hearing protection/noise cancellation for the patient; and 3) provide patients with the opportunity to listen to self-selected music. **OVERVIEW:** A total of 10 teams, consisting of 2 members each (simulating a patient/provider team), participated in the study. All team members were outfitted with a communication system that consisted of a Bose active noise reduction (ANR) headset and a portable Android device along with the appropriate interconnection cables. This setup allowed team members to "patch-in" to each other's headset signal in order to communicate without interference from other communication. In the first experiment, team members responded to queries and responses in simulated C-17 and C-130 noise while wearing the new system, and their performance was compared to control conditions where the same tasks were performed wearing EAR earplugs (current standard practice). Two teams participated in similar query-response tasks simultaneously so as to evaluate the effectiveness of the new system to provide point-to-point communication. In a second experiment, listeners were asked to adjust the levels of several samples of music to a "preferred" listening level in the same simulated noises used in the previous experiment. Results indicated that the new communication system outperformed the EAR earplugs in providing effective communication between AE patients and AE providers in addition to diminishing the harmful effects of noise exposure, even while listening to music. **SIGNIFICANCE:** This information will provide evidence needed to improve safety (by reducing noise exposures) and facilitate effective communication for a wide variety of patients.

**Learning Objectives:**

1. The participant will be able to understand how to safely manage and oversee real-time en route care for a wide variety of patients.

**[113] THERE IS A DOCTOR ON THE PLANE! BUT WHERE'S THE AIRWAY EQUIPMENT?!**

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**MOTIVATION:** One in-flight emergency occurs every 600 flights (44,000 episodes annually worldwide). The incidence is rising due to aging populations and increasing numbers of long haul flights. Medical emergencies present many challenges to medical professionals, who volunteer onboard in 75% of instances. While the majority of in-flight emergencies are minor, and amenable to onboard treatment of light headedness/headache, pre-syncope episodes, and gastrointestinal symptoms, 3% actually lead to aircraft diversion, and 0.3% are due to cardiac arrest. The mandated contents of onboard emergency medical kits has not been updated by the FAA since 2004, which lacks advanced airway equipment. Though commercial aircraft are not air ambulances, under such unordinary conditions, they should contain the vital items used daily to save lives in more controlled settings on the ground. **OVERVIEW:** Medical volunteers assisting with in-flight emergencies must quickly adapt to work in unfamiliar conditions with limited resources. If one is skilled at both procedures and airway management, he/she may be needed to place an intravenous line, taking attention away from the airway. An inexperienced provider's inability to deliver effective mask ventilation in an obtunded patient may ultimately contribute to their demise. U.S. commercial carriers are only required by the FAA to have oral airways and a bag-valve-mask resuscitator onboard, both of which require training and experience. The mandated contents of the emergency medical kit was last updated in 2004, just a year after the laryngeal mask airway (LMA) became a critical component of the American Society of Anesthesiologists' "Difficult Airway Algorithm" revision in 2003. **SIGNIFICANCE:** This raises the issue of whether advanced airway equipment should be mandated onboard U.S. commercial aircraft for advanced practitioner use, as they are in Europe. Data supporting ventilation as a major contributor to survival is limited, but withholding the ability to secure an airway by a skilled airway professional in this setting is controversial. With proper direction, any volunteer could

ventilate with an airway in place, freeing up the hands of a skilled professional to further care for the patient.

**Learning Objectives:**

1. Identify what emergency medical equipment is mandated onboard commercial aircraft in the United States. Debate the pros and cons of advanced airway equipment onboard commercial aircraft in the United States.
2. Indicate the challenges of effective in-flight resuscitation.

**[114] DEVELOPMENT OF A HYPOBARIC CHAMBER FOR THE EVALUATION OF THE EFFECT OF PRESSURE VARIATION ON MEDICATION**

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**INTRODUCTION:** A gap in international law exists regarding the effects of pressure variation on medications/cosmetics transported in airplanes, either military or commercial. The expiry date established by the respective manufacturers of these medications continues to be considered valid on aircraft. However, there are reports indicating visual alterations in medicines, even while within the valid expiry date. This study aimed to develop a ground-based equipment for simulation of the pressure conditions that occur inside an aircraft during flight, seeking to determine the effect of pressure changes on medications/cosmetics in order to confirm the safety of their use. **METHODS:** Suitable materials and equipment were chosen for assembly of a hypobaric chamber. After manufacture of the chamber (in acrylic), the compressed air and vacuum connections were defined, and flux valves selected. Subsequently, the microcontroller and sensor communication interfaces, IHM display, power source and valve-driving mechanisms were chosen. **RESULTS:** The hypobaric chamber developed can simulate pressure variations that occur in altitudes between 0 and 33000ft. A compressed air line generates the necessary vacuum to decrease chamber internal pressure through a set of valves and a vacuum pump. A PID-type controller was implemented in order to regulate the chamber's internal pressure, adjusted by the user. The chamber was made to allow visual observation of alterations in medication packaging. This prototype also allowed definition of the climb and descent rates, flight altitude and duration for each phase of the process. Pressure and temperature sensors were connected to the microcontroller's A/D convertor to measure environmental variables. **DISCUSSION:** The constructed hypobaric chamber permits the simulation and monitoring of the pressure variations that occur within an aircraft. A vibration platform is also being developed to submit the medications to the same vibrations that occur during commercial flights, thus determining if the expiry date established by the manufacturing industry can be taken as a reference.

**Learning Objectives:**

1. The participant will be able to know that is possible to build an equipment that permits the simulation and monitoring of the pressure variations that occur within an aircraft that will be use as a tool to determine if the expiry date established by the manufacturing industry can be taken as a reference for pharmaceutical products submitted to internal aircraft conditions.

**[115] REPORTED OCCURRENCE OF CEREBROVASCULAR ACCIDENT IN THE NASA ASTRONAUT CORPS**

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**BACKGROUND:** The development of atherosclerosis is strongly associated with an increased risk for a cerebrovascular accidents (CVA), including stroke and transient ischemic attacks (TIA). Certain unique occupational exposures that individuals in the NASA astronaut corps face are hypothesized to cause changes to the cardiovascular system that may contribute to the development of atherosclerosis and subsequent CVA. The purpose of this study was to review cases of CVA in the NASA astronaut corps and describe the comorbidities and occupational exposures associated with CVA. **METHODS:** Cases of CVA were identified

from review of NASA's Electronic Medical Record (EMR) and death certificates using ICD-9 codes 434 – 436 and string searches of physician notes for text "Stroke," "Cerebrovascular Accident/CVA" and "Transient Ischemic Attack" between 1959 and 2014. Comorbidities, non-modifiable and modifiable risk factors, and a variety of occupational exposures in active and retired astronauts were evaluated based on the hypothesis that they may increase the risk for CVAs. **RESULTS:** Of 338 NASA astronauts selected, a total of nine CVA events (2.7%) were documented. All cases were Caucasian males with military and/or NASA high-performance aircraft training. Three astronauts suffered a transient ischemic attack, three suffered an ischemic stroke, and three suffered a life-ending stroke of unknown type (detail not provided on death certificates). All nine CVA occurrences were initial events; none were recurrent. The average age at the time of CVA event was 70 years (range: mid-40 to mid-80s). Common comorbidities encountered were hyperlipidemia, hypertension, atrial fibrillation, and carotid artery disease. **CONCLUSIONS:** Current astronaut medical selection criteria and preventive measures help to keep the incidence of CVA low. A study is currently in development that aims to examine the differences between the NASA astronaut corps and a matched cohort of United States Air Force aviators in cardiovascular disease outcomes (including CVA) and comorbidities, which will shed additional light on the risk for developing several types of cardiovascular disease that astronauts face as a result of spaceflight.

#### Learning Objectives:

1. Determine whether NASA astronauts are at a higher risk for CVA compared to the U.S. population based on their exposure to radiation, isolation and associated mental stress, extended periods of time in microgravity, high-performance aircraft training, and other relevant occupational exposures.

#### [116] MEDICAL CERTIFICATION OF SPACE TOURISTS - A PROCESS DEVELOPED BY GERMAN AEROSPACE CENTER (DLR) FOR PARTICIPANTS OF SUBORBITAL SPACE FLIGHTS

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**MOTIVATION:** Already today different private companies contribute successfully and effectively to space flight programs of national space flight agencies. Within near future we also expect private suborbital space flights for space tourists to be realized. XCOR, a company based in Mojave, California, who are developing re-usable rocket systems, plan to have the first test flights of XCOR Lynx scheduled within the next 12 months. Since May 2015 DLR (German Aerospace Center) provide the governing medical officers for XCOR. The Institute of Aerospace Medicine, Flight Medicine Clinic will make all final decisions regarding participants' certification to fly.

**OVERVIEW:** The DLR - Institute of Aerospace Medicine in Cologne has been engaged in selection, certification and mission support for all German and ESA (European Space Agency) astronauts since 1977. The Flight Medicine Clinic in addition has a long and successful history of carrying out screening examinations also for commercial and private pilots, air traffic personnel and cabin crew members. The new developed certification process for participants of suborbital space flights - as presented in this poster - defines the organizational structure, medical requirements and recommended training activities based on the specific flight profile of XCOR Lynx. This flight profile involves take-off from the runway reaching 103 km altitude in five minutes. At this point the engines are switched off and the Space Flight Participant (SFP) enjoys six minutes of weightlessness. There is a 40 minute re-entry back to the runway, in which the SFP experiences up to 4 Gz lasting 20 – 30 seconds. **SIGNIFICANCE:** With minor adaptations the process is also applicable to other suborbital space flight systems. Furthermore - as a research project - DLR - Institute of Aerospace Medicine will collect all medical data related to XCOR Lynx suborbital space flights (pre-, in- and post-flight) and use these data sets to gradually modify the medical requirements. In this way an evidence based examination protocol for suborbital space flight participants will be achieved.

#### [117] THE EFFECTS OF HEAD DOWN TILT ON PUPILLARY REACTIVITY IN SUBJECTS WITH IDIOPATHIC INTRACRANIAL HYPERTENSION

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**INTRODUCTION:** The Visual Impairment Intracranial Pressure (VIIP) syndrome is a critical risk for astronauts, but only invasive methods, which carry risks can reliably monitor intracranial pressure (ICP). The primary objective of our study was to assess the utility of quantitative infrared pupillometry for detecting changes in pupillary reactivity related to HDT in subjects with idiopathic intracranial hypertension (IIH), a condition which shares similar ophthalmological findings with VIIP syndrome. We had previously reported on changes in pupillary reactivity with HDT and other maneuvers in healthy subjects. **METHODS:** We obtained approval from Baylor College of Medicine IRB for the study. Our inclusion criteria were: IIH diagnosis, ages 18-55, no history of intracranial masses, or other chronic illnesses. We assessed pupillary reactivity with the NPi-Pupillometer (Neuropics, Irvine, CA) in the upright, supine, 15, 30, and 45 degree HDT positions. The nPI is a composite measure of several parameters of pupillary reactivity and ranges from 0 to 5; 0 indicating no reaction and 5 briskly reactive. **RESULTS:** We enrolled 9 subjects so far (15 target enrollment), and report an interim analysis. The mean age was 35 years (range 25 to 49), 8 women. There was a trend toward decreased nPI from upright and supine positions as compared to 45 degrees HDT; 4.22 vs 4.08, p=0.086 and 4.21 vs 4.08, p=0.066 for pairwise comparisons respectively. There was a significant increase in both the minimum and maximum pupil size in the HDT position compared to supine position (2.8 to 3.4 mm, p=0.011) and (4.1 to 4.9 mm, p=0.015) respectively. There were no significant changes in the constriction velocity, or percentage pupil size (max to min) change by body position. **CONCLUSIONS:** We observed a trend of decreased pupillary reactivity as measured by nPI in IIH subjects during HDT compared to upright or supine positions. The minimum and maximum pupil sizes were higher in the HDT compared to supine position. Further work is needed to determine whether the pupillary changes in HDT as compared to upright and supine position will be useful for monitoring ICP.

#### Learning Objectives:

1. The participant will be able to discuss the relationship between intracranial pressure and pupillary reactivity.
2. The participant will be able to evaluate the diagnostic value of quantitative pupillometry in assessing increased ICP in subjects with IIH.
3. Understand the role of head down tilt for increasing hydrostatic pressure as a method for increasing intracranial pressure.

#### [118] BENEFICIAL AND POSSIBLE ADVERSE EFFECTS OF INTERMITTENT ARTIFICIAL GRAVITY ON ARTERIES OF SIMULATED MICROGRAVITY RATS

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**INTRODUCTION:** Microgravity induced vascular remodeling contributes to occurrence of postflight orthostatic intolerance. As a countermeasure, intermittent artificial gravity (IAG) has showed its efficiency and effectiveness in simulated microgravity rats to prevent microgravity induced vascular remodeling. But further works indicated the increasing possibility of adverse effects of IAG on arterial health of simulated microgravity rats. **METHODS:** A hindlimb unweighting rat model was used to simulate the cardiovascular alterations of microgravity in rats. All detections of rat arteries were taken after 4 weeks hindlimb weighting. **RESULTS:** 1. Daily one hour standing can significantly increasing both apoptosis and proliferation of arterial smooth muscle cells of abdominal aorta and common carotid artery in rats. Compared with simulated microgravity rats, increased TUNEL Staining Positive Cell numbers, enhanced expression of apoptosis molecular markers (BAD, BCL-2, FasL and Caspase-3), and enhanced expression of proliferation molecular markers (PDGFRA, VEGF and PCNA) have been found in IAG rats. 2. The IAG of 1 hour standing daily elevate the level of oxidative stress in rat arteries. The detection results of ROS Fluorescent Probe-DHE demonstrated that compared with control and hindlimb unweighting group, the level of superoxide anions and expression of p22phox increased significantly in middle cerebral arteries, common carotid arteries and abdominal arteries in 1 hour daily standing rats. 3. Daily 1 hour standing may enhance the inflammatory responses in rat arteries. Western blotting and immunohistochemistry staining showed that the expression of

inflammatory responses-related factors VCAM-1, E-selectin, and MCP-1 significantly increased in the abdominal aorta, common carotid and cerebral artery in IAG rats. **DISCUSSION:** The more active vessel remodeling, elevated ROS level and enhanced inflammatory responses may indicate the possibility of adverse effects of IAG on arteries of simulated microgravity rats, and more works are needed in future to elucidate the possible adverse effects of IAG on arterial health. (This work was supported by Natural Science Foundation of China, Grant 30871218, 30971423, 31271279)

#### Learning Objectives:

1. Recognize the effects of microgravity on arterial system, and investigate the beneficial and possible adverse effects of intermittent artificial gravity on arterial system.

### [119] CANCER RATES AMONG MILITARY AVIATORS AND NON AVIATORS

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<sup>1</sup>USASAM/NAMI, U.S. Army, Pensacola, FL; <sup>2</sup>NAVMED ED TRN CMD, U.S. Navy, Pensacola, FL

**INTRODUCTION:** Aviation crewmembers work in an environment with exposure to multiple occupational hazards such as ultraviolet radiation, cosmic rays, jet engine emission and low intensity microwave. Multiple studies have shown increased rates of melanoma, brain, prostate, colon, leukemia, bladder, testicular, and breast cancer amongst aviation crewmembers. This study will compare the rates of the above mentioned cancers between military aviation crewmembers and non-aviation military personnel. **METHODS:** Data was collected from Defense Medical Surveillance System (DMSS) and was stratified by sex and age groups (18-25, 26-30, 31-35, 36-40, 41-45, 46-50, and >50). Person-years, incidence density (IDR) and 95% confidence interval (CI) were calculated for each age group.

Incidence rate ratio (IRR) was used to compare cancer rates between aviation crewmembers and non-aviation military personnel. The statistical significant of the IRR was determined by computing p-value and 95% CI. **RESULTS:**

There was a statistical difference in the overall rate of cancer between female aviators and non-female aviators. The same was also found for breast cancer between female aviators and non female aviators. There was no significant difference in cancer rates between male aviators and male non-aviators and no significant cancer rate difference between pilots that fly helicopters and fixed wing aircrafts. No difference was found between different services.

**CONCLUSION:** There is no significant difference in the incidence of cancer in male aviators and non-aviators. However, it was found that there is a difference in incidence of cancer among female aviators and non-aviators.

#### Learning Objectives:

1. Aviation crewmembers work in an environment with exposure to multiple occupational hazards such as ultraviolet radiation, cosmic rays, jet engine emission and low intensity microwave. Are aviators and aviation crewmembers have higher rates of cancers comparing to non-aviation personnel.

### [120] USE OF HOST NATION TOOLS TO PROVIDE SURVEILLANCE AND RISK COMMUNICATION; AEOLIAN DUST IN SOUTH KOREA AND JAPAN

A.J. Wagner

Theater Preventive Medicine Laboratory, 18 AMDS, APO, Japan

**PROBLEM STATEMENT:** November through May each year Aeolian Dust (a.k.a. Particulate Matter, PM 2.5, PM 10) from arid and industrial regions of China is an environmental health hazard that has the capability to effect service member performance and their families health in Japan and South Korea. High tempo military operations along with limited resources create challenges in monitoring Aeolian Dust events. **TOPIC:** Theater Preventive Medicine Laboratory along with tri-service preventive medicine experts in the Pacific region worked several initiatives related to force health protection, surveillance and risk communication: (A) reviewed past Epidemiology Studies (B) authored U.S. Forces Japan Air Quality Instruction; (C) developed provider CME; (D&E) leveraged Host Nation air monitoring data; (F) utilized of Host Nation models; (G&H) conducted initial dust characterization and medical visit trend analysis; (I) reviewed of scientific literature. A critical review of these efforts took place to make risk management-based recommendations to PACOM Public Health decision makers. Recommendations include: 1) Finalize a regional Joint instruction for U.S. Forces in Japan

and Korea; 2) continued use of host nation tools and web-pages to provide predictions and public service announcements (PSAs); 3) utilize PSAs in a proactive manner to warn, advise and educate; 4) through the review of scientific literature improve provider CME and expand knowledge of PM composition and health trends/impact, and 5) create a current environmental health site assessment that can be documented in each military members longitudinal exposure record. **LESSONS LEARNED:** At no cost, host nation data resources can be leveraged to create products that provide predictions and real-time PM 2.5, PM 10 and Air Quality data to keep the public informed 24 hours a day 7 days a week. Collection of PM exposure data, along with reviews of scientific literature concerning regional dust composition and investigated health trends, can be used to create regional specific documentation for military member's longitudinal exposure records.

#### Learning Objectives:

1. The attendee will understand how host nation data was used to provide health risk information to military members and their families 24 hours and day 7 days a week.
2. The attendee will understand how web-based tools were used to create simple tools to educate, warn and advise military members and the public of precautions needed to take during poor air quality days.
3. The attendee will understand how these monitoring tools could be utilized with existing epidemiology software like ESSENCE to quickly identify medical visit trends.

### [121] THE RATES OF EARLY REDEPLOYMENT IN ARMY PERSONNEL WITH AND WITHOUT MODIFICATION WAIVERS FOR CARDIOPULMONARY CONDITIONS

T. Rund<sup>1</sup>, C. Cronrath<sup>1</sup>, N.M. Solana<sup>1,2</sup>, J. Benincasa<sup>1</sup>, T.H. Cho<sup>1</sup> and J. Venezia<sup>3</sup>

<sup>1</sup>Aerospace & Occupational Medicine Residency, U.S. Army School of Aviation Medicine, Pensacola, FL; <sup>2</sup>United States Army School of Aviation Medicine, Pensacola, FL; <sup>3</sup>U.S. Army - Natick Soldier Systems Center, Natick, MA

**INTRODUCTION:** Over 80% of U.S. Army medical evacuations from the recent wars in Iraq and Afghanistan have been due to disease non battle injury (DNBI) reasons. There is limited published information in regards to Soldiers with medical deployment waivers and the rate of early redeployment. The purpose of this study is to examine the deployment duration and likelihood of early redeployment of U.S. Army Soldiers with a medical deployment waivers for cardiopulmonary conditions which represents a defined strata within a larger study. **METHODS:** This was an IRB approved retrospective review of U.S. Army Soldiers deploying to U.S. Central Command's (CENTCOM) Area of Responsibility (AOR) between Jan 2008 and Dec 2013. Cases were matched to controls at a 1:5 ratio for gender, age, component, rank and deployment date. Soldiers with missing data fields from the medical deployment waiver databases and those medically evacuated from theater for battle injuries were excluded. A conditional logistic regression model was used on the entire matched data set covering all medical and behavioral health strata. Cardiopulmonary strata (N=1,550 matched pairs). The odds ratio for DNBI medical redeployment was calculated with the 95% confidence interval (95% CI). Wald Chi Square Test determined significance at alpha = 0.05 level.

Limitations are largely associated with the limitations of MOD waiver databases. Other limitations include selection bias, changes in CENTCOM policy and its administration over time as well as the use of non-standardized coding for waived conditions. **RESULTS:** There is a statistically significant association with having a cardiopulmonary waiver and being medically evacuated due to a DNBI (p < 0.0001), controlling for the matched variables. The odds ratio was 3.5, with a 95% CI [2.6,4.7].

**CONCLUSIONS:** Although statistically significant, this may not be militarily significant in context with larger military considerations, planning and objectives. This study provides outcome based results related to MOD waiver issuance and medical redeployment. As such, this information can be used by senior military leaders to make decisions and formulate courses of action in context of future military campaign objectives and needs.

#### Learning Objectives:

1. Distinguish between statistical significance and clinical significance and how this must be translated into a military context for operational needs and requirements in support of our nation's defense and strategic objectives.

### [122] RECOMMENDED METHODS FOR MONITORING SKELETAL HEALTH IN ASTRONAUTS TO DISTINGUISH SPECIFIC EFFECTS OF PROLONGED SPACEFLIGHT

L.J. Vasadi<sup>3</sup>, E. Spector<sup>2</sup>, S.A. Smith<sup>2</sup>, G.L. Yardley<sup>2</sup>, H.J. Evans<sup>2</sup> and J.D. Sibonga<sup>1</sup>

<sup>1</sup>Bone & Mineral Lab, NASA Johnson Space Center, Houston, TX;

<sup>2</sup>Bone & Mineral Lab, Wyle Science, Technology and Engineering, Houston, TX; <sup>3</sup>National Biomedical Research Institute, Houston, TX

**MOTIVATION:** NASA uses areal bone mineral density (aBMD) by dual-energy X-ray absorptiometry (DXA) to monitor skeletal health in astronauts after typical 180-day spaceflights. Population studies of osteoporosis have recently demonstrated the insufficiency of DXA aBMD as a sole surrogate for fracture risk. This is a concern for NASA as it attempts to expand fracture risk assessment in astronauts, given the complicated nature of spaceflight-induced bone changes and upcoming longer, 1-year missions. In the past decade, emerging analyses for indices of Bone Quality have been tested in clinical trials; we will present potential uses of these technologies to monitor the biomechanical integrity of the astronaut skeleton. **OVERVIEW:** An advisory panel of osteoporosis policy-makers provided NASA with an evidence-based assessment of astronaut biomedical and research data. The panel concluded that spaceflight and terrestrial bone loss have significant differences and that certain factors may predispose astronauts to premature fractures. Based on these concerns, a proposed surveillance program is presented that: (a) uses Quantitative Computed Tomography (QCT) scans of the hip to monitor the recovery of spaceflight-induced deficits in trabecular BMD for 2 years after return, (b) develops finite element models (FEM) of QCT data to evaluate spaceflight effects on calculated hip bone strength, and (c) generates trabecular bone score (TBS) from serial DXA scans of the lumbar spine to evaluate the effects of age, spaceflight, and countermeasures on this novel index of bone microarchitecture. **SIGNIFICANCE:** DXA aBMD is a widely-applied, evidence-based predictor for fractures, but is not applicable as a fracture surrogate for premenopausal females and males < 50 years. Its inability to detect structural parameters is a limitation for assessing changes in bone integrity with and without countermeasures. Collective use of aBMD, TBS, QCT, and FEM analysis for astronaut surveillance could accommodate NASA's aggressive schedule for risk definition and inform a NASA-developed model that assesses the probability of overloading bones during mechanically-loaded tasks of a mission and with physical activities after return to Earth.

#### Learning Objectives:

1. Understand why the sole measurement of bone mineral density by DXA technology is not sufficient for monitoring spaceflight effects on skeletal integrity of long-duration astronauts.
2. Understand the rationale for transitioning research technologies for skeletal health surveillance in astronauts in the context of NASA's constraints and aggressive schedules.

### [123] DEVELOPMENT AND VALIDATION OF AN IMAGING SYSTEM FOR REGISTERING GROWTH OF PLANTS SUBMITTED TO HYPERGRAVITY

J.M. de Lima<sup>2,3</sup>, R. Coimbra<sup>2</sup>, T. Russomano<sup>3,4</sup> and M.A. dos Santos<sup>1,3</sup>

<sup>1</sup>Pharmacy, PUCRS, Porto Alegre, Brazil; <sup>2</sup>School of Engineering, PUCRS, Porto Alegre, Brazil; <sup>3</sup>Microgravity Centre, PUCRS, Porto Alegre, Brazil; <sup>4</sup>School of Medicine, PUCRS, Porto Alegre, Brazil

**INTRODUCTION:** Studies have shown that plants can grow faster in simulated hypergravity, but none have precisely addressed the impact of hypergravity on the different phases of plant growth. This research developed an image acquisition system capable of monitoring each growth phase of the plants during hypergravity exposure in a centrifuge. **METHODS:** A centrifuge allowing simultaneous observation of 36 samples and 1280 x 1024 pixel cameras with memory cards for image storage were used. An external circuit was designed for the control of the cameras. Supports were developed on which to attach the cameras, so they were always aligned with the plants being monitored, both at rest and during rotation. A synchronization algorithm used through a microcontroller was developed, which

triggered the cameras and allowed simultaneous monitoring of all the samples submitted to hypergravity. The microcontroller features an adjustable time-slicing scheme in order to collect a larger number of images. The imaging system can be powered by battery or by electric mains. **RESULTS:** It was observed that the activity in the initial phases of plant growth was lower, with the moment of germination being the point at which the system captured a greater number of images. The findings obtained through evaluation of the circuit control of the cameras proved that it is an efficient system, with one microcontroller only being able to manage all cameras simultaneously. **DISCUSSION:** The application of hypergravity for the accelerated growth of plants seems to be a very useful and promising tool for both terrestrial and space environments. The developed imaging system allowed different phases of plant growth to be captured. This enabled identification of the growth rate of the plants submitted to hypergravity in comparison to the control group.

#### Learning Objectives:

1. The participant will be able to identify the effect of simulated hypergravity on the differences in growth stages of the plants, through image capture by the imaging system developed.

### [124] NEEDS ASSESSMENT OF TELEMEDICINE IN AFGHANISTAN AND A GLOBAL CALL FOR ACTION FOR AN INTERNATIONAL TRI-PARTNERSHIP MECHANISM

R. Qassimyar<sup>2</sup> and S. Fischer<sup>1</sup>

<sup>1</sup>Public Health, Walter Reed National Military Medical Center, Silver Spring, MD; <sup>2</sup>Healthcare Administration, Assure Senior Living, San Diego, CA

In spite of great progress, Afghanistan continues to face widespread poverty, limited delivery of public services, instability arising from violent extremists, weak governance and corruption. Corrosive effects of the informal economy, traditional hawala finance network and growing influence of the "narco state" exacerbate matters. Afghanistan's health indicators have been near the bottom of international indices. In Afghanistan there is one doctor for every 100,000 people, compared to one for every 365 in France and one for every 500 in the United States. For 35 million Afghan citizens delivery of healthcare services is thwarted by paucity of healthcare providers, regional instability, tyranny of distance and poor transportation infrastructure. Telemedicine and "telementoring" can help remedy this situation if Afghan healthcare leaders are ready. Telemedicine surveys were conducted to determine the perceptions and attitudes on the strength of knowledge of telemedicine utilization within Afghanistan and to determine the current needs of healthcare leaders and community health centers in providing, continuing, and expanding telemedicine services. Databases were searched for primary studies involving telemedicine in Afghanistan: Cochrane Central Register of Controlled Trials, MEDLINE, PUBMED, Ovid, Google Scholar, using the key terms associated with telemedicine: eHealth, telemedicine, developing countries, and Afghanistan. Selection criteria included randomized controlled trials and non-randomized controlled trials and/or studies pertaining to telemedicine initiatives/projects in Afghanistan for the civilian/national population. Electronic search produced a total of 56 records for review. A questionnaire measure for Afghan healthcare leaders was designed and 22 healthcare leaders completed the survey out of 32 healthcare professionals who were provided a link to telemedicine questionnaire, yielding a response rate of 68.8% (22/32). As a result it was determined that public private partnerships are realizing telemedicine in Afghanistan: healthcare capacity building business proposals and a newly established Afghan Telemedicine Society. Afghanistan is ready for Telemedicine and Telementoring.

#### Learning Objectives:

1. Understanding the gaps in delivering a basic package of health services in Afghanistan.
2. Review of Telemedicine Initiatives in Afghanistan.
3. Design of questionnaire measure targeting Afghan healthcare leaders in effort to characterize the readiness to adopt telemedicine and the barriers thwarting implementation of e-health technologies.

Monday, April 25

4:00 PM

Avalon 1-3

**S-20: SLIDE: NECK INJURIES IN AVIATION****Chair: Tim Duffy**  
Bellbrook, OH**Chair: Philippe Souvestre**  
Vancouver, BC, Canada**[125] CLINICIAN ASSESSMENT OF CURRENT SPINAL IMMOBILIZATION TECHNIQUES AND NEUROTRAUMA MANAGEMENT DURING AEROMEDICAL TRANSPORT**R. Khouri<sup>3,1</sup>, R. Kinsler<sup>1</sup>, K. Barazanji<sup>2</sup>, J. Lee<sup>4</sup> and J. Hatzfeld<sup>5</sup>  
<sup>1</sup>USAARL, Dothan, AL; <sup>2</sup>Zymica, Enterprise, AL; <sup>3</sup>NorthTide, Fort Rucker, AL; <sup>4</sup>USAMMDA, Fort Detrick, MD; <sup>5</sup>Combat Casualty Care Research Program, Fort Detrick, MD

**INTRODUCTION:** Anecdotal reports and emerging research have raised concerns that current methods of spinal immobilization during aeromedical transport may be associated with significant morbidity. Other reports suggest aspects of the aeromedical environment (e.g., vibration, immobility) may adversely affect outcome in neurotrauma patients. This report details the results of a survey distributed to clinicians who were involved in operational enroute care during recent conflicts. **METHODS:** Clinicians were invited via email to complete a 50-item internet-based survey aimed at spinal immobilization technologies and neurotrauma patient transport. The survey elicited opinions regarding the effects of current methods of spinal immobilization and characteristics of the flight environment on patient outcome. **RESULTS:** There were 139 respondents to the survey, including medics, corpsmen, nurses, physicians, and other medical professionals. Overall, 59% of respondents believed that environmental stressors, including noise and vibration, influenced patient physiological status. A majority (72%) believed that there could be an association between the challenges of transporting patients with head or spine injuries in ground vehicles and a need for additional sedation. These challenges include the jolts, vibrations, and quick starts/stops during transport of patients. Of the respondents who have never transported a patient, 25% felt improvements need to be made. However, of those who have transported at least one patient in the last five years, 59% felt that spinal immobilization techniques needed to be improved. **DISCUSSION:** While subjective, this survey adds to the case for reviewing current clinical practices in the transport environment. When asked if improvements needed to be made to current spinal immobilization technologies, past experience played an influence in respondents' answers. Aspects of the enroute care environment that could adversely affect outcomes from neurotrauma need further study.

**Learning Objectives:**

1. The participant will be made aware of various concerns with current spinal immobilization technologies and aeromedical transport.

**[126] SPINE FRACTURES RELATED TO CENTRIFUGE TRAINING, TWO CASES**M. Puderbaugh<sup>2</sup> and R. Sumrall<sup>1</sup><sup>1</sup>USAF School of Aerospace Medicine, Peterson AFB, CO; <sup>2</sup>86 AMDS, Wright-Patterson AFB, OH

**BACKGROUND / LITERATURE REVIEW:** Spinal fracture related to +Gz exposure in a centrifuge is rare; one case of L5 compression is reported in the literature. This review summarizes two cases of spine fracture diagnosed after centrifuge training. **CASE PRESENTATION:** The first case was a 32 year old male T-38 pilot undergoing a refresher protocol (max 7.5Gz) after no high-performance aircraft flying for more than 3 years. He completed the session uneventfully and had no complaints. He presented to his flight surgeon 3 days after the training with back pain. After two months of conservative treatment, imaging revealed a 30% anterior wedge compression fracture of L5. DEXA scan

found spinal osteopenia with a T-score of -1.9 (-1 - -2.5 osteopenia). Comprehensive endocrine evaluation (thyroid, PTH, vitamin D, testosterone, calcium) found no underlying cause. Five months after the exposure, he underwent kyphoplasty and did well. He was granted a waiver that excluded ejection seat aircraft. The second case was a 32 year old female flight surgeon. She completed a qualification protocol (max 9Gz) but had complaints of back pain. Initial exam found no focal findings or "red flags," and her back pain considered to be typical for not uncommon low back pain after centrifuge training. Two weeks later, imaging revealed transverse process fractures at L2 and bilaterally at L3. She was treated with a lumbosacral orthotic back brace. Endocrine evaluation (PTH, DEXA) was normal, but vitamin D was low at 19.7 ng/mL (20-30 insufficient, >30 normal). After replacement for 3 months, her vitamin D was 25.1 ng/mL. She had long-term back pain, and is has not returned to aircrew duties as of this writing. **OPERATIONAL / CLINICAL RELEVANCE:** Any aeromedical exposure, training or operational has risks, including +Gz acceleration. Underlying osteopenia may be a risk for vertebral fracture in subjects undergoing +Gz acceleration exposure. Imaging should be done early evaluating back symptoms after centrifuge exposure.

**Learning Objectives:**

1. Review two cases of spine fracture diagnosed after centrifuge training, and the long-term implications.

**[127] THE INCIDENCE AND OPERATIONAL SIGNIFICANCE OF FLYING-RELATED NECK PAIN IN RAAF AIR COMBAT GROUP.**

A. Smith

RAAF Institute of Aviation Medicine, Edinburgh, Australia

**INTRODUCTION:** Neck pain remains a perennial problem for military aircrew despite the many advances made in aircraft capabilities over the years. This paper describes a survey delivered to fast-jet aircrew looking at the incidence and operational impact of neck pain, and describe the factors that contribute to flying-related neck pain. **METHODS:** A voluntary survey was sent to 140 aircrew in RAAF Air Combat Group. The survey explored the 12 month incidence of neck pain, the extent to which aircrew managed their flying schedule to avoid flying with neck pain and the ways neck pain impacted the nature of flying itself, as well as the extent to which neck pain interfered with activities of daily living. The survey also explored neck conditioning practices. This study was approved by the Australian Defence Human Research Ethics Committee. **RESULTS:** Of the 115 completed surveys (82% response), results indicate a 77% incidence of operationally-significant neck pain. 93% of respondents believed their flying had been impacted by flying-related neck pain. 68% admitted to managing their roster to avoid flying due to neck pain for up to 3-5 days. With a second or subsequent episode of neck pain in the year, 47% recommended prescription medication without seeing a doctor, and 86% recommended physical therapy exercises without seeing a physiotherapist. BFM, frequent high-G flying, head-supported mass, and moving the head under G were the factors most commonly linked to flying related neck pain. Restricting head movement under G, avoiding flying, limiting high-G exposures, and electing to not wear NVGs or JHMCS were common reported consequences of flying-related neck pain. Only 61% of aircrew claim to undertake regular neck conditioning exercises; the results indicate that unstructured neck conditioning did not influence the frequency or severity of flying-related neck pain. The Neck Disability Index was a relatively insensitive marker of flying-related neck pain. **DISCUSSION:** This survey offers a new way of quantifying the operational impact of flying-related neck pain, and identifies a number of factors that should be incorporated into a systemic approach to moderating flying-related neck pain in military aircrew.

**Learning Objectives:**

1. Delegates will be able to understand the operational and non-operational factors that contribute to flying-related neck pain.
2. Delegates will be able to understand the importance of assessing aircrew flying behaviors as an adjunct to evaluating the incidence of flying-related neck pain.
3. Delegates will be able to identify a number of flying and non-flying-related activities that should be considered as part of a neck-pain mitigation strategy.

### [128] INTERNATIONAL COLLABORATION FOR DEVELOPMENT OF CERVICAL SPINE HEALTH MAINTENANCE PROGRAM IN AIR AND SPACE CREW

J.A. Jones<sup>1,3</sup>, I. Kozlovskaya<sup>4</sup>, R.A. Scheuring<sup>5</sup>, A. Smith<sup>6</sup>, R. Ramakrishnan<sup>7</sup>, C.M. Perry<sup>8</sup>, A. Ostrofe<sup>9</sup>, R. Filler<sup>10</sup>, G. Gizaw<sup>11</sup>, P. Baumeister<sup>11</sup> and B.S. Shender<sup>2</sup>

<sup>1</sup>Center for Space Medicine, Baylor College of Medicine, Houston, TX; <sup>2</sup>Human Systems, NAVAIR, Patuxent River, MD; <sup>3</sup>United States Navy Reserve, Fleet Logistics Support Wing, Fort Worth, TX; <sup>4</sup>Institute for Biomedical Problems, Moscow, Russian Federation; <sup>5</sup>NASA-JSC, Houston, TX; <sup>6</sup>Royal Air Forces, Melbourne, Australia; <sup>7</sup>Baylor College of Medicine, Houston, TX; <sup>8</sup>Branch Health Clinic Naval Station, Mayport, FL; <sup>9</sup>Naval Station Norfolk, Norfolk, VA; <sup>10</sup>United States Marine Corps, Pendleton, CA; <sup>11</sup>Naval Health Clinic Patuxent River, Patuxent River, MD

**MOTIVATION:** Cervical spine-associated symptoms (sxs) are found acutely in up to 55% of high-performance jet aircraft pilots & ~85% lifetime. Rotary wing pilots also have high rates of cervical & lumbar-associated sxs. Herniated nucleus pulposus has a higher rate of occurrence in the operational aviation community & has occurred repeatedly in astronauts following spaceflight in both the cervical & lumbar regions. **OVERVIEW:** The sxs can result from multiple factors, but repeated exposure to flight is the most significant correlation to both risk & magnitude. Flight stressors include increased g-loading on the spine, esp. in the neck with helmet weight & neck rotation under load, chronic vibratory oscillations & high impact landing events. Multiple prior studies have demonstrated morbidity due to spinal pain which degrade mission performance, decrease operational readiness & result in significant health care expenditures for acute episodes, rehab & for post career disability. While the significance of the health effects have been recognized by international organizations, such as AGARD, a NATO agency from 1952 to 1996, & MMOP, to date there has not been an international collaboration to develop a common program for aircrew & command risk assessment, education, training & exercise countermeasure development, that could be implemented by flight surgeons, physiologists & therapists across all theaters of operational aerospace medicine. **SIGNIFICANCE:** A protocol for the comprehensive study of cervical spine associated sxs & use of a novel cervical exercise device & prescription is now ongoing among Royal & U.S. DOD Air Forces, as well as several space program physicians. The specific aims are to fully characterize the scope & causative factors of cervical spine symptoms, to assess the efficacy & safety of a tailored exercise countermeasure program to prevent or reduce sxs. Objective measures of not only sxs, but also important cervical function parameters such as flexion-extension, side bending & rotary range of motion & endurance are being quantitated. The ultimate goal is to provide a program for cervical spine health maintenance, which can be taught & implemented for air/space crew internationally.

#### Learning Objectives:

1. To recognize that cervical spine health is a significant issue in air and space crew.
2. To understand the factors in the development of spinal symptoms during and after flight.
3. To raise awareness of the possible role that educational and exercise training intervention may play in reducing the frequency and magnitude of symptoms.

### [129] IDENTIFYING NECK INJURY PREVALENCE IN FIGHTER PILOTS-MEDICAL RECORDS REVIEW

M. Cowgill<sup>1</sup>, B. Wright<sup>2</sup>, M. Taylor<sup>2</sup> and J. Serres<sup>1</sup>

<sup>1</sup>U.S. Air Force, Wright-Patterson AFB, OH; <sup>2</sup>Aeromedical Research, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

**INTRODUCTION:** Since the implementation of the fighter jet, pilots have been experiencing neck pain and injury due to the combination of high +Gz and awkward positions (e.g. "check six") experienced during sorties and simulated air combat maneuvers. Anonymous surveys in current literature show self-reported neck injuries occurring in rates ranging from 50-95%, but there has been no standardization to the way fighter pilots prepare for flight. This project

reviews medical records of pilots and determines if there is a statistically significant difference in the occurrence of neck injury in the fighter pilot population. **METHODS:** The problem was addressed by comparing fighter pilots to a control group of fixed-wing pilots, comparing the rate of neck injuries among the fighter jet platforms, and investigating the possible correlation between flight hours and neck injury occurrence. Air Force Personnel Center Air Force Specialty Code was used to define the study population between 2003 and 2012. Age, gender, rank, International Classification of Diseases-Ninth Revision codes, total flying hours, combat hours, and primary aircraft type were used in the analysis. In total, 24,060 subjects with 975,091 medical records and 17,089 flying hours records were compiled for review. Data were analyzed with analysis of variance using statistical software. **RESULTS:** The rate of neck injuries in the fighter pilot group was 2% compared to 1.5% in the fixed wing pilot group ( $p=0.05$ ). The newer platforms were associated with more neck injuries. There was a weak correlation between flight hours and neck injury. **DISCUSSION:** By identifying the significance of the injury rate in the population, steps can be taken to investigate proper training guidelines and interventions to help prevent and treat neck injuries in a susceptible population. The identification of higher rates of injury in certain platforms can lead to an understanding of the true underlying causes of neck injury and support efforts to help prevent injuries.

#### Learning Objectives:

1. Understand that medical records reviews can be used to investigate whether further, more costly research is necessary to address a problem.

### [130] THE USE OF HOME CERVICAL TRACTION TO REDUCE NECK PAIN IN FIGHTER PILOTS

E. Chumbley<sup>1</sup>, N. O'Hair<sup>2</sup>, C. Lienesch<sup>1</sup>, A. Stolfi<sup>1</sup>, B. Wright<sup>3</sup> and J. McEachen<sup>3</sup>

<sup>1</sup>Aerospace Medicine, Wright State University, Dayton, OH; <sup>2</sup>Sky Lakes Medical Center, Klamath Falls, OR; <sup>3</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH

**INTRODUCTION:** Most fighter pilots report cervical pain during their careers. Recommendations for remediation lack evidence. We sought to determine whether the regular use of a home cervical traction device could decrease reported cervical pain in F-15C pilots. **METHODS:** An IRB-approved/HIPAA-compliant, controlled crossover study was undertaken with twenty-one male F-15C fighter pilots from the Oregon Air National Guard between February and June 2015. Twelve fighter pilots completed all facets of the study. Intervention included 6 weeks with a cervical traction device used 10 minutes, 3 times weekly, while control was 6 weeks without traction. Participants logged pain using the Numerical Rating Scale (NRS) initially each day, post-flying, and post-traction. We compared average pain scores between the two time periods, changes in initial pain scores to post flying, and after traction with paired t-tests. **RESULTS:** For fighter pilots who reported an initial daily pain rating  $\geq 1$ , a significant improvement ( $0.4 \pm 0.4$  on NRS,  $p = 0.025$ ) was noted amongst those pilots using cervical traction along with a linear increase in pain relief relative to the amount of pain reported post-flight ( $r = -0.624$ ,  $p = 0.013$ ). We also found a possible reduction of initial daily pain when comparing all participants who completed the study using traction versus not using traction that did not reach statistical significance ( $0.2 \pm 0.5$  on NRS,  $p = 0.168$ ). **DISCUSSION:** To our knowledge, this is the first study of cervical traction to intervene in fighter pilots' cervical pain. We found a small but meaningful average improvement in daily pain rating amongst pilots who used cervical traction during the study. The greater the post-flight pain, the greater the relief with cervical traction. These results help inform countermeasure development directly related to the health and wellbeing of pilots flying high performance aircraft. Further study should clarify the optimal traction dose.

#### Learning Objectives:

1. The participant will identify the inherent risk of neck pain that flying high performance fighters carries.
2. The participant will recognize the use of home cervical traction as a valid modality to minimize the operational impact of neck pain in flying fighters.

**Monday, April 25**  
**Avalon 7-9**

**4:00 PM**

## **S-21: PANEL: PAROXYSMAL NEUROLOGIC DISORDERS**

**Chair: Roger Hesselbrock**  
*Wright-Patterson AFB, OH*

**PANEL OVERVIEW:** Paroxysmal neurologic disorders are among the most worrisome and challenging conditions encountered in aerospace medicine. While some paroxysmal conditions such as seizures are incompatible with aviation or space activities, the outlook for other conditions is not as bleak and may be compatible with resumption of aviation-related activities in selected cases. This panel will present and discuss several paroxysmal neurologic conditions that are commonly encountered by aerospace medical examiners. Conditions to be presented will include "spells" (syncope and seizure), migraine, and transient global amnesia. Dedicated time will be allotted for panel discussion and audience questions after the formal presentations. Audience participants will increase their knowledge about these paroxysmal neurologic conditions, which will improve their evaluation and aeromedical management skills.

### **[131] MIGRAINE**

R.R. Hesselbrock<sup>1</sup> and T. Cook<sup>2</sup>

<sup>1</sup>*Aerospace Medicine Consultation Division, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH;* <sup>2</sup>*United States Air Force, Dayton, OH*

**PROBLEM STATEMENT:** Migraine is a common paroxysmal neurological disorder with significant aeromedical concerns. **TOPIC:** Migraine is a recurrent disorder, with specific diagnostic criteria outlined by the International Headache Society. It affects approximately 12% of the general population, with highest prevalence in the 25-55 age group. Migraine attacks vary in intensity, duration, frequency of occurrence, and in their associated features. **APPLICATIONS:** Migraine is disqualifying for aviation duties, but with appropriate management, many aviators with migraine are able to be returned to flight duties. Aeromedical concerns with migraine include impact on operational safety from the migraine attack itself, medication effects, and risk of recurrence. Aeromedical disposition of migraine is based on attack severity, frequency, absence or presence of associated symptoms such as aura or neurologic deficits, and effects of treatments used for management. The diagnosis, evaluation, treatment options, and aeromedical disposition of migraine will be discussed in this presentation.

#### **Learning Objectives:**

1. List the major aeromedical concerns of migraine.
2. State the International Headache Society criteria for migraine with and without aura, and for migraine aura without headache.
3. List factors that favor a return to fly recommendation for aviators with migraine.

### **[132] TRANSIENT GLOBAL AMNESIA: WHAT ARE THE MEDICAL CERTIFICATION ISSUES?**

J.D. Hastings<sup>1</sup> and M. O'Brien<sup>2</sup>

<sup>1</sup>*Aerospace Neurology LLC, Tulsa, OK;* <sup>2</sup>*United Kingdom Civil Aviation Authority, London, United Kingdom*

Transient Global Amnesia (TGA) is a clinical syndrome first described in 1964. It has a reported overall incidence of between 3.4 and 10 per 100 000 population per year, which includes 23 to 32 per 100 000 per year over the age of 50. It usually affects patients between the age of 40 and 80 years, with an average age of about 60 years. The condition has no male or female preponderance. An episode of TGA is characterized by the abrupt onset of severe anterograde amnesia, which usually lasts between four and six hours. Patients become bewildered and disorientated in time and often place, but never in person. They may question their companions repetitively about their immediate circumstances, due to their inability to retain the information, illustrating the anterograde amnesia for events occurring during the attack, while patients remain able to converse and perform

some routine and accustomed tasks, such as dressing and driving. Recall for events preceding the attack may also be impaired and this retrograde amnesia usually fades with time. However, there remains a permanent dense memory loss for the period of the attack. The clinical criteria for the diagnosis and appropriate investigations are well established and will be outlined. There are three significant aeromedical implications to consider for recertification following an episode of TGA. The first is the possibility of misdiagnosis - that is although the event was diagnosed as TGA, it was in fact the first presentation of epilepsy (transient epileptic amnesia) or a transient ischemic attack. Secondly, there is the association with migraine and hypertension, both of which have aeromedical implications. Thirdly, there is the risk of recurrence of a further episode of TGA. These issues will be discussed and be the basis for discussion. At present there is no international agreement on the recertification of pilots who have experienced an episode of TGA. Hopefully this session will contribute to consensus on criteria for certification.

#### **Learning Objectives:**

1. To describe Transient Global Amnesia and its clinical features.
2. Through strict diagnostic criteria to distinguish Transient Global Amnesia from other transient disturbances of neurological function that can mimic Transient Global Amnesia.
3. To discuss recurrence risk of Transient Global Amnesia and implications of in flight recurrence.

### **[133] THE DIAGNOSIS OF SYNCOPE AND SEIZURES IN AVIATORS**

C.R. Skinner

*Neurology, Ottawa Hospital, Ottawa, ON, Canada*

The evaluation of unheralded loss of consciousness in an aviator is usually grounds for immediate grounding. The differentiation between syncope and seizures is often difficult. In the acute phase, the attending medical staff must make every effort to gather as much information about the sequence of symptoms and signs surrounding the event. This often makes use of eye witness accounts of the event as well as simple clinical observations such as blood pressure and pulse during and after the event are essential. The other main distinguishing features include the presence or absence and type of prodrome, focality of signs, and mental status on regain of consciousness. The second phase of evaluation which usually involves a clinical specialist who will order neuroimaging, ECG, Echocardiogram, Holter, EEG and other appropriate investigations. This presentation will propose a checklist and algorithmic approach which can be of assistance especially for the clinicians involved in the initial evaluation.

#### **Learning Objectives:**

1. To provide flight surgeons a framework for the evaluation of episodes of loss of consciousness in aviators.
2. To provide an algorithmic approach to the diagnosis of syncope and seizures.
3. To provide an approach to the investigation and disposition aviators presenting with an episode of loss of consciousness.

**Monday, April 25**

**4:00 PM**

**Avalon 10-12**

## **S-22: SLIDE: SPECIAL SENSES AND SITUATIONAL AWARENESS**

**Chair: Walter Dalitsch**  
*Antioch, IL*

**Chair: Patricia MacSparran**  
*Edwards, CA*

### **[134] AIRCREW AUDIO SITUATIONAL AWARENESS AND THE EFFECTS OF ENHANCED NOISE PROTECTION**

S.H. James

*Air Division, QinetiQ, Hants, United Kingdom*

**INTRODUCTION:** Whilst UK noise exposure regulations require military personnel to be provided with adequate levels of hearing

protection to ensure compliance with legislative exposure limit criteria, they also guard against 'overprotection' which may isolate operators from their working environment. There is now good understanding of the hearing protection requirements for UK military aircrew but a lack of information regarding the types of audio cues they take from their ambient environment to support flying operations. Without understanding the audio characteristics of these cues it is not possible to define whether enhanced hearing protection systems will inhibit their detection which, in turn, could have implications for operational effectiveness and flight safety.

**METHODS:** A survey covering the aircrew of 19 military air platforms was conducted to build an understanding of the types of audio cues aircrew use. A structured interview technique was adopted and interviews included aircrew of varying roles and experience. The audio cues identified by the aircrew were initially categorized on whether they related to 'safety' or 'situational awareness' and then prioritized to reveal the most critical cues. **RESULTS:** The survey showed that whilst similar audio cues are monitored across platforms and some specific audio cues were identified for individual platforms, the main cue aircrew reported listening for was a change in the normal noise environment; the change acting as a primary indicator that something has happened or is about to happen. Some aircrew also reported that the introduction of enhanced hearing protection had impacted their ability to hear their ambient audio cues. For some platforms this did not significantly impact operations but others found it necessary to remove the additional protection during particular operations or to help fault find during an emergency. **DISCUSSION:** When procuring new aircrew hearing protection solutions to ensure compliance with UK noise exposure legislation, the system must also allow aircrew to continue to hear the audio cues identified during this survey. If enhanced protection reduces certain tonal components without regard to the total audio environment, aircrew may lose key audio cues. It is also important aircrew receive adequate training on how the sound of particular cues may be modified with the new hearing protection and receive sufficient acclimatization to the 'new' listening environment.

**Learning Objectives:**

1. To understand some of the potential implications enhanced hearing protection may have on audio situational awareness.

**[135] OPTIMAL MOTION CUEING (OMC) – OPTIMIZING MOTION PERCEPTION TO ALLOW SIMULATION TO FEEL REAL**

J. Schwandtner<sup>1</sup>, K. Beykirch<sup>1</sup>, W. Kallus<sup>2</sup>, C.M. Talker<sup>2</sup>, M. Mayrhofer<sup>3</sup> and J. Joachimbauer<sup>4</sup>

<sup>1</sup>Research and Development, AMST Systemtechnik GmbH, Ranshofen, Austria; <sup>2</sup>Institute for Psychology, University of Graz, Graz, Austria; <sup>3</sup>Research and Development, AMST Systemtechnik GmbH, Ranshofen, Austria; <sup>4</sup>Sales Department, AMST Systemtechnik GmbH, Ranshofen, Austria

**INTRODUCTION:** Flight simulators are widely used for pilot training. To produce realistic perception, yet stay within the simulator workspace, motion cueing algorithms are required. Many motion simulators still use algorithms based on a so-called classical washout filter (CWF), that attempt to best represent the *physical* aircraft motion acting on the pilot (linear accelerations, angular velocities) with filters to address some perceptual features, i.e. *pilot perception* is not dynamically incorporated. An algorithm, which optimizes perceived pilot motion rather than physical pilot motion should result in more realistic flight simulation. A new algorithm, OMC (optimal motion cueing), was developed, using optimization techniques and incorporating a model of human self-motion perception, to minimize the discrepancy between perceived pilot motion in the simulator and in real flight. **METHODS:** Thirteen private pilots took part in a pilot study, with a development version of the OMC. In the current evaluation study, eight professional pilots are asked to rate the motion quality during four typical flight maneuvers (slip, climb then level, fast turn/divert, turbulence). Each scenario was flown four times and rated on a five-point scale (1-indistinguishable from reality, to 5-worse than no motion, distracting). OMC-I and OMC-II (two parameter sets) were each compared to CWF. The experiments are conducted with ethics committee approval (Univ. Graz). **RESULTS:** The evaluation study will be completed this year and analysis will be completed before presentation

at the scientific meeting. The pilots reported a clear preference for OMC in the debriefing interviews of the pilot study, and rigorous statistical tests for significance of the evaluation study results are planned. Based on this using OMC's development version, a preference for the perception-based cueing is expected. **DISCUSSION:** Optimizing simulator motion to better recreate perception during actual flight should offer better and broader use of simulators in pilot training, leading to both greater mission effectiveness and less simulator sickness. Future studies are planned to extend the results to g-loading scenarios using a centrifugal simulator (Desdemona).

**Learning Objectives:**

1. A new motion cueing approach using perceived pilot motion rather than physical pilot motion was presented. This will increase the quality of motion simulator based training.

**[136] VARIFOCAL LENSES IN FAST JET AIRCREW, AN EQUIVALENCE STUDY**

S.C. Dillard

U.S. Air Force, APO

**INTRODUCTION:** Multi-focal lenses are commonly required by pilots of advancing age. Bifocals are permitted to be worn by aircrew operating all types of UK Royal Air Force (RAF) aircraft. Varifocals are now commonly prescribed, but are not cleared for use in RAF fast jets. Several incidents of varifocals inadvertently being used in fast jets have been noted. Historically varifocal lenses had large areas of distortion at the periphery of the lens. Lens technology has improved, dramatically reducing this peripheral distortion. This is a subjective study with the goal of proving non-inferiority of varifocals to bifocals in fast jet use.

**METHODS:** Eight volunteers with previous fast jet experience and current prescription for multifocal lenses were recruited for the study. After acquiring a pair of each spectacles, they were given at least 1 month ground adaptation period. They were then flown in a Hawk T Mk 1 fast jet aircraft using a sortie profile designed to test their visual perception during multiple aspects of flight. Each aspect of the sortie was flown once in varifocals and once in bifocals. After the sortie the subjects completed a questionnaire. Subjects were asked to rate the ease with which they were able to perform a variety of visual tasks on a 5 point scale. **RESULTS:** One recruited subject failed to adapt to varifocal lenses and was not flown in the study. Of the remaining seven participants, the mean rating for varifocals and bifocals were  $4.46 \pm 0.51$  and  $4.00 \pm 0.78$  with a  $Z = 1.35$  and  $p = 0.176$ . When directly compared, 5 subjects rated the visual tasks easier to achieve with varifocals (Avg 0.8 higher), 2 rated tasks easier to achieve with bifocals (Avg 0.5 higher). Cockpit task during taxi received the lowest rating for varifocals (3.9) while instrument flying received the lowest rating for bifocals (3.0). **DISCUSSION:** Each type of lens holds its own set of limitations, whether it is the area of distortion requiring greater head movement to achieve focus or the line between the lenses obscuring the instrument panel. However, based on a subjective rating of the participants of this study, spectacles with varifocal lenses were not more difficult to use than those with bifocal lenses and there is no evidence of a flight safety or performance decrement associated with their use in flight.

**Learning Objectives:**

1. The participant will be able to identify benefits and deficits of bifocal vs varifocal lens use in aviation.

**[137] DOES INCLUDING YELLOW/BLUE COLOR VISION SCREENING ADD VALUE TO THE PREDICTIVE VALIDITY FOR AVIATION COLOR-CODED TASK PERFORMANCE?**

N. Milburn and T. Chidester

CAMI, Federal Aviation Administration, Oklahoma City, OK

**INTRODUCTION:** The Federal Aviation Administration (FAA) requires red/green (RG) color vision screening for pilots but currently does not require yellow/blue (YB) screening. In each of four recent studies, the Colour Assessment and Diagnosis (CAD) test classified a small percentage of individuals as having anomalous YB CAD standard normal unit (SNU) thresholds, while some participants exhibited both anomalous RG and YB CAD thresholds. The purpose of this study was to determine whether adding YB color vision screening would improve predictive



validity for identifying individuals' ability to perform color-coded aviation tasks. **METHODS:** Forty-eight individuals with color vision deficiencies (CVD) diagnosed as 16 protans, 20 deutans, 3 tritans, and 9 with both RG & YB types of deficiencies, and 47 participants with normal color vision (NCV) performed several color-coded aviation tasks. Those tasks included the signal light gun (SLG), precision approach path indicator (PAPI) lights presented as light-emitting diodes (LEDs) and as incandescent lights, and a typical cockpit display. The pass cut-point for the occupational tasks was set at the 5<sup>th</sup> percentile for the NCV group; however, no errors were permitted to pass the SLG to match the criterion outlined for field testing.<sup>[1]</sup>

**RESULTS:** Consistency between 7 tests (the CAD; the Rabin Cone Contrast full and staircase; the Hardy, Rand, Rittler (HRR); the YB HRR Subset; the Waggoner HRR; and the ColorDx) for diagnosis of normal vs. deficient YB color vision was somewhat disappointing. The NCV vs. CVD diagnoses agreement (Kappa) between the YB HRR Subset diagnosis and the CAD YB diagnosis was very low ( $K_{95}=.237$ ), as was agreement between "fail any vs. pass all" delineations for the 7 YB screening tests vs. the aviation occupational color-coded tasks ( $K_{94}=.284$ ). This was predominantly because most people with CVD have normal YB color vision, but it is their poor RG color vision that causes them to perform poorly on the color-coded occupational tasks. **DISCUSSION:** Modifying the cut-score for the YB HRR Subset (from zero errors to permitting one error) improved agreement with performance on occupational tasks ( $K_{95}=.368$ ), and adding YB screening to the existing RG screening will improve the FAA's color vision screening predictive validity. [1] Title 14 of the Code of Federal Regulations (CFR) Part 67, §67.401, 8900.1

#### Learning Objectives:

1. The participant will understand the relationship between one's color perception, their ability to correctly interpret color-coded aviation tasks, and the need for appropriate screening for pilots.

### [138] OBJECTIVE DIAGNOSIS OF COLOR DEFICIENCY WITH CONE-SPECIFIC VEPS

J. Rabin, A. Kryder and D. Lam

UIW ROSENBERG SCHOOL OF OPTOMETRY, San Antonio, TX

**PURPOSE:** Normal color vision depends on normal red, green and blue (R, G, & B) cones. Hereditary color vision deficiency (CVD; 8% males, 0.5% females) impairs performance and delays reaction time in cue-limited settings. CVD also can be acquired in ocular, systemic and neurologic disease. Most color tests detect CVD but few diagnose type and severity, important for linking performance to real-world operational demands. The computer-based Cone Contrast Test and other new tests diagnose CVD type and severity but require subjective input and are not suitable for young children and patients with cognitive impairment. Our purpose was to develop and evaluate a quantitative, objective test of color vision which utilizes visual-evoked potentials (VEPs) to generate R, G and B cone-specific VEPs for detection and diagnosis of hereditary and acquired CVD. **METHODS:** A Diagnosys LLC VEP system with color LCD display was used to generate cone-specific R, G & B checkerboards on a grey background in pattern onset mode (2 onsets/sec.) based on luminance and CIE chromaticity measures and transforming these values to cone contrasts (Spyder-4 colorimeter). VEPs were recorded from 17 color vision normal (CVN) subjects and 11 CVDs confirmed to be CVN or CVD with a battery of standard color tests. VEPs were also recorded from acquired CVD patients with retinal, optic nerve, and cortical dysfunction. **RESULTS:** Cone-specific VEPs showed 100% sensitivity for detection and diagnosis of CVD and 100% specificity for confirming CVN. R cone (protan) CVDs showed a significant increase in R cone VEP latency (mean increase = 52 milliseconds,  $p<0.004$ ) and decrease in amplitude (mean decrease = 10.4 microvolts,  $p<0.004$ ) but normal green and blue VEPs ( $p>0.31$ ). G cone (deutan) CVDs showed a significant increase in G cone VEP latency (mean increase = 32 milliseconds,  $p<0.001$ ) and decrease in amplitude (mean decrease = 8.4 microvolts,  $p<0.02$ ) but normal R and G cone VEPs ( $p>0.52$ ). Abnormal cone VEPs were found in retinal, optic nerve and cortical disease including traumatic brain injury.

**CONCLUSIONS:** Cone specific VEPs offer a sensitive, objective measure of color vision which readily diagnoses hereditary CVD and detects clinical and sub-clinical defects in acquired CVD from conditions which span the visual system. This novel approach requires only 5-10 minutes and is applicable to infants, young patients, adults and those with cognitive impairment.

#### Learning Objectives:

1. To understand the basis for normal color vision.
2. To understand the basis for abnormal color vision including hereditary and acquired.
3. To understand the importance of using VEPs for objective diagnosis of color vision.

### [139] ASSESSMENT OF SOUND SOURCE PERCEPTION OF HUMAN UNDER NOISE INDUCED STRESS

M. Khan<sup>1</sup>, B.B. Sharma<sup>1</sup>, R. Ohara<sup>3</sup> and A.K. Salhan<sup>2</sup>

<sup>1</sup>Electrical Engineering, Jamia Millia Islamia, New Delhi, India;

<sup>2</sup>Biomedical Instrument Division, DIPAS DRDO (Scientist 'G' Retired), Timarpur, India; <sup>3</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, Dayton, OH

**BACKGROUND:** Sound source perception (SSP) of human refers to ability to classify incoming sensory information into coherent representations of distinct sound sources in the surroundings. Noise induced stress (NIS) disturbs SSP of human and reduces their concentration for a task. Therefore, an attempt has been made to assess impact of NIS on SSP of human subjects. **METHODS:** A sound source device has been designed and developed using piezo speakers, integrated circuit (IC) chips, frequency controller, and various electronic components. Various sets of number of experiments were planned for exposure of sound levels with different frequencies range from 12 KHz to 19.5 KHz with fixed interval of 0.5 KHz. Total 25 human volunteers (15 Males and 10 Females) were asked to score or rate quality of sound perceived and provides their responses in a tabulated form. The 17 subjects have age range from 22 to 32 year and 8 subjects of 50 years plus and none of them have issue of abnormal or defective hearing. Duration of 2 minutes exposure is fixed during experiments on the subjects and performed under noise free environment and with NIS of 30dB. The comparative analysis was done for both the cases. **RESULTS:** The SSP of 17 subjects were assessed as 80 % while SSP of other 8 subjects as 68% under noise free environment. The presence of NIS reduced SSP of 17 subjects to 59.8 % and SSP of other 8 subjects to 49.2 %. **DISCUSSION:** Comparative analysis shows the SSP of human subjects is reduced to 20% with NIS of 30dB as compared to SSP of human subject under noise free environment. Response obtained from older subjects provides information of low SSP and younger subjects have higher SSP in both cases of noise free and induced noise environments. Variation in the frequency spectra also resulted same pattern of SSP in older and younger subjects in both environments.

#### Learning Objectives:

1. Sound source perception of human being at audible frequency range starting from 12 KHz to 19.5 KHz.
2. Effect of age of human being on sound perception under induced noise stress with frequency variations.

Monday, April 25

4:00 PM

Avalon 13-14

### S-23: PANEL: BEHAVIORAL HEALTH AND PERFORMANCE IN HUMAN SPACEFLIGHT

Sponsored by the Space Medicine Association

Chair: Lauren Leveton

Houston, TX

Chair: Steve Vander Ark

Houston, TX

**PANEL OVERVIEW:** BODY: The Behavioral Health and Performance (BHP) group at NASA Johnson Space Center completes both operational support for International Space Station (ISS) missions and manages a portfolio of research to address the BHP risks for future exploration. Since April 2015, BHP has been providing monitoring and support services for the one-year ISS crewmember and his family. The first presentation will include a summary of BHP's results from that experience and how planning may be impacted for future ISS missions. Presentations two and three

will describe BHP Research's recent requirement development projects that specifically inform where BHP may have gaps in their knowledge as mission durations and challenges increase. These include the importance of meaningful work in a spaceflight environment and what support and surveillance may be needed postflight. Presentation four will provide a detailed discussion of BHP Operation's recent activity to review their current approach for monitoring cognitive functioning during spaceflight, and evaluate it against best practices that may inform a new approach to cognitive assessment. Finally, presentation five will provide a summary of BHP Research's ongoing work to identify behavioral health monitoring technologies and capabilities that could be applied in future exploration missions.

#### [140] TITLE: PSYCHOLOGICAL SUPPORT OPERATIONS AND THE ISS ONE-YEAR MISSION

G. Beven<sup>1</sup>, S. Vander Ark<sup>2</sup> and A. Holland<sup>1</sup>  
<sup>1</sup>NASA JSC, Houston, TX; <sup>2</sup>Wyle, Houston, TX

**MOTIVATION:** In March 2015 NASA and Russia embarked on a new era of International Space Station (ISS) utilization, with two of their crewmembers conducting a one-year mission onboard ISS. The mission has been useful for both research and operations to better understand the challenges that may be faced on missions beyond Low Earth Orbit. March 2016 marks the end of the one-year mission and this presentation will provide timely sharing of experiences and lessons learned by NASA's BHP team. **OVERVIEW:** For NASA's one-year mission on ISS, Space Medicine's Behavioral Health and Performance (BHP) group provided pre-flight training, evaluation, and preparation as well as in-flight psychological support for the NASA crewmember and his family. The work completed during the first 42 ISS missions provided the basis for this preparation and support, and our Russian colleagues provided valuable insights from their experience with missions lasting 10-14 months, which predated the ISS era. While the BHP team planned for this mission with the help of all ISS international partners' behavioral health teams to leverage their collective expertise, the U.S. and Russian BHP personnel were responsible for their respective crewmembers. The presentation will summarize the lessons and experience gained within several important areas as determined by this team, including monitoring and managing the following: Work/Rest Schedule; Behavioral Health; Scheduled Time off; Contingency Planning; Crew-Ground Relationships; Enhanced Psychological Support Resources; and Enhanced Communication with International BHP Partners. **SIGNIFICANCE:** The BHP team at NASA had worked closely with the crewmember and his family to define a specific support plan, and remained closely engaged with them for the duration of the mission to modify support and monitoring as required. Further, coordination during the mission with the Family Support Office, Crew Surgeon and Crew Support Astronaut allowed support resources to be modified real-time. The experience gained from this one-year mission will be used to guide future planning and preparation for any future one-year missions, and for exploration missions beyond Low Earth Orbit.

##### Learning Objectives:

1. This presentation will help participants understand the success of the behavioral health monitoring and support activities for crewmembers of a one-year ISS mission and how they differed from what was originally planned and how they differed from a six-month mission.

#### [141] THE ROLE OF MEANINGFUL WORK IN ASTRONAUT HEALTH AND PERFORMANCE DURING LONG DURATION SPACE EXPLORATION MISSIONS

T.W. Britt, K. Jennings, K. Goguen and A. Sytine  
*Psychology, Clemson University, Clemson, SC*

**INTRODUCTION:** The present study examined how engagement in meaningful work may decrease the demands associated with boredom and monotony on LDSEM, as well as buffer astronauts from the negative consequences associated with stressors likely to be encountered on these missions. Although many authors have noted that meaningful work may be beneficial for astronauts on LDSEM, these authors have not detailed the sources of meaningful work for astronauts and how these sources

may differ between astronauts. **METHODS:** In order to more comprehensively address the sources of meaningful work among astronauts on LDSEM, we conducted interviews with nine subject matter experts (SMEs). The job titles of individuals who were interviewed included two former astronauts, a crew psychologist, an operations planner, a flight director, a crew trainer, an analog environment researcher, a capsule communicator, and an Antarctic explorer. Questions addressed the sources of meaning for astronauts, the determinants of astronauts being engaged in meaningful work, and recommended interventions to sustain engagement and meaning. **RESULTS:** SMEs mentioned contributing to humanity, contributing to the mission, and exploration as the most meaningful aspects of their work. SMEs also mentioned overcoming challenges and using their skills and abilities on experiments as meaningful. The most frequent responses to what makes tasks meaningful were the tasks using a variety of skills and not being monotonous, feeling personal control over their schedule and autonomy in the execution of tasks, and understanding the importance of the experiments that were conducted. The SMEs also mentioned being acknowledged and given genuine feedback by the principal investigators, and understanding how the tasks contributed to the "big picture" of the mission. Top recommendations to sustain meaning were the strategic use of social media, giving astronauts autonomy as well as structure, and conducting training during transit. **DISCUSSION:** The interview responses highlight the importance of helping astronauts realize the impact their involvement is having on LDSEM. Future research is needed to evaluate the efficacy of recommendations to enhance meaning during LDSEM.

##### Learning Objectives:

1. Understand the major sources of meaning for astronauts on long duration missions, and recommendations for enhancing astronaut engagement in meaningful work.

#### [142] ASSESSMENT OF ASTRONAUT BEHAVIORAL HEALTH FOLLOWING THE RETURN FROM LONG-DURATION SPACE FLIGHT: CAPABILITY GAPS AND A WAY FORWARD

C.J. Bryan

*National Center for Veterans Studies, The University of Utah, Salt Lake City, UT*

**MOTIVATION:** Space flight occurs in extreme environments characterized by relative isolation, confinement, and crowding, each of which can have a negative impact on the behavioral health and well-being of astronauts. As NASA shifts its focus towards long-duration human exploration missions to asteroids and Mars, increased attention has been directed towards understanding the behavioral health needs of those astronauts selected to participate in these missions. Specifically, rates of behavioral health problems such as depression, anxiety, and neurocognitive deficits are expected to increase concurrent with the length of space flight. **OVERVIEW:** In order to identify potential capability gaps specific to the assessment and monitoring of astronaut behavioral health following return from long-duration space flight, an extensive literature review and series of semistructured interviews with subject matter experts was conducted. The results of this effort identified existing and potential future methods for assessing and monitoring astronauts' behavioral health following their return from long-duration space flight, possible countermeasures to mitigate and offset threats to astronauts' post-mission behavioral health, and recommended directions for future NASA research to address existing knowledge gaps in behavioral health assessment among astronauts. **SIGNIFICANCE:** NASA's current methods for long-term behavioral health assessment and monitoring is therefore considered to be inadequate by many stakeholders: current and former astronauts, behavioral health support staff, and researchers. In light of the anticipated stressors associated with long-duration space flight and the increased likelihood of behavioral health problems afterwards, enhanced methods for identifying and tracking behavioral health is clearly needed. The results of this research provide clear recommendations for NASA operations to improve behavioral health monitoring assessment among astronauts post-mission.

##### Learning Objectives:

1. To identify likely contributors to post-mission behavioral health issues and psychological well-being among astronauts.
2. To identify potential methods for monitoring and assessing astronaut behavioral health post-mission.

### [143] UPGRADING COGNITIVE ASSESSMENT CAPABILITIES ONBOARD THE INTERNATIONAL SPACE STATION

J.J. Picano<sup>1</sup>, K. Seaton<sup>2</sup> and A. Holland<sup>3</sup>

<sup>1</sup>DSLS, USRA/NASA, League City, TX; <sup>2</sup>UTMB/Wyle, Houston, TX;

<sup>3</sup>Behavioral Health and Performance, NASA/JSC, Houston, TX

**MOTIVATION:** Spaceflight poses varied and unique risks to the brain and cognitive functioning including radiation exposure, sleep disturbance, fatigue, toxin exposure, among others. These potential threats to cognitive functioning are capable of degrading performance and compromising mission success. Furthermore, threats may increase in severity, and new types of threats may emerge for longer duration exploration missions. This presentation will describe the process used to identify gaps in our current approach, evaluate best practices in cognitive assessment, and transition new cognitive assessment tools to operational use. **OVERVIEW:** Risks to brain health and performance posed by spaceflight missions require sensitive tools to assess cognitive functioning. The Spaceflight Cognitive Assessment Tool for Windows (WinSCAT) is the automated cognitive assessment tool currently deployed onboard the International Space Station (ISS). WinSCAT assesses 5 discrete cognitive domains, is sensitive to changes in cognitive functioning, and was designed to be completed in less than 15 minutes. However, WinSCAT does not probe other areas of cognitive functioning that might be important to mission success. Researchers recently have developed batteries that may expand current capabilities, such as increased sensitivity to subtle fluctuations in cognitive functioning. Therefore, we engaged in a systematic process review in order to improve upon our current capabilities and incorporate new advances in cognitive assessment. This process included a literature review on newer measures of neurocognitive assessment, surveys of operational flight surgeons at NASA regarding needs and gaps in our capabilities, and expert panel review of candidate cognitive measures and assessment issues and procedures. **SIGNIFICANCE:** Our process and the results that flowed from it may be helpful to aeromedical professionals charged with transitioning research findings to operational use. Our specific findings regarding cognitive assessment tools are of significance to professionals who must assess readiness to perform in mission critical situations in environments involving threats to cognition and performance.

#### Learning Objectives:

1. Participants will understand the process we used to understand gaps to our current approach to cognitive assessment on-board the International Space Station, and transition new cognitive assessment tools to operational use.

### [144] BEHAVIORAL HEALTH AND PERFORMANCE MONITORING TECHNOLOGIES AND TOOLS FOR LONG DURATION SPACEFLIGHT

J. Schneiderman

Behavioral Health and Performance, NASA/Wyle, Houston, TX

**PROBLEM STATEMENT:** To ensure mission success for long-duration spaceflight, it is crucial to monitor the behavioral health and neuropsychological performance of spaceflight crews. **TOPIC:** The spaceflight environment; however, provides unique challenges that the Behavioral Health and Performance (BHP) Element within NASA's Human Research Program is working to address. One of these challenges is that as astronauts are highly skilled and trained experts near the top of the population in terms of intelligence and education, monitoring tools such as neuropsychological tests that are used in other populations often lack the sensitivity to detect changes in the astronaut population. Another significant challenge is that in spaceflight, crew time is at a premium and resources are extremely limited. Additionally, as astronauts face long-duration exploration missions, there is limited utility in repeatedly implementing traditional self-report measures (e.g., lengthy questionnaires).

**APPLICATIONS:** This presentation will review the latest work sponsored and supported by BHP to address these challenges and the development of monitoring tools and technologies for long-duration spaceflight missions, including computerized testing, wearables, and audio, video, and textual analyses. Data will be presented on the development and validation of these tools and technologies, including preliminary results from NASA's Human Exploration Research Analog (HERA) and the NASA Extreme Environment Mission Operations (NEEMO) analog.

#### Learning Objectives:

1. Learn the unique challenges that the Behavioral Health and Performance (BHP) Element within NASA's Human Research Program is working to address for monitoring astronauts.
2. Review the latest work sponsored and supported by Behavioral Health and Performance (BHP) to address these challenges and the development of monitoring tools and technologies for long-duration spaceflight missions.
3. Review data on the development and validation of Behavioral Health and Performance (BHP) monitoring tools and technologies.

Monday, April 25

4:00 PM

Avalon 15-16

### S-24: PANEL: THE FAA'S RESEARCH AND ANALYSIS TO IDENTIFY COMMON INFORMATION REQUIREMENTS FOR EN ROUTE AND TRACON AIR TRAFFIC CONTROLLERS

Sponsored by AsMA Aerospace Human Performance Committee and the Aerospace Human Factors Association

Chair: Jerry Crutchfield

Oklahoma City, OK

Chair: Carol Manning

Oklahoma City, OK

**PANEL OVERVIEW: MOTIVATION:** En Route and TRACON air traffic controllers perform the same air traffic control (ATC) functions using similar systems but different human-system interfaces. Reducing these differences can provide cost savings in system development and training. Moreover, some interface features are only available to one ATC option (En Route or TRACON), although it may be beneficial, from a human performance perspective, to make them available to both. Designing future controller tools that share a common look and feel across options and redesigning legacy tools that foster commonality requires human factors analysis. **OVERVIEW:** The Common Information Requirements (CIR) analysis includes several steps: Identifying En Route and TRACON controller functions and common information requirements and recommending ways to present information to promote convergence of human-system interfaces over time. The results of this work will inform the design/development of common TRACON and En Route systems and decision support tools, enable cost savings, and minimize risks of controller inefficiencies and errors, thereby increasing safety. Including the results of the CIR analysis early in development of new automated tools and decision aids will reduce the risk of costly re-design prior to implementation. **SIGNIFICANCE:** This panel describes the FAA's research to 1) identify information requirements common to controllers in both options, 2) determine which options currently have access to that information, and 3) identify current and future air traffic functions that might be converged on ATC human-system interfaces to provide common information. Jerry Crutchfield will discuss the theoretical basis of the CIR project and the methods used for validating candidate functions. Angel Millan will discuss the development of comparable task analyses used to identify candidate functions that can provide common information about both controller options. Kenneth Allendoerfer will describe methods for prototyping candidate functions on En Route and TRACON displays. Ben Willems will discuss new measurement techniques that can be used to assess the effects of changes to human-system interface information on controller workload and activities.

### [145] COMMON INFORMATION REQUIREMENTS VALIDATION

J. Crutchfield<sup>1</sup>, A. Millan<sup>2</sup>, M. Dworsky<sup>4</sup>, K.R. Allendoerfer<sup>3</sup> and B.F. Willems<sup>3</sup>

<sup>1</sup>FAA Civil Aerospace Medical Institute AAM-520, Oklahoma City, OK;

<sup>2</sup>Cherokee CRC, Tulsa, OK; <sup>3</sup>Human Factors Lab, FAA Technical Center, Atlantic City International Airport, NJ; <sup>4</sup>Engility, Inc., Chantilly, VA

**INTRODUCTION:** Given that En Route and TRACON radar displays evolved over the last 50 years to meet the unique needs of these two controller options, standardizing the two displays for the sake of standardization alone creates the risk of negatively impacting the ability of controllers to perform their jobs. There is reason to believe, however, that some features and functions currently available to only one controller option may provide benefits if also made available to the other option. For example, TRACON spacing tools might be beneficial to en route controllers, and en route flight re-routing tools might be beneficial to TRACON controllers. The same belief exists for proposed NextGen tools such as the interface and symbology provided by the Data Communications (DataComm) program to support controller coordination. **METHOD:** We proposed a list of 14 candidate display features and functions that we presented to subject matter experts (SMEs) for validation. Validation exercises occurred in three phases. During the first phase, PowerPoint slides were used to present the candidate features and functions to three retired TRACON controllers and three retired En Route controllers, who provided feedback and prioritized the list. The second phase consisted of validating and further prioritizing the list of candidate features and functions by presenting them to members of acquisition teams. In the third phase, we provided simulated examples of the selected features and functions to two current TRACON and two current En Route controllers during cognitive walkthroughs. They provided feedback about the features' usability and applicability to their jobs. **RESULTS:** SME feedback led to two features being dropped from the list and a new one being added. SMEs indicated that some features made certain tasks easier but that those tasks were not ones they performed very frequently. We will present the final list of candidate display features and functions and the results of these validation exercises. **DISCUSSION:** We will also discuss the general issues and theoretical background involved in making the displays used by the two controller options include more similar interfaces and allow more common interactions.

**Learning Objectives:**

1. Information requirements for new features and functions should be elicited from qualified subject matter experts who can interact with the features and functions in a context that closely represents the one in which they will be used.

**[146] ANALYSIS OF JOB TASK ANALYSIS FOR AUTOMATION TOOLS: COMMONALITY BETWEEN EN ROUTE AND TRACON**

A. Millan<sup>1</sup> and J. Crutchfield<sup>2</sup>

<sup>1</sup>Cherokee CRC, Tulsa, OK; <sup>2</sup>FAA Civil Aerospace Medical Institute, AAM-520, Oklahoma City, OK

**INTRODUCTION:** A variety of task analyses (TAs) exist describing the job of the air traffic control specialist (ATCS). In these TAs, subject matter experts (SMEs) identified the many activities that ATCSs conduct while interacting with the airspace, ATC systems, and other ATCSs. This information is hierarchically organized in categories such as activities/functions, sub-activities/sub-functions, and tasks. Task analyses provide information to support investigations of safety risks, job efficiency, staffing, tools and training needs. **METHODS:** The objective of this study was to compare TAs conducted for en route and TRACON controller options. This comparison will inform the selection of candidate ATC display features available for one controller option that might also be useful for a second controller option. Recent TAs have either focused only on one controller option or lacked the specific fine-grained details needed to conduct a thorough comparison for display design purposes. For example, Human Solutions Incorporated (HSI) conducted a fine-grained TA for en route operations in 2011 but did not complete similar analyses for any of the other controller options. Also in 2011, American Institutes for Research (AIR) conducted a TA that covered all controller options but did not collect the type of fine-grained details such as task elements, tools, or task frequency and criticality ratings needed to perform the required comparison. Hence, using SMEs, we created a translation between the AIR and HSI TAs for en route. **RESULTS:** Through this translation, we were able to map 1643 out of 1704 task elements from the HSI analysis to all 352 tasks of the AIR en route analysis. By mapping the lowest component of the TAs, task elements to tasks, we were also able to effectively translate all HSI's functions (9) and sub-functions (36) to AIR's activities (11) and sub-activities (42). Results showed consistent compatibility between TAs and feasibility of the translation to

complete the TRACON analysis. **DISCUSSION:** The consistent terminology used by AIR for both ATCS option, allowed us to extend the comparison to AIR's TRACON analysis.

**Learning Objectives:**

1. Understanding of how comparison of task analyses led to information requirements for commonality between air traffic control systems.

**[147] PROTOTYPING AS A MECHANISM FOR COLLABORATION WHEN DEVELOPING COMPLEX SYSTEMS**

K.R. Allendoerfer<sup>1</sup>, B.F. Willems<sup>1</sup> and M. Dworsky<sup>2</sup>

<sup>1</sup>Aviation Research Division, Human Factors Branch, Federal Aviation Administration, Atlantic City, NJ; <sup>2</sup>Engility/TASC, Atlantic City International Airport, NJ

**MOTIVATION:** Existing air traffic control (ATC) workstations and other complex aviation systems were developed by many vendors over many years. As a result, there are many examples of inconsistent and poorly integrated systems in aviation domains. **OVERVIEW:** In recent years, researchers at the Federal Aviation Administration have conducted a series of prototyping studies that examined new functions and human-machine interfaces for ATC workstations. Some studies examined planned upgrades to existing systems or the addition of new capabilities such as Data Communications and Time-Based Flow Management. Other studies examined how to integrate across systems so that the workstation represents a unified and cohesive product rather than a set of independent components. The studies also examined interactions among independent systems and synergistic effects. This body of research informed the Common Information Requirements project discussed by the other members of this panel. **SIGNIFICANCE:** We offer our philosophy and technical approach to prototyping that can be applied to aviation and other complex technological systems, processes, workflows, and procedures. In our view, the goal of prototyping is not the prototype itself. Instead, prototyping serves as a mechanism for researchers, users, engineers, and other stakeholders to collaborate on the elicitation and refinement of requirements. The prototype is a shared artifact of the development team. It allows team members to make explicit their tacit knowledge and ideas. The best prototyping processes also include iterative assessments. The complexity and realism of the prototype increases with each iteration. We find that the best outcomes result from a series of rapid, smaller scale, low-fidelity prototypes and assessments followed by a high-fidelity capstone evaluation at the end of the process.

**Learning Objectives:**

1. To understand how the techniques and philosophy of iterative prototyping can be applied to the development of complex technological systems, processes, workflows, or procedures.

**[148] ASSESSING NEW AIR TRAFFIC CONTROL AUTOMATED SYSTEMS AND PROCEDURES USING NEW MEASUREMENT TECHNIQUES**

B.F. Willems and K.R. Allendoerfer

Aviation Research Division, Human Factors Branch, Federal Aviation Administration, Atlantic City, NJ

**MOTIVATION:** The Federal Aviation Administration have long used Subject Matter Expert (SME) opinion and estimates to assess the impact of new or changed Air Traffic Control (ATC) automated systems and procedures. We have also used measurement techniques to obtain objective data including air traffic controller interactions with ATC systems, system variables, and physiological measures. We surround SMEs with these measures to detect any changes in performance and behavior that may occur with the anticipated updates of the Next Generation Air Transportation System (NextGen). One of the challenges that NextGen faces is the integration of many new data elements, automation functions, and procedures; sometimes across air traffic domains. Assessment of the impact of that integration as part of the Common Information Requirements study described by some of the other members of this panel will require new measurement techniques particularly when measuring air traffic controller workload. When asking controllers to introspect and report

their instantaneous workload, they may compare the operational environment under study with workload they have previously experienced. Because NextGen introduces new concepts, controllers have no previous experience as a reference and may report incorrect workload values. We have found that physiological techniques such as functional Near Infra Red Spectrography (fNIRS) can provide an objective measure of (mental) workload. **OVERVIEW:** During the development and integration of new and changed automated systems under NextGen, subjective assessment of the impact of these changes on controller behavior and performance plays an important role. Subjective workload assessment may not be reliable because of a lack of experience with the changed ATC environment. Physiological techniques such as fNIRS may provide an objective alternative to assess the impact of ATC environment changes on controller workload. **SIGNIFICANCE:** When examining the introduction of changed or new automated systems, one should use subjective measures of workload with caution. Physiological measures such as fNIRS may provide a viable alternative.

#### Learning Objectives:

1. To realize that one should use caution when applying subjective measures of workload to new systems.
2. To introduce the attendee to the ongoing transformation of the Federal Aviation's National Airspace System into the Next Generation Air Transportation System (NextGen).
3. To inform the attendee about the challenge of integrating new data elements, automated systems, and procedures that NextGen will introduce.

**Monday, April 25**  
**Avalon 17**

**4:00 PM**

### S-25: PANEL: GOTHAM CITY READINESS SKILLS VERIFICATION (RSV) FOR FLIGHT SURGEONS

*Sponsored by the Society of USAF Flight Surgeons*

**Chair: Douglas Files**  
*Fairborn, OH*

**Chair: Ann Hoyniak-Becker**  
*Beavercreek, OH*

**Chair: Dale Tidaback**  
*Fairborn, OH*

**Chair: Russell Turner**  
*Fairborn, OH*

**PANEL OVERVIEW: BODY:** This panel will update flight surgeons on issues that affect the safety, health, and well-being of aviators and aviation operations in their local community. Aerospace Medicine professionals may need to act like superheroes at times, protecting the community from harm. The first presentation will be on sanitation and food and water vulnerability assessments. Keeping the airfield food and water resources safe. The industrial shop visit session will follow in the same vein...keeping airfield workers healthy and safe. The third program in this panel will be a travel medicine update, how to prepare aircrew for flying missions outside their local airfield. The fourth program features human factors briefings. The programs link together in that they are about issues that revolve around the airfield proper and support the aviator prior to going afield. They are representative of times when the flight surgeon must work in concert with allied professionals in the community to support aviation operations. Each session will be interactive and informative. This panel affords aerospace medicine professionals the opportunity to do more than learn didactic information. Participants will perform virtual inspections or briefings. We anticipate they will leave the panel better prepared to support the airfield and aviators.

### [149] PUBLIC HEALTH SANITATION, FOOD, AND WATER INSPECTIONS

R. York

*USAF School of Aerospace Medicine, San Antonio, TX*

**MOTIVATION:** Aerospace medicine professionals oversee public health and preventive medicine operations at their worksites. Performing sanitation or food/water vulnerability assessments are often assigned tasks. However, some flight surgeons struggle to participate in these tasks making currency an issue. This presentation will assist aerospace medicine professionals to maintain currency by participating in a prototypical virtual food/water vulnerability inspection. **OVERVIEW:** Aerospace medicine professionals are concerned with the safety, health, and well-being of their populations. Flight surgeons, occupational, and preventive medicine specialists perform sanitation and food/water vulnerability assessments in order to ensure mission completion and flying safety. However, guidelines change and aerospace medicine professionals can lose currency. This program will update aeromedical and allied professionals on sanitation and food/water vulnerability inspection issues by providing an opportunity for individuals to participate in a virtual inspection. **SIGNIFICANCE:** Sanitation and food/water vulnerability inspections should be performed regularly at airfields and other workplaces. Lapses can affect mission completion and flying safety. This session will give preventive medicine and occupational health specialists an opportunity to learn the latest guidelines, tips, and techniques in how to perform these inspections. International professionals will gain insight into United States food and water standards, their use in performing these inspections, and how performing these inspections can positively affect airfield safety and health in their own countries. Thus, all services and all countries will have an opportunity to experience sanitation, food, and water inspections.

### [150] INDUSTRIAL HYGIENE SHOP VISIT

R. York

*USAF School of Aerospace Medicine, San Antonio, TX*

**MOTIVATION:** Aerospace medicine professionals oversee airfield operations that affect the safety and well-being of populations supporting the flying mission. Jointly performing industrial hygiene shop visits with industrial hygienists do just that. This presentation will assist aerospace medicine professionals to maintain currency by participating in a virtual industrial hygiene shop visit. **OVERVIEW:** Aerospace medicine professionals frequently perform occupational health duties. Changing guidelines and standards make it challenging for individuals to maintain currency, especially regarding chemicals. This program will update aeromedical professionals on industrial hygiene shop visits. They will be provided an opportunity to participate in a virtual inspection. They will see how to use toxicology in a shop, what to look for other than toxic substance exposures, and how to pass along knowledge to the worker. The session will benefit international military flight surgeons as well as occupational medicine specialists. **SIGNIFICANCE:** Industrial hygiene shop visits are often performed by occupational health specialists and aviation medicine personnel in their efforts to affect the safety and well-being of the airfield population. These shop visits are common practice in the military, but the cost of sending a doc on these visits can be lost on people that don't see the benefit. All AsMA attendees are invited and will take back to their practice the latest guidelines, tips, and techniques for doing a shop visit as well as an understanding of the importance to the worker, physician, and airfield operations.

### [151] TRAVEL MEDICINE BRIEFINGS

R. York

*USAF School of Aerospace Medicine, San Antonio, TX*

**MOTIVATION:** Aerospace medicine professionals exercise oversight of airfield operations that potentially affect the safety, health, and well-being of populations directly or indirectly supporting the flying mission. However, airfield operations are not always in the nation of origin, thus flight surgeons and the people they support need to be prepared to deploy worldwide. This presentation will assist aerospace medicine professionals to maintain currency by participating in travel medicine research, briefings, and administrative tasks. **OVERVIEW:** Aerospace medicine professionals are concerned with the safety, health, and well-being of the entire airfield population. Duties, tasks and responsibilities of flight surgeons at airfields include being the medical expert. This task is complicated by the wide variety of locations where airfield operations can occur. Medical travel guidelines are always changing. This

program will allow the aeromedical professionals to participate in travel medicine research, briefings, and administrative tasks. **SIGNIFICANCE:** Health risks to aircrew have expanded with global travel. The risks are so great that currency in travel medicine must include participation in research, briefings, and administrative tasks annually. While there are numerous venues for flight surgeons to work and keep abreast of immunizations and health risks, there is no venue that also helps them how to plan and present a briefing on the subject. This program will give national and international aerospace medicine specialists an opportunity to experience the presentation of a travel update that incorporates some of the latest medical guidelines along with tips and techniques on how to do one.

### [152] HUMAN FACTORS BRIEFINGS

R. York

USAF School of Aerospace Medicine, San Antonio, TX

**MOTIVATION:** Aerospace medicine professionals show leadership in the aviation world. Presenting aeromedical issues on health, disease, safety, human factors, and others to aircrew and their support staff is an important skill to practice. This presentation will assist professionals to maintain currency by participating in a human factors briefing. **OVERVIEW:** Aerospace medicine professionals present medical topics to aviators. This can occur during initial flight training, instrument refresher training, during safety briefings, HUD (Head-up Display) tape reviews, etc. This program will reinforce techniques to ensure flight surgeons are successful in presenting human factors topics by providing an opportunity for individuals to participate in a human factors briefing. **SIGNIFICANCE:** We present human factors briefings because of all the causes of aircraft mishaps, controlled flight into terrain (spatial disorientation... a human factor) is the one mishap cause we have been unable to decrease. Aerospace medicine professionals are medical experts. Our role in the aviation community encompasses promoting health and safety in the communities we serve. As such we should expect to be called upon to present medical topics to aviators. The U.S. Air Force has determined that currency in human factors briefings should be performed annually. This will give airmen an opportunity to experience the latest briefing tips and techniques. All attendees will walk away from the presentation with a better understanding of human factors topics and how to communicate the human factors message to aviators.

Monday, April 25

4:00 PM

Avalon 6

### S-26: SLIDE: CLINICAL AVIATION CARDIOLOGY

Chair: Charles Mathers

Galveston, TX

Chair: Robert Orford

Fountain Hills, AZ

### [153] CARDIAC OUTCOMES IN AVIATORS AFTER REVASCUARIZATION FOR CORONARY ARTERY DISEASE: AVIATOR STUDY

W.E. Bennett<sup>2</sup>, T. Toole<sup>2</sup>, V. Skaggs<sup>3</sup>, A. Norris<sup>1</sup>, V.H. Villalaz<sup>1</sup>, J.A. Gonzalez Portilla<sup>3</sup>, A. Cirales<sup>3</sup>, R.W. Farr<sup>4</sup> and D. Hinkley<sup>4</sup>

<sup>1</sup>Civil Aerospace Medical Institute, FAA, Oklahoma City, OK;

<sup>2</sup>Cardiology, Naval Medical Center San Diego, San Diego, CA; <sup>3</sup>FAA, Oklahoma City, OK; <sup>4</sup>NAMI, Pensacola, FL

**INTRODUCTION:** The diagnosis of Coronary Artery Disease and requirement for revascularization is a defining event that temporarily or permanently impacts flight status. The medical outcomes and flight status of aviators following revascularization, has not been evaluated in the era of drug eluting stents. We retrospectively reviewed aviators who underwent revascularization from 2005 until 2015 extracting data from waiver submissions. We evaluated their cardiac risk factors and the proportion of subsequent major adverse cardiac events (MACE) in comparison to the general public and historical rates previously published. **METHODS:**

Information was obtained from the Civilian Aerospace Medical Institute (CAMI), Naval Aerospace Medical Institute (NAMI) and the Armed Forces Health Longitudinal Technology Application (AHLTA). Baseline traditional cardiac risk factors were gathered in all subjects. Additionally, clinical characteristics such as stent type, ejection fraction and medication use were examined. Categorical variables were examined with the Fischer's exact test, while continuous variables were analyzed with the student's t test or rank sum test as appropriate. **RESULTS:** We reviewed 349 subjects, the primary outcome of MACE occurred in 25% of the population, driven largely by revascularization procedures. There were 2 neurovascular events and 1 myocardial infarction. Average time to first MACE event was 1.07 years. Initial review of baseline risk factors suggests BMI, ACE inhibitor use, clopidogrel use, and duration of clopidogrel therapy may be weak predictors of future events. Reclassification of flight status occurred in 17% of subjects after their initial event. **DISCUSSION:** Our review of cardiac outcomes in aviators demonstrates a MACE rate higher than what is reported in the general literature (25% vs 10%). The increased MACE was driven by repeat revascularization procedures, in particular repeat coronary stenting. We hypothesize this higher than previously published MACE rate was driven largely by annual stress testing surveillance required in this population to maintain flight status. The flight status of 74% of the study population remained unchanged at the last waiver submission.

#### Learning Objectives:

1. Understand the rates of revascularization procedures in aviators and understand potential risk factors for repeat revascularization.
2. Understand the impact of repeat revascularization on flight status.

### [154] W/D

### [155] BICUSPID AORTIC VALVE IN AN ASYMPTOMATIC PARACHUTIST – A CASE REPORT

M.L. Anghel<sup>1</sup> and R.D. Hristea<sup>2</sup>

<sup>1</sup>Head of Expertise and Specialty Medical Assistance, National Institute of Aeronautical and Space Medicine, Bucharest, Romania, Bucharest, Romania; <sup>2</sup>General Manager, National Institute of Aeronautical and Space Medicine, Bucharest, Romania

**PROBLEM STATEMENT:** This case report describes a young military parachutist, very well trained, asymptomatic, who was diagnosed at his annual medical exam with bicuspid aortic valve (BAV). **BACKGROUND / LITERATURE REVIEW:** Adequate natural history data of BAV, with studies of large numbers of subjects and long-term follow-up, are lacking in paratroopers. Aeromedical concerns are related to complications (significant aortic stenosis and/or insufficiency, ascending aortic dilation). Risk of a sudden incapacitating event is very low and aeromedically acceptable in the absence of complications (there are no other well-documented suddenly incapacitating events of concern associated with BAV). According to USAF regulations, all trained aviators with BAV are followed-up closely with serial echocardiography, regardless of baseline regurgitation or stenosis, with potential disqualification of the aviator late in his or her career due to associated significant AS or AI, valve surgery, or aortic complications. **CASE PRESENTATION:** The studied subject was a 26-yr old Romanian parachutist in a very well trained unit. He performed his annual medical exam at N.I.A.S.M, Bucharest. The subject had no pathology in his medical history, had no relative with significant disease or sudden death. He performed sustained and strenuous physical training. Clinical exam was normal (with no aortic murmurs). Laboratory testing was normal, except for a mild hypokalemia. ECG revealed minor non-specific T waves changes that led to further investigations. Doppler echocardiography showed suggestive aspect of athlete's heart, bicuspid aortic valve and mild aortic regurgitation. Exercise stress ECG testing and Holter ECG 24 hours were normal. CT angiography – aorta revealed mild ectasia of aortic sinuses with no dilatation of ascending aorta. Prognosis in this case is good. After completion of medical investigations, he returned to his activity, with annual follow-up (including CAD risk factors evaluation) and serial Doppler echocardiography every 2 years. **OPERATIONAL / CLINICAL RELEVANCE:** This case highlights the possibility to diagnose a relative rare disease in a young parachutist asymptomatic, apparently healthy and the importance of serial monitoring for evidence of disease progression and complications. We need larger studies to better understand potentially harmful effects of high-level strenuous activities on parachutists with BAV to subsequently help prevent heart injury.

**Learning Objectives:**

1. Understand the aeromedical implications of bicuspid aortic valve in asymptomatic paratroopers.

**[156] VASODEPRESSIVE SYNDROME OF FIGHTER PILOT - A CASE STUDY**T.K. Leino<sup>1</sup> and R. Sovelius<sup>2</sup><sup>1</sup>*Air Force Command Finland, Tikkakoski, Finland;* <sup>2</sup>*Centre for Military Medicine, Finnish Defence Forces, Pirkkala, Finland*

**PROBLEM STATEMENT:** Medical standards for military pilot who has pacemaker due to vasodepressive syndrome. **BACKGROUND:** Vasodepressive syndrome can lead to unconsciousness without any warning symptoms. During vasodepressive attack autonomic nervous system response will lead to asystole and vasodilatation. **CASE PRESENTATION:** 40-yr-old male F/A-18 fighter pilot of the Finnish Air Force fainted for 30 sec during morning shower in December 2009. In January 2010 during 24 h-Holter monitoring he fainted again after wake-up (25 sec asystole was recorded with spontaneous recovery). DDD pacemaker was chosen by cardiologist after second vasodepressive syndrome episode. Year 2015 flight physical findings were: RR 102/77, BMI 23 (172 cm, 68 kg), non-smoker, max bicycle test Vo<sub>2</sub> 54.6 ml/kg/min, PEF 570 ml/sec, ECG: sinus rhythm and gradus 1 AV-block. Neurological evaluation normal (EEG normal) and glucose tolerance test was normal. Rapid decompression test up to 22 000 ft was normal and normal pacemaker function after chamber test was checked. In test flight with two-seated F/A-18D there were no electromagnetic interference. Centrifuge run with rapid on-set profile to +8 Gz was done and DDD pacemaker function was normal after centrifuge run. No vasodepressive episodes has been reported during DDD pacemaker treatment. **OPERATIONAL RELEVANCE:** If documented asystole is over 20 sec, DDI or DDD pacemaker is primary treatment. In our case report pilot did not experienced any vasodepressive syncope episodes after DDD pacemaker attachment. Waiver was granted to the military pilot to fly single seated fighter after operational risk assessment.

**Learning Objectives:**

1. In vasodepressive syndrome pacemaker is one of the safe treatment options also for fighter pilots.
2. DDD pacemaker is validated up to +8 Gz acceleration.
3. DDD pacemaker is validated up to 22 000 ft cabin altitude.

**[157] EDUCATION: CASE STUDY: SEVERE ASYMPTOMATIC MITRAL REGURGITATION IN A NAVAL FLIGHT OFFICER**E.R. Vaught<sup>1</sup>, R.J. Carpenter<sup>2</sup> and J.T. Lavan<sup>1</sup><sup>1</sup>*Residency in Aerospace Medicine, Naval Aerospace Medicine Institute, Pensacola, FL;* <sup>2</sup>*Internal Medicine, Naval Aerospace Medicine Institute, Pensacola, FL*

**PROBLEM STATEMENT:** This presentation describes a case of severe mitral regurgitation (MR) in a Naval Flight Officer with discussion of the aeromedical implications. **BACKGROUND/LITERATURE REVIEW:** In military aviation, one out of every 250 aviators meets the echocardiographic criteria for mild MR. Causes of MR include rheumatic heart disease, mitral valve prolapse, coronary artery disease, bacterial endocarditis, mitral annular calcification, left ventricular dilation, and other rheumatologic disorders. As MR worsens there is reduction in cardiac output, increased left ventricular filling pressure, and ultimately pulmonary hypertension leading to nonischemic heart failure. Left ventricular ejection fraction is preserved in low-normal (50-60%) range. The natural length of progression from mild to severe MR is unknown, and is highly variable, but cardiologists estimate the natural progression is greater than ten years. The estimated 5-year risk of death is 22% in all patients with untreated asymptomatic severe MR and in pilots may lead to sudden incapacitation in flight from tachyarrhythmias and heart failure. **CASE PRESENTATION:** A 26 year old active duty naval flight officer presented for continuation of a waiver for previously diagnosed asymptomatic mild MR. Repeat echocardiography showed a jet area of 48cm<sup>2</sup> and retrograde flow velocity of 558.5 cm/s consistent with moderate MR and a severely dilated left atrium. She was permanently disqualified from aviation duties and is currently being evaluated for surgical repair. **OPERATIONAL / CLINICAL RELEVANCE:** This case highlights value of echocardiographic monitoring aircrew with MR. A previous Air Force study showed a 0.3% risk of sudden incapacitating

events in flight in pilots with echocardiographic MR findings. Further, in high performance aircraft personnel, there is concern for MR causing reduced +Gz tolerance and +Gz-induced tachyarrhythmias. Finally, left atrial enlargement and atrial fibrillation, diagnosed in 42% of severe MR patients, increases the risk of venous thromboembolism which may lead to rapidly incapacitating chest pain and dyspnea caused by pulmonary emboli.

**Learning Objectives:**

1. Discuss the clinical signs and symptoms of patients with mitral regurgitation.
2. Review the Doppler echocardiographic findings and severity classification system associated with mitral regurgitation.
3. Discuss the aeromedical implications of an aviator with mitral regurgitation.

**[158] ROLE OF FUNCTIONAL ASSESSMENT IN CORONARY ARTERY DISEASE**

B. Haaff, R. Quast and S. Roelcke

*Aeromedical Center Germany, Filderstadt, Germany*

**BACKGROUND:** One task of aviation medicine is to judge the level of risk that can be tolerated but it is nearly impossible to discern which pilots "at risk" will have a coronary event in the immediate future. Moreover, medicine is not able to determine which lesion in an individual will rupture, resulting in an acute MI, and even in the cases we have a coronary angiography it is difficult to decide whether a stenosis is hemodynamically significant or not. But this decision is crucial. There are two different approaches to evaluate functional relevance of CAD: the assessment of myocardial perfusion under stress [A] and the measurement of FFR [B]. **METHOD:** Medline analysis: availability and prognostic value of FA. **RESULTS:** [A] A high number of single and multicenter studies have proved the excellent sensitivity and specificity of stress-CMR for diagnosis of CAD [B] Fractional Flow Reserve (FFR) = accurate assessment of hemodynamic significance, FFR can be expressed as the ratio of maximum blood flow after coronary artery stenosis to maximum blood flow. Coronary artery lesions with FFR ≤ 0.80 have been proved to receive benefits from revascularization while, in a setting of a stenosis with a FFR > 0.80, the patient can be safely deferred to optimal medical treatment [13, 14]. Noninvasive Approach. The new Fractional Flow Reserve by Cardiac Computed Tomography (FFR-CT), results from 3 prospective multicenter trials have validated the accuracy of FFR-CT as compared to invasive FFR [86-88]. [C] Intravascular imaging (IVUS/OCT), no robust prognostic data available. **CONCLUSIONS:** In cases with not critical coronary stenosis functional assessment of a coronary stenosis is indicated to clear the hemodynamic relevance. With proven prognostic value this can be done invasively by the FFR, noninvasively by a stress-MR. Only in stenosis with hemodynamic relevance PCI is done. If the stenosis shows no hemodynamic relevance the prognosis - regardless of the angiographic visual impression - is not restricted. Thus, an angiography should be complemented by a functional assessment. A promising, non-invasive method is the FFR-CT, but the prognostic value needs to be further investigated. An OCT is useful in the technical implementation of a PCI, the prognostic significance is unclear. The functional assessment should be implemented into aviation medicine rules, the functional significance determines, not the visual impression of a coronary stenosis.

**Learning Objectives:**

1. Stress-MR as non-invasive method is appropriate to recognize the hemodynamic relevance of a coronary stenosis.
2. FFR is the appropriate invasive method to recognize the hemodynamic relevance of coronary stenosis.
3. FFR and Stress-MR are the methods for proven prognostic value about the significance of coronary stenosis.

**TUESDAY, APRIL 26, 2016***Tuesday, April 26  
Wildwood 27-28***8:00 AM****3RD ANNUAL REINARTZ LECTURE***Frank K. Butler, Jr., CAPT (Ret.), MC, USN***"The Top Ten Lifesaving Advances in Aeromedical Evacuation from 14 Years of Conflict"**