

of how to deliver feedback will also be modeled and practiced, so participants in the workshop can practice effective feedback. Finally, identifying barriers to giving feedback will enable participants to mitigate situations that inhibit feedback.

#### Learning Objectives

1. Learning Objectives 1. Understand the critical importance of effective feedback in resident education.
2. Name the three pillars that establish an environment where feedback can flourish.
3. Learn how to identify and mitigate barriers to feedback.

#### [424] TARGETED ROTATION COORDINATION TO OPTIMIZE EDUCATIONAL QUALITY AND COMMUNITY EFFICIENCY

Paul Newbold<sup>1</sup>

<sup>1</sup>USAF School of Aerospace Medicine, Oklahoma City, OK, USA

(Education - Program/Process Review)

**BACKGROUND:** Due to the unique curriculum requirements surrounding the specialty, most ACGME-accredited residency programs in Aerospace Medicine require the accomplishment of certain rotations via locations other than their home facility (remote). As a result, multiple residency programs send multiple groups of residents to these locations at various times throughout the academic year. **OVERVIEW:** The community of ACGME-accredited Aerospace Medicine residency programs currently consists of just three military and two civilian programs, which combined graduate less than 40 board-eligible Aerospace Medicine specialists per year. This number is quite small when compared to other specialties such as Family Medicine, or even Occupational Medicine. Most programs include remote experiences such as the Johnson Space Center (National Aeronautics and Space Administration) and the Civil Aviation Medical Institute (Federal Aviation Administration) as core components of their curricula. **DISCUSSION:** The purpose of this presentation is to explore ways for all current ACGME-accredited residency programs in Aerospace Medicine to establish synchronized remote experiences, thereby facilitating the attendance of these rotations by residents from several programs during the same blocks of time. The coordination of remote rotation schedule blocks across multiple programs clearly presents a challenge. However, successful execution driven by proper planning would likely provide a more robust remote educational experience for residents and minimize the frequency of potential workflow interruptions for institutions hosting these rotations.

#### Learning Objectives

1. The participant will consider which specific remote rotations are common to most residency programs in Aerospace Medicine.
2. The participant will explore the advantages, limitations and challenges surrounding the attendance of a remote rotation by residents from multiple programs.

#### [425] AEROSPACE MEDICINE IN AN MPH CURRICULUM - NAVIGATING EDUCATIONAL HURDLES OUTSIDE THE CLASSROOM

Thomas Jarnot<sup>1</sup>

<sup>1</sup>Wright State University, Dayton, OH, USA

(Education - Program/Process Review)

**BACKGROUND:** Accreditation Council for Graduate Medical Education (ACGME) Program Requirements for Graduate Medical Education in Preventive Medicine stipulate that "residents must complete a master's degree program in public health (MPH) or another equivalent degree prior to completion of the residency program". Coursework in Biostatistics, Epidemiology, Environmental Health, Health Services Management, and Behavioral Aspects of Health are required components of such curricula. Remaining course work to meet graduation requirements varies among programs and electives in specialized areas of study are common. **OVERVIEW:** Integration of Aerospace Medicine (ASM) centric courses as part of a broader MPH curriculum exists to varying degrees in ASM residencies. Inclusion of such didactics represents an opportunity to introduce specialty concepts and augment the fund of knowledge gained by residents during practicum rotation experiences. **DISCUSSION:** Incorporation of Aerospace Medicine courses in an MPH curriculum provides a flexible yet focused didactic learning environment

for residents than can be tailored to the needs of the residency program. These advantages can be of significant benefit during periods of change that affect practicum experiences including rotation availability, mode of delivery, funding, and other modifications beyond the control of the residency program.

#### Learning Objectives

1. The participant will learn current approaches to MPH curricula for residency programs that incorporate ASM subject material.
2. The audience will be able to identify opportunities to incorporate areas of didactic ASM study that can augment practicum rotations while striving to meet ACGME graduation requirements.

### MONDAY, AUGUST 30, 2021

Monday, 08/30/2021

8:00 AM

Plaza Ballroom

OPENING CEREMONIES & 66<sup>TH</sup> ANNUAL LOUIS

H. BAUER LECTURE

Brig. Gen. Paul Friedrichs

The Urgency of Doing

Monday, 08/30/2021

10:30 AM

Governor's Square 14

#### [S-03]: PANEL: COGNITIVE PERFORMANCE TESTING FOR THE AEROSPACE ENVIRONMENT

Chair: Ryan Mayes

Co-Chair: Richard Arnold

**PANEL OVERVIEW:** The aerospace environment poses multiple challenges to pilots and other operators; one of the most important challenges is high cognitive demand. Consequently, tests that accurately capture cognitive performance relevant to the aerospace environment are necessary for use in selection and classification, medical screening, training, and research. This panel will present several different tests used by various U.S. federal aeromedical labs and aviation support functions; for each test, development, validity, and implementation will be discussed. The Naval Air Warfare Center Aircraft Division will present SYNWIN, which is used in aviation research. NASA will present MAT-B. The Navy Medical Center Portsmouth will present the Cog Screen tool used in aeromedical evaluation. The US Air Force School of Aerospace Medicine (USAFSAM) will present Microcog, which it uses in its evaluation of aviators. USAFSAM and the Institute for Human and Machine Cognition will present a newly developed cognitive test designed to aid in sensor development, followed by a comparison of the novel assessment to existing tools. Finally, the panel will lead a discussion comparing the various cognitive tests.

#### [4] SYNTHETIC WORK (SYNWIN) PROGRAM TO TRACK COGNITIVE CHANGES DURING HYPOXIC STRESS

Barry Shender<sup>1</sup>, Gregory Askew<sup>1</sup>, Jeremy Beer<sup>2</sup>, Stephen Coleman<sup>1</sup>, Carla Mattingly<sup>1</sup>, Michelle Warren<sup>1</sup>, Phillip Whitley<sup>3</sup>

<sup>1</sup>Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; <sup>2</sup>KBR Space & Mission Solutions Group, Brooks City-Base, TX, USA; <sup>3</sup>Criterion Analysis, Inc., Miami, FL, USA

(Education - Tutorial/Review)

**PROBLEM STATEMENT:** When developing an aircrew monitoring system to mitigate physiologic episode risk, it is critical to relate changes in physiological response to degraded cognitive state. NAWCAD uses SynWin (ver 1.2.39, ARS, Chula Vista, CA) to track this in real time. **TOPIC:** SynWin (3) provides a generic work environment where subjects are required to remember and classify items on demand, perform an arithmetic task, and monitor and react to visual and auditory prompts. It presents four simultaneous tasks on a

computer screen, one per quadrant. Subjects use a mouse to enter responses. Each task is customizable for difficulty and data sampling rate. The tasks are: 1. Sternberg memory task (SMT): Displays a string of 2-6 upper-case letters for 5s, which subjects memorize before disappearing. Then, a single letter randomly appears (up to 20s), and subjects indicate if it was part of the string or not. Score is based on accuracy, reaction time (RT), misses, and peeks (displays the string). 2. Math task: A self-paced task to add 2-3 random three-digit numbers, using a mouse to enter the sum. Score is based on accuracy and response time (RESP). 3. Visual monitoring task: Subjects are presented with a gas gauge that they must click to "refill tank" before it is empty. Points are awarded proportional to proximity to 0 and are deducted for each second the pointer is at 0. Score is based on the number of lapses and how consistently the gauge is reset. 4. Audio vigilance task: Short individual tones (1000Hz and 2000Hz) are presented for 0.15s every 10-20s. The task is to click a button when subjects detect the higher pitch. Score is based on accuracy, RT, and misses. A Composite score is calculated as the sum of the four task scores. **APPLICATIONS:** Over 100 datasets have been collected under normo-baric and hypobaric exposures up to 7620m since 2014 (1). Math accuracy and RESP are the most sensitive to these exposures. For example, in a 2018-19 hypobaric study with nine consented volunteers exposed to 5335m while breathing air, math score dropped by  $52 \pm 27\%$  and RESP increased by  $62 \pm 58\%$  vs. SMT score increasing by  $8 \pm 30\%$  and RT rising by  $9 \pm 20\%$ . Math metrics have been used along with real-time changes in pulse oximetry as inputs to a USN neurological model (2) to develop an index of cognitive degradation (3). **RESOURCES:** (1) AMHP 2017. 88(7): 616-26; (2) IEEE Trans BME 1988. 45: 1017; (3) Behav Res Meth Inst Comp 1994. 26(4):421-6; (4) AMHP 2019. 90(3): 249

#### Learning Objectives

1. To understand how SynWin has been used to quantify cognitive deficit during hypoxia exposures.
2. To understand how multitask instruments that provide continuous feedback are more appropriate to determine correlations between real-time changes in physiology and cognitive performance.

#### [5] USING THE NASA MULTI-ATTRIBUTE TASK BATTERY WITH PSYCHOPHYSIOLOGICAL ASSESSMENT

Kellie D. Kennedy<sup>1</sup>, Chad L. Stephens<sup>1</sup>, James R. Comstock<sup>1</sup>, Nicholas Napoli<sup>2</sup>, Alan T. Pope<sup>1</sup>, Eric T. Chancey<sup>1</sup>

<sup>1</sup>NASA Langley Research Center, Hampton, VA, USA; <sup>2</sup>University of Florida, Gainesville, FL, USA

#### (Education - Tutorial/Review)

**INTRODUCTION:** The Multi-Attribute Task Battery (MATB-II) developed at NASA Langley Research Center (LaRC). The MATB is a computer-based task designed to evaluate operator performance and workload. MATB provides a benchmark set of tasks and analogous to activities that aircraft crewmembers perform in flight, with freedom to use by non-pilot subjects. The performance of multiple tasks is a central feature of the MATB and it is this feature that is consistent with most operational systems and thus makes the task useful for our purposes as a research platform. Development of the original and current MATB as well as implementation of the biocybernetic capability will be covered. **TOPIC:** The MATB requires rapid task-switching to perform monitoring, dynamic resource management, and tracking tasks in near-simultaneous operation with a composite score calculated from the sum of the four task scores. **System Monitoring:** Simulates the demands of monitoring gauges and warning lights. **Tracking:** Simulates the demands of manual flight control to keep the target at the center target point. **Communications:** Determine which messages are relevant and to respond by selecting the appropriate radio and frequency on the communications task window. **Resource Management:** Toggle any of the eight fuel pumps to maintain balanced fuel and respond to pump failures. **APPLICATIONS:** The MATB has been used in hundreds of studies to examine work behavior or sustained performance across various research subdisciplines and in applied settings such as the hypoxia training environment. One use configured the automation state of the Tracking subtask to be driven by an operator engagement

index derived from EEG in real-time. This novel capability enabled brain-computer interface methodologies to expand into adaptive neurotechnologies. The closed-loop configuration allowed psychophysiological assessment of cognitive performance and real-time adaptation of the sub-task difficulty levels in response to the operator engagement state. The results of previous studies will be presented to demonstrate the efficacy of MATB as a research tool across a wide range of application areas. The potential applications of MATB as a standalone test for cognitive performance testing will be considered. Additionally, the possibility of combining the MATB with other cognitive performance tests will be discussed. Finally, a discussion of conceptual MATB configurations will be included in the proposed presentation.

#### Learning Objectives

1. To understand how to use the MATB-II for subject response data.
2. To understand the various application of the MATB-II for subject response data.
3. To understand the use of the subtasks within the MATB-II.

#### [6] THE USE OF A MOBILE COMPUTERIZED NEUROCOGNITIVE SCREENING TEST TO DETERMINE RETURN TO FLIGHT AFTER NEUROLOGIC INSULT IN NAVAL AVIATORS

Shawwna Chee<sup>1</sup>, Veronica Bigornia<sup>2</sup>

<sup>1</sup>Naval Medical Center Portsmouth, Portsmouth, VA, USA; <sup>2</sup>USS Harry S. Truman, Norfolk, VA, USA

#### (Education - Program/Process Review)

**INTRODUCTION:** Subtle neurocognitive changes after neurologic insults can be missed through gross medical examination, particularly in high functioning personnel such as aviators. A situation where an illness or injury has an adverse impact on cognitive functioning is where neurocognitive assessment is indicated. Neurocognitive evaluation data has provided both general and specific information about current levels of cognitive performance and can indicate level of recovery or need for further treatment. **TOPIC:** The US Navy has conducted research to determine cause and potential future ramifications of cognitive changes due to Physiologic Episodes (PEs) with military pilots in high performance aircraft. In order to return to flight following a PE, a pilot must be asymptomatic from all physical and neurocognitive symptoms. One way to assess cognitive recovery from these symptoms is comprehensive neurocognitive testing, however most comprehensive testing lasts several hours and far from the environment where military aviators fly. Screening tests can indicate if more comprehensive evaluation is even necessary. Computerized screening tests can be administered by trained medical personnel deployed with aviators such as aerospace medicine technicians or flight surgeons embedded in squadrons or aboard aircraft carriers. A detailed review of a mobile, computerized neurocognitive screening test will be discussed, including historical development, extensive normative data collection, recent operational validation studies and its use in research with hypoxia and rapid cockpit pressure fluctuations. The successful application and implementation of this test in Naval Aviation to determine an aviator's ability to return to flying after neurologic insult while deployed to remote operational environments will be reviewed. **APPLICATION:** Neurocognitive testing has been shown to be sensitive and specific for subtle cognitive changes in pilots after neurologic insult. Utilizing brief, computerized neurocognitive screening tests in the operational environment can determine if further evaluation is required to decrease downtime for an aviator and overall disruption of the mission. Data show the successful implementation of this computerized screening test is a key component to determine when a pilot who suffered neurologic insult requires medical evacuation or can return to flying.

#### Learning Objectives

1. The participants will be able to state how computerized cognitive screening tests can be used for an aeromedical determination in a deployed environment.
2. The participants will identify ways neurocognitive assessment applies to aviation.

**[7] TEST-RETEST RELIABILITY OF THE US AIR FORCE PERFORMANCE ASSESSMENT TOOL**Ryan Mayes<sup>1</sup>, Jeffrey Phillips<sup>2</sup><sup>1</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA;<sup>2</sup>Florida Institute for Human-Machine Cognition, Pensacola, FL, USA*(Original Research)*

**INTRODUCTION:** In an attempt to develop a rapid cognitive-perceptual task that is sensitive to the effects of stressors while also having high operational face validity, the U.S. Air Force School of Aerospace Medicine (USAFSAM) developed the Performance Assessment Tool (PAT). The PAT is designed to rapidly assess cognitive performance and is based on a cognitive task analysis specific to aviation; this analysis suggested that four tasks would be sufficient to measure the cognitive attributes required for aviation: tracking, math, short-term memory, and mannequin. PAT development occurred in three iterations, the second was tested in an academic setting; this informed the third iteration, tested here. PAT is a computerized test that requires "multi-tasking," there is a primary tracking task with simultaneous presentations of three different secondary tasks. The current study was performed to provide an evaluation of PAT (version 3)'s test-retest reliability across twenty sessions conducted over two days. **METHODS:** Twenty-five student Naval Aviators at Naval Air Station Pensacola, FL participated in the study. All were men with ages ranging from 22 to 29 years ( $M = 23.48$  years,  $SD = 1.56$  years). Participants performed 24 iterations of the PAT across two days. Several dependent variables were assessed, including performance on tracking, math, mannequin, memory, and two composite scores called PAT Composite and PCOLA Composite (PCOLAC). Cronbach's alpha was calculated as a measure of internal consistency or reliability for each variable across the last ten Day 1 sessions, across the last ten Day 2 Sessions, and across 20 sessions. **RESULTS:** Day 1 reliability scores were generally low. By contrast, Day 2 scores were higher: Cronbach's alpha for the PAT Composite Score was 0.733, with PCOLAC=0.927 and Tracking=0.917. Reliability analysis across the 20 sessions from Days 1 and 2 shows good reliability for Tracking (0.890) and PCOLAC (0.811). **DISCUSSION:** PAT variables possessed low reliability across the first 10 sessions completed during Day 1. Conversely, the reliability of PAT improved dramatically across the second ten sessions completed on Day 2. PCOLAC and PAT Tracking showed excellent reliability, while the PAT Composite showed good reliability. In total, the results demonstrate that PAT possesses high internal consistency, and is more than adequate to use in human performance and stress work.

**Learning Objectives**

1. Understand the attributes of a novel rapid cognitive performance assessment task.
2. Discuss the reliability of a novel rapid cognitive performance assessment task.

**[8] Criterion Validity of the Air Force Performance Assessment Tool**Jeffrey Phillips<sup>1</sup>, Ryan Mayes<sup>2</sup>, Brittany Neilson<sup>2</sup>, Sabrina Drollinger<sup>3</sup>, Steven Linnville<sup>4</sup><sup>1</sup>Florida Institute for Human and Machine Cognition, Pensacola, FL, USA;<sup>2</sup>U.S. Air Force School of Aviation Medicine, Wright-Patterson AFB, OH, USA;<sup>3</sup>Naval Aerospace Medicine Institute, Pensacola, FL, USA; <sup>4</sup>Parsons,

Pensacola, FL, USA

*(Original Research)*

**INTRODUCTION:** The purpose of the current study was two-fold: 1) to determine the Performance Assessment Tool (PAT)'s sensitivity to the performance effects of hypoxia exposure at two levels of workload (high and low) and 2) to establish criterion validity by comparing the PAT at two levels of workload to hypoxia effects measured by the CogScreen Visual Sequence Comparison (VSC), which has been previously established as being sensitive to hypoxia. **METHODS:** Twenty-five student Naval Aviators at Naval Air Station Pensacola, FL participated in the study. All were men with ages ranging from 22 to 29 years ( $M = 23.48$  years,  $SD = 1.56$  years). Participants performed three cognitive tasks (PAT low workload/tracking only, PAT high workload/multitasking, and CogScreen VSC) across three trials during a normoxia session first and then again for three trials during the hypoxia session that followed. **RESULTS:** Three 2 (normoxia vs. hypoxia) x 3 (trial)

Factorial Repeated-Measures Analysis of Variance were computed for performance on each task (PAT low workload/tracking only, PAT high workload/multitasking, and CogScreen VSC). The analysis of hypoxia effects across the two PAT variables of interest showed significant and large effects. Tracking only (low workload) resulted in a significant main effect for hypoxia,  $F(2,24) = 18.194, p < .001$ , partial  $\eta^2 = .43$ . The composite score of full PAT performance (high workload) showed a significant main effect for hypoxia,  $F(2,24) = 14.630, p = .001$ , partial  $\eta^2 = .362$  and a significant stress by time interaction  $F(2,48) = 3.477, p = .039$ , partial  $\eta^2 = .127$ . CogScreen VSC showed a significant hypoxia effect,  $F(2,24) = 27.218, p < .001$ , partial  $\eta^2 = .564$ , but did not show a significant hypoxia by time interaction. **DISCUSSION:** The PAT is sensitive to the performance effects of hypoxia across both high and low workload measures. The observed stressor by time interaction for full PAT suggests that hypoxia performance effects get larger as time at altitude increases. CogScreen VSC showed the highest effect size but was not sensitive to the cumulative effect of hypoxia associated time at altitude.

**Learning Objectives**

1. Understand what it means for a measure of human performance to possess criterion validity within the context of aviation related environmental stress?
2. Understand the important characteristics that measures of human performance must possess in order to be relevant in aviation environmental stress testing.
3. Understand how to determine whether human performance effects found in research are relevant to a given operational context?

**Monday, 08/30/2021**  
**Governor's Square 15****10:30 AM****[S-04]: SLIDE: THE CORONA-COASTER****Chair: Marian Sides****Co-Chair: Wilfred Lim****[9] COVID-19 AND AIRLINE CREWMEMBERS. INITIAL ASSISTANCE EXPERIENCE.**Justin Devlin<sup>1</sup>, Paulo Alves<sup>1</sup>, David Farnnie<sup>1</sup>, Neil Nerwich<sup>2</sup><sup>1</sup>MedAir Inc., Phoenix, AZ, USA; <sup>2</sup>International SOS, London, United Kingdom*(Original Research)*

**INTRODUCTION:** Crewmembers could be particularly exposed to Covid-19, given their peculiar activity. Opportunities for contact with infective people occur with their interaction with passengers, other crew colleagues and within the communities they live or layover. This study aims to understand the epidemiology of COVID-19-related cases affecting airline crewmembers during the early period of COVID-19 Global Pandemic. **METHODS:** The database of company providing assistance services to airline crews was reviewed for Covid-19 related cases from 03/01/20 to 05/03/20. Demographics (age, gender, crew type), clinical and operational data were collected for each case. Cases seeking just educational information and not specifically related to the presence of symptoms nor to a potential exposure were excluded. **RESULTS:** 235 cases (71/30.2% pilots and 164/69.8% flight attendants) from 24 different airlines representing 10 countries were available for analysis. Most cases (138/58.7%) were from US based carriers, followed by Australia (32/13.6%), Canada (25/10.6%) and UK (21/8.9%). In 104 (44.3%) of the times the crewmember was away from home. 209 (88.9%) individuals presented with symptoms. Two asymptomatic cases tested positive. 94 crews presented no symptoms, 80 (38.3%) one symptom, 40 (19.1%) two symptoms and 16 (7.7%) reported 3 or more. Most common symptoms were fever/chills (72/34.4%), cough (70/33.5%), and sore throat (60/28.7%). Anosmia was reported by 2 (1.0%) crews. Seven crewmembers (3.0%) were hospitalized, of those only 3 tested positive. 135 suspected their source of exposure as being: another crew (75/31.9%), a passenger (50/21.3%), family/friends (10/4.3%). Eighty (34.0%) patients provided PCR results 17 (21.3%) of those were positive for SARS-Cov-2. Median number of follow-up ill days was 3 (range: 0-100). **CONCLUSION:** COVID-19 posed unprecedented challenges in the management of crew cases. Awareness of Covid-19 was high among crewmembers along the first weeks of 2020 since the declaration of a PHEIC by the WHO.



Presenting symptoms were non-specific and case definition changed frequently. Crew self-reported potential exposure more often related to another crew, although community exposure could not be ruled-out. The positivity rate at 21% is very similar to the rate for the general population in the US in the same period, noting the limited availability and different criteria to be observed for testing in different countries.

#### Learning Objectives

1. The participant would be able to understand the level of exposure of crewmembers during the Covid-19 pandemic.
2. The participant would be able to understand aspects of medical assistance for crewmembers when away from home base

### [10] COVID-19 AND ROTARY-WING MEDEVAC BEST PRACTICES – A PROCESS IMPROVEMENT PROJECT

Nicole Powell-Dunford<sup>1</sup>, John Crowley<sup>1</sup>

<sup>1</sup>USAARL, Ft. Rucker, AL, USA

(Original Research)

**INTRODUCTION:** COVID-19 presents a special aeromedical evacuation challenge within the rotary-wing environment given close quarters for medical care. There is ubiquitous concern for transmission of this highly infectious disease in flight, yet no national or international standard exists for rotary-wing management. Elucidating best practices is an important preliminary step in developing an evidence based standard. **METHODS:** A 24-item voluntary process improvement survey as well as solicitation e-mails were deemed exempt from Institutional Review Board review by the U.S. Army Aeromedical Research Laboratory Regulatory Compliance Office. Medical evacuation volunteers completing the survey had the option of including personal contact information for the sole purposes of facilitating follow-on questions and to enable final report distribution but otherwise the survey was anonymous. Volunteers were also asked to provide local Standardized Operating Procedures and lessons learned. **RESULTS:** In a preliminary assessment of best COVID-19 rotary-wing medical evacuation practices, our team conducted a literature review and collected 55 SOPs, photographs, lessons learned, and surveys from 01 May 2020 through 08 September 2020 across the international medevac community. On the basis of their aeromedical experience, study authors identified 37 best practices with regards to pre-flight, en route care, patient transfer and decontamination procedures. Five divergent practices, which have potential utility, were also identified, specifically regarding the use of cabin screens, isolation pods, maxillofacial shields, UV decontamination and the use of nebulizers in the management of COVID-19 patients. COVID-19 related practices most diverged between military and civilian rotary-wing organizations. **DISCUSSION:** Best practices identified through the survey and literature search should be further validated by a broader panel of international experts. Divergent practices which are potentially beneficial should undergo experimental testing, with aerosolized fluorescent dye potentially serving as a surrogate for viral transmission during simulated en route care. Despite the benefits of formulating a best practice standard, uniting military and civilian rotary-wing practices may not be achievable due to cost, resourcing, equipment, and flammability concerns.

#### Learning Objectives

1. The participant will understand the best protective measures that have been identified against the transmission of COVID-19 in rotary wing flight.
2. The participant will understand divergent measures taken against the threat of COVID-19 transmission in rotary wing flight.
3. The participant will understand the limitations of developing a universal COVID-19 standard operating procedure for rotary wing aircraft.

### [11] COVID-19 OUTBREAK AMONG MILITARY MEMBERS IN A GEOGRAPHICALLY ISOLATED LOCATION: A PUBLIC HEALTH PERSPECTIVE

Jason Burchett<sup>1</sup>, Matthew Negrey<sup>1</sup>, Joleen Darby<sup>2</sup>, Mary Rose Valina<sup>2</sup>

<sup>1</sup>USAFSAM, Wright-Patterson AFB, OH, USA; <sup>2</sup>HQ Pacific Air Forces, Hickam AFB, HI, USA; <sup>3</sup>36 MDG Unit, Anderson AFB, U.S. Territories and Minor Outlying Islands

(Original Research)

**INTRODUCTION:** The COVID-19 pandemic remains a significant concern of the U.S. Armed Forces. Knowledge gained from COVID-19 will be essential to mitigating further impact of COVID-19 as well as improving response in future outbreaks. This is a retrospective cohort study which examines an isolated outbreak of COVID-19 amongst the members of a flying squadron. It evaluates demographic risk factors for infection, transmissibility, outcomes and clinical factors for diagnosis.

**METHODS:** Contact tracing data was reviewed from members of the unit, descriptive statistics were calculated for demographic information to include, age, sex, if symptomatic, rank and location. Means and standard deviation were calculated for continuous variables and frequencies were calculated for all dichotomous variables and the groups were compared between positive and negative COVID-19 cases. A primary and secondary attack rate were calculated for all members in the unit as well as by location. Finally sensitivity and specificity were also calculated for presence of symptoms as a predictor of Covid-19 infection. **RESULTS:** A total of 98 members were traced at Location "A" and 21 at Location "B", the mean age was 36.99, 87.4% were men, 82.4% were at Location "A", 87.4% were asymptomatic ( $p=0.026$ ), and 86.6% were enlisted ( $p=0.002$ ). There were 41 positive COVID-19 results. The primary attack rate was 34.2%, in Location "A" 36.7% and Location "B" 22.7%. The secondary attack rate was 0.9% in Location "A" 1.2% and Location "B" 0.0%. All cases recovered without complications. The sensitivity of presence of symptoms is 22.0% 95% CI (10.6%, 37.6%), and specificity 92.3% 95% CI (84.0%, 97.1%). **DISCUSSION:** A high primary attack rate was identified in close contacts when no mitigation practices were utilized, however after restriction of movement the rate significantly dropped. This is consistent with previous studies. The only significant risk factor that was identified was enlisted vs officer in the study population, there were no differences between ages in the two groups in secondary analysis. This study suggests that universal COVID-19 mitigation practices such as social distancing in addition to aggressive contact tracing and isolation of new cases are essential interventions to limit the operational impact.

#### Learning Objectives

1. Audience will understand the attack rate of COVID-19 in an operation flying squadron as well as the demographic of this population.
2. Audience will understand lessons learned from the public health measures used in this isolated outbreak.

### [12] SIMULATED FATES OF COUGHED MICROBES IN A COMMERCIAL AIRCRAFT CABIN

Arthur Kreitenberg<sup>1</sup>

<sup>1</sup>University of California Irvine School of Medicine, Irvine, CA, USA

(Original Research)

**INTRODUCTION:** Commercial air travel has been associated with influenza and recently Covid-19 transmission. In October 2020, three major aircraft manufacturers "confirmed that aircraft airflow systems do control the movement of particles in the cabin, limiting the spread of viruses". The CDC states that "It is possible that a person could get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or eyes." The purpose of this study was to image, via high speed video and still photographs, the path and fate of multiple particle sizes in a simulated un-masked cough in the commercial aircraft cabin. **METHODS:** A simulated aircraft cabin environment with 2 rows of actual airplane seats with tray tables, armrests and overhead bins covered with black fabric. A vacuum driven filtered multiport inlet system was constructed along the simulated fuselage floor. Fluorescing Glogerm® 5µm powder with some clumping was launched at average cough air velocity of 15m/sec, direction, and duration from a passenger mouth position. 120 frame/sec video recordings were made from 2 orthogonal camera angles with blacklight illumination. After 10 minutes, still photographs were obtained to determine where the Glogerm® was deposited on cabin surfaces and air system filter. It was then determined how readily the Glogerm® was transferred to a gloved human hand and

re-launched into cabin air. **RESULTS:** The vast majority of the larger particles quickly settle onto and adhere to cabin surfaces. A difficult to quantify amount of very small particles enter the air treatment system. **DISCUSSION:** The very small particles that enter modern aircraft cabin air systems are efficiently eliminated, but it is difficult to know what proportion actually do so. Some smaller and most larger particles quickly settle onto cabin surfaces, consistent with published fluid mechanics data. Those larger particles may become airborne again or touched and transferred to other passengers. In addition to the cabin air treatment system, it is also important to disinfect high touch interior surfaces between flights.

#### Learning Objectives

1. The audience will be able to describe the path of coughed particles by an un-masked passenger in a commercial aircraft cabin.
2. The participant will be able to describe the common air flow pathway in a commercial air cabin.

### [13] NUMERICAL PREDICTIONS OF AIRFLOW PATTERNS ABOARD MILITARY CARGO AIRCRAFT TO INFORM CROSS-INFECTION RISK

Daniel Reilly<sup>1</sup>

<sup>1</sup>Air Force Research Laboratories/711th Human Performance Wing, Dayton, OH, USA

(Original Research)

**INTRODUCTION:** There is currently a gap in the understanding of how airflow patterns influence cross-infection risk aboard military aircraft during open air high-capacity airlift. This gap became particularly relevant for high-capacity airlift of COVID-19 infected passenger in April 2020. **METHOD:** A series of high-fidelity computational fluid dynamic models we developed to investigate internal aircraft cabin flow physics on a variety of military airframes which could be outfitted for aeromedical evacuation, including the C-17, KC-135, C-130J, C-5M, KC-46, and KC-10. A novel internal geometry development process was first executed which allowed for rapid transition of these real-world cabin geometries to their virtual counterparts through usage of high-definition laser scanning paired with computer aided engineering. After generating the virtual counterpart of each cabin, discretization was executed using a uniform polyhedral grid. Boundary conditions for inlet and outlet vents were defined based on manufacturer provided values for mass flow rates and pressurization. Simulations were computed in collaboration with the DoD High Performance Computing Modernization Program (HPCMP) and employed a steady Reynolds Averaged Navier Stokes (RANS) scheme using an uncoupled flow solver and a K-Omega turbulence model. Airflow patterns were analyzed for flow direction, speed, and compartment-to-compartment transition, all of which play a significant role in expiratory droplet dispersion. **RESULTS:** Airflow patterns varied significantly airframe to airframe and were often dependent on the specific inlet mass flow rate to compartment volume ratio. Smaller compartments with higher mass flow rates tended to exhibit higher velocities correlating to more frequent air change rates while the opposite was also true. Further, air mass movement efficiency was highly influenced by outflow vent locations and air flow was highly recirculatory prior to exiting ECS outlets. **DISCUSSION:** These models provide critical information needed to implement protective actions to mitigate cross-infection on each airframe. In follow-on studies, these models will be manipulated in a high-throughput manner to mimic different cargo and passenger scenarios during different phases of flight. Further, bioaerosols will be introduced to evaluate dispersion, deposition, and removal from the aircraft for different airflow dynamics and bioaerosol release locations.

#### Learning Objectives

1. The presenter will describe computational methods used to predict airflow and bioaerosol dispersion on Air Mobility Command cargo aircraft to inform methods to reduce cross-infection and streamline decontamination post COVID-19 passenger air lift.
2. After listening to the talk, the audience will have a better understanding of exposure risk of to aircrew and passengers when transporting COVID-infected patients in an open-air aeromedical evacuation (AE) scenario

### [14] FITNESS TO DIVE AFTER SARS-COV-2 INFECTION

Brian Pinkston<sup>1</sup>, Cheryl Lowry<sup>1</sup>

<sup>1</sup>Kinetic Adventure Medical Education, Wichita Falls, TX, USA  
(Education - Case Study)

**INTRODUCTION:** As the COVID-19 pandemic evolves, many recreational and professional scuba divers are questioning the safety of returning to scuba diving after SARS-CoV-2 infection. This presentation will consist of a case presentation, review current diving medicine literature related to COVID-19, and fitness for diving assessment methodology. **BACKGROUND:** The long-term sequelae of SARS-CoV-2 infection are still not fully understood, making it difficult to determine when recreational, scientific, and commercial scuba divers can safely return to diving. The pulmonary, cardiac, and thromboembolic pathophysiological effects of this disease are relevant to scuba divers. **CASE PRESENTATION:** A 22-year-old female presented for a recreational scuba diving preparticipation exam following recent infection with SARS-CoV-2. Approximately six weeks prior to examination she had mild symptoms consistent with COVID-19 including fever, headache and cough. She was never hospitalized and did not seek medical treatment. Her university-required SARS-CoV-2 screening (antigen) test was negative; however, a PCR (molecular) test was positive a month after her COVID-19 symptoms resolved. The patient was told by another physician that she would need to wait at least one year before she could be cleared to dive, prompting her to seek a second opinion with our office. She was feeling well, had no residual symptoms, and had returned to baseline exercise tolerance. Her history and physical exam will be discussed. **DISCUSSION:** A hyperbaric medicine literature review revealed that there was no consensus opinion about returning to diving following COVID-19. Return to diving recommendations ranged from one month to never diving again. The presentation will review important focus areas for this post-COVID-19 scuba diving medical examination, including recommended imaging and additional testing, and discuss the methodology used to evaluate this patient. While it could be argued that recreational divers never "need" to dive, it is reasonable to expect that these divers are anxious to return to the water. Additionally, scientific and occupational divers have ongoing missions where their work is required. This presentation will discuss methodologies for assessing fitness to dive following SARS-CoV-2 infection.

#### Learning Objectives

1. The audience will learn about methodologies for assessing fitness for diving after SARS-CoV-2 infection.
3. Attendees will be able to describe COVID-19 health concerns related to scuba diving.

Monday, 08/30/2021  
Plaza A/B

10:30 AM

### [S-05]: PANEL: IMPACTS OF DIVERSITY IN ASTRONAUTICS AND AEROSPACE MEDICINE

Sponsored by Aerospace Medicine Student & Resident Organization (AMSRO)

Chair: Nicolas Nelson

Co-Chair: Karen Ong

**Panel Overview:** This panel will explore the impacts of diversity and inclusion on the past, present, and future of human spaceflight and aerospace medicine. As a branch of preventative medicine, aerospace medicine drives mission success via rigorous research, analysis of complex factors, and implementation of countermeasures. Our panel will review the evidence-based costs, benefits, and considerations for supporting diverse astronaut crews, medical teams, and others who work in extreme and high-performance environments. This panel focuses on an illustrative set of demographic dimensions: nationality, race, residence, socioeconomic status, sexual orientation, gender identity, and physical and mental health. We will examine how selection and training mutually relate to diversity within and between astronautical professions, and we will discuss implications for the optimization of human performance, data collection, and mission execution as well as ongoing AMSRO initiatives that address diversity and inclusion.

*Our examination will include policies and precedents for flight in air and space with rationales and key interpersonal and physiologic implications, including insights from the events of 2020. As access to space continues to expand, so too does the purview of aerospace medicine. The considerations outlined in this panel are increasingly important, both for public engagement and for success in the future of human spaceflight. Presentations will highlight potential barriers and knowledge gaps regarding readiness and representation for flight surgeons and spacefarers, concluding with proposals for future research.*

### [15] CONSIDERATIONS OF INTERNATIONAL DIVERSITY FOR ASTRONAUT & AEROSPACE PHYSICIAN POPULATIONS

Benjamin Johnson<sup>1</sup>

<sup>1</sup>Johns Hopkins University School of Medicine, Baltimore, MD, USA

*(Education - Program/Process Review)*

**BACKGROUND:** The fields of astronautics and aerospace medicine have diversified significantly since their roots in the 1950s and 60s; people of different races, genders, nationalities, and sexual orientations regularly form successful aerospace teams. To optimize human performance, the effects of diversity cannot be overlooked. This conference's focus on advancing aerospace endeavors through research also includes the benefits and considerations to be accounted for when building diverse, multinational teams. **OVERVIEW:** The habitation of the International Space Station by people of 18 nations marks a high point in aerospace history for international collaboration. Literature is mixed on the effects on multinational diversity in high-pressure environments such as spaceflight, with some studies arguing that it can strain teams, compromise cohesion, and create conflict. In the medical workforce, diversity is seen as crucial to providing competent care to diverse patient populations; furthermore, institutions are advocating for greater inclusion of women and minorities in biomedical research in order to reach equitable conclusions. **DISCUSSION:** The inevitable increase in national and cultural diversity in astronautics needs to be met with the selection of culturally competent, commensurately diverse aerospace medical trainees. In space, and on Earth, this increase in diversity is expected to expand viewpoints and innovative solutions to the challenges faced by high-performing teams. Increased national diversity may also increase interpersonal conflict, but this can be minimized through adequate training and the promotion of cohesive, team-forward mindsets. Successful implementation of team diversity research can increase team and task performance in astronauts and aerospace physicians alike.

#### Learning Objectives

1. The audience will learn about specific considerations for building multinational teams.
2. The audience will learn about international collaboration and cross-cultural interfaces in space.

### [16] RACIAL, GEOGRAPHICAL, & SOCIOECONOMIC FACTORS IN AEROSPACE MEDICINE

Jevons Wang<sup>1</sup>, Ste'Von Voice<sup>2</sup>

<sup>1</sup>McGovern Medical School at UT Health Science Center Houston, Houston, TX, USA; <sup>2</sup>University of the Incarnate Word School of Osteopathic Medicine, San Antonio, TX, USA

*(Education - Program/Process Review)*

**BACKGROUND:** There are well-documented advantages to building diverse teams in high-performance occupations, but there are pervasive factors that can contribute to the underrepresentation of some ethnic, racial, and socioeconomic populations. The field of aerospace medicine could benefit from either identifying or refuting potential disparities; bridging any identified gaps; and leveraging the field's existing diversity to promote further inclusion, optimize team performance, create generalizable knowledge, and provide equitable preventative care.

**OVERVIEW:** Presently, there is a lack of consistently available demographic data for aerospace medicine physicians; underrepresented minorities in medicine who are interested in aerospace lack the means to gauge the field's inclusivity. A potential intervention may be anonymous demographics surveys in preventative medicine, compared against the field of medicine at large. This research could then be used to inform

outreach initiatives for underrepresented students, including those from backgrounds of ethnic minority and/or socioeconomic disadvantage. Furthermore, cited barriers to academic advancement in aerospace medicine include geographical limitations, lack of awareness or support, and cost. **DISCUSSION:** This presentation examines potential barriers to entry for aerospace medicine as well as approaches to ethnic diversity and disparities in the field. We describe existing resources as well as envisioning avenues for further improvement, briefly discussing how precedents of race-based medicine factor into aerospace medicine research and practice. The perspectives to be gained have the potential to form a more robust community of aerospace medical professionals, aviation crew, and astronaut corps who can also serve as public examples of the benefits of equitable inclusion.

#### Learning Objectives

1. The audience will learn about barriers to entering the fields of astronautics and aerospace medicine, including lack of awareness, geographical obstacles, financial hardship, and minority status.
2. The audience will learn about resources and suggestions for increasing inclusivity in the field while supporting ethnic and racial diversity.

### [17] SEXUAL & GENDER MINORITY KNOWLEDGE GAPS IN ASTRONAUTICS & AEROSPACE MEDICINE

Nicolas Nelson<sup>1</sup>, Kseniya Masterova<sup>2</sup>, Kristi Ray<sup>3</sup>, Hector Salazar Martinez<sup>4</sup>, Rita Shehirian<sup>5</sup>, Brent Monseur<sup>6</sup>

<sup>1</sup>Thomas Jefferson University, Philadelphia, PA, USA; <sup>2</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>3</sup>Tulane University, New Orleans, LA, USA; <sup>4</sup>Cornell University, New York, NY, USA; <sup>5</sup>University of Michigan, Ann Arbor, MI, USA; <sup>6</sup>Stanford University, Palo Alto, CA, USA

*(Education - Program/Process Review)*

**BACKGROUND:** Sexual and gender minority (SGM) populations have specific health risks to consider, spanning a range of preventative medicine topics from cancer screening to sexual health; however, there is an absence of published literature concerning lesbian, gay, bisexual, transgender, queer/questioning, intersex/differences of sex development, etc. (LGBTQI+) persons in spaceflight. Bodies of research in other fields have attempted to characterize specific, measurable, clinically relevant variations and neurobehavioral profiles for LGBTQI+ individuals. As modern spaceflight moves toward longer-duration missions for astronauts and increased access for space tourists, research and discourse in aerospace medicine should be prepared to include considerations for SGM health and performance. **OVERVIEW:** Astronautic literature is devoid of LGBTQI+ related discourse, and there are no published data on attitudes, readiness, and representation in the field of aerospace medicine. We will discuss why these factors are relevant beyond the performance and mental wellness of individual spacefarers who belong to a sexual orientation/gender identity minority, for example, toward advancing the psychobiology of sex, gender, and sexuality, which would broaden horizons for personalized medicine and other terrestrial applications. In addition to addressing underrepresentation in astronautics and aerospace medicine, this presentation aims to introduce specific operational and medical considerations for the future of human spaceflight research, citing existing precedents in analogous high-performance fields and/or extreme environments. **DISCUSSION:** Great strides have been taken in sex-specific space medicine, but none regarding SGMs. These knowledge gaps place undue restrictions on research-based advancements in human performance; insights for long-duration space biology; and potential discoveries in the fields of human sexuality, reproductive biology, and sex and gender development on Earth. Closing these gaps for aerospace medicine is a population health task that may entail cultural adaptation within the space industry. If successful, this could directly benefit flight surgeons and their patients by informing rational improvements to space medicine research, astronaut performance, and cross-cultural collaboration.

#### Learning Objectives

1. The audience will learn about specific considerations for gender minorities and nonheterosexual persons in space, reviewing existing policies and precedents regarding these populations.
2. The audience will be able to understand key rationales for closing specific knowledge gaps in aerospace medicine regarding sexual and



gender minorities, including the advancement of sex-specific space medicine.

3. The audience will be able to consider the future care and training of LGBTQ+ individuals in spaceflight and their families on Earth by expanding on prior research in high-performance and/or extreme environments.

### [18] THE EVOLUTION OF HEALTH STATUS AND FLIGHT REGULATIONS USING DIABETES AS A MODEL OF DISCUSSION

Lynda Chowdhury<sup>1</sup>, Andrew Zeiger<sup>2</sup>, Amy Kreykes<sup>3</sup>

<sup>1</sup>Methodist Health System of Dallas, Dallas, TX, USA; <sup>2</sup>Thomas Jefferson University, Philadelphia, PA, USA; <sup>3</sup>University of Texas Medical Branch, Galveston, USA

(Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine is frequently described as the care of healthy individuals in extreme environments. Rigorous screening protocols have ensured that active astronauts are an extraordinarily fit patient population; however, in the future, the field may serve a broader demographic. As access to space continues to increase with developments in private spaceflight, health standards for civilian spacefarers may become less exclusive. Astronauts may be at risk of developing disease during long-duration exploration missions while others may succumb to precipitating events associated with chronic disease states as shown with vascular thrombosis and theorized with insulin dysregulation. Research might consider not only primary and secondary prevention for the healthiest but also tertiary prevention for individuals who have certain preexisting conditions or happen to develop one in flight. **OVERVIEW:** Here we use diabetes as a model for approaching chronic conditions in aviation and spaceflight. Because of the potential diabetogenic effects of microgravity and the prevalence of undiagnosed diabetes and prediabetes in the population, it is suitable to use this disorder to illustrate how translational research endeavors can inform disease in flight. Solutions would increase access to space for persons with conditions that prove manageable while making spaceflight safer for previously healthy individuals who might develop them later. Historically, insulin-dependent diabetes has been disqualifying for pilots due to concerns about acute hypoglycemia. Studies in the UK have outlined the relative safety of allowing insulin users to fly under standard operating procedures; in the US, the Federal Aviation Administration has now lifted previous bans on certifying insulin-dependent diabetics as commercial pilots. Medical advancements will likely change the contexts of prior screening practices.

**DISCUSSION:** Translational research could make flight safer for spacefarers with common health conditions. Reevaluating aerospace standards in light of ongoing research might increase the representation of manageable health states in the industry. Understanding space physiology across a broader continuum will unveil unexpected clinical principles, advancements in personalized medicine, and ultimately inform other possible terrestrial applications. Furthermore, it will enable equitable provision of care for the population as we progress as an increasingly spacefaring species.

#### Learning Objectives

1. The audience will learn about the evolution of regulations and guidelines related to health status and flight using diabetes as a model for relevant discussions.
2. The audience will learn about potential spaceflight considerations and countermeasures for persons living with well-controlled diabetes including but not limited to hypothesized hormonal fluctuations in the microgravity environment.

### [19] MENTAL HEALTH STANDARDS & COPING IN MODERN SPACEFLIGHT

Linh-An Cao<sup>1</sup>, Ami Mange<sup>2</sup>, Michael Yue<sup>3</sup>

<sup>1</sup>Michigan State University, Lansing, MI, USA; <sup>2</sup>Yale University, New Haven, CT, USA; <sup>3</sup>USN, Baltimore, MD, USA

(Education - Program/Process Review)

**BACKGROUND:** Mental health has always been a central concern of human performance in space. At various levels, existing screening criteria for aviation and spaceflight—and indeed diagnostic questionnaires—rely

heavily on subjective interpretations and/or self-reported responses.

Training for space missions entails a paradigm of evidence-based psychiatric strategies for maintaining behavioral health and wellness, and it remains an ongoing challenge to determine the effective outcomes of these evidence-based strategies in the context of spaceflight.

**OVERVIEW:** This presentation explores the development and evolution of mental health standards for military pilots compared with astronauts, reviewing current literature either in favor of or against existing practices. While there are barriers to reporting mental disturbances, supporting a more well-rounded outlook on mental health and wellness may improve accurate data collection, facilitate the implementation of healthier coping strategies, and improve overall team performance. Because flight surgeons often function in high-stakes environments, we will briefly extend these concepts to the practice of aerospace medicine.

**DISCUSSION:** We will discuss general psychiatric and selection-based countermeasures and potential directions regarding mental health in astronaut populations. By thoughtfully aligning screening and training practices to the highest quality and most up-to-date evidence, and tailoring these practices for individual crews and astronauts, aerospace medicine practitioners can promote healthier team structures and effective coping strategies without unnecessarily excluding qualified candidates.

#### Learning Objectives

1. The audience will learn about the development and evolution of mental health standards for military pilots as compared to astronauts.
2. The audience will learn about existing countermeasures and future directions regarding mental health in astronaut populations, including pharmacotherapy.

Monday, 08/30/2021  
Governor's Square 12

10:30 AM

### [S-06]: PANEL: FLYING WITH PTSD – AN 8 YEAR REVIEW OF PTSD DISQUALIFICATIONS AND WAIVERS IN THE UNITED STATES AIR FORCE

Chair: Kevin Heacock

**Panel Overview:** The United States Air Force (USAF) has long made various psychiatric disorders disqualifying for flight duties due to their potential adverse aeromedical impact on aviation safety and flying duties. Posttraumatic Stress Disorder (PTSD) poses significant cognitive, emotional, and behavioral difficulties that can lead to observable as well as subtle changes in functioning that negatively affect performance under physically and psychologically taxing conditions in aviation. Unidentified, untreated, or under treated PTSD may have potentially disastrous consequences. Since 2013 the USAF Aeromedical Consultation Service (ACS) has closely evaluated and monitored aviators with PTSD to mitigate such outcomes. The outcomes have varied, at times resulting in disqualifications and at other times resulting in waiver. This panel looks at the ACS PTSD study program, the data collected, and case studies including a disqualification and a waiver to provide guidance for a way forward with this all too common diagnosis in the military population.

### [20] IDENTIFYING AND ADDRESSING THE PTSD PANDEMIC AMONG THE UNITED STATES AIR FORCE FLYING COMMUNITY

Terry Correll<sup>1</sup>

<sup>1</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Tutorial/Review)

**INTRODUCTION:** This panel will examine posttraumatic stress disorder (PTSD) in U.S. Air Force (USAF) aviators and special forces. Both groups are uniquely positioned to experience significant trauma via extensive combat exposure, especially over the last few decades with ongoing conflicts throughout the world and recurring deployments.

**TOPIC:** When PTSD is suspected or diagnosed in Airmen, the USAF mandates top-notch evaluation, treatment, and thorough study of

every impacted individual. State-of-the-art treatment plans are required to potentially include psychotherapy, healthy lifestyle interventions, and psychotropic medication(s), or other appropriate somatic treatments.

**APPLICATION:** If the service member is able to continue performing his/her primary duties while getting treatment for PTSD, the USAF supports this approach. When necessary, the service member can be taken out of his/her primary USAF duties to allow full treatment and resolution of symptoms to occur. The Aeromedical Consultation Service (ACS) for the USAF has oversight on all aviators and select special forces impacted by PTSD, and they conduct a mandatory USAF study of those individuals. This presentation will describe the history, establishment, protocol, and findings of this very progressive and forward thinking PTSD study.

#### Learning Objectives

1. To understand posttraumatic stress disorder and how it can be impairing and appropriately diagnosed and managed in the aerospace environment.
2. Review how the U.S. Air Force extensively evaluates, treats, and studies posttraumatic stress disorder in aviators and special forces and successfully returns them to duty.

### [21] LONGITUDINAL ASSESSMENT OF UNITED STATES AIR FORCE AVIATORS DIAGNOSED WITH POSTTRAUMATIC STRESS DISORDER

Monica Malcein<sup>1</sup>

<sup>1</sup>U.S. Air Force School of Aerospace Medicine, Dayton, OH, USA

#### (Education - Tutorial/Review)

**INTRODUCTION:** Involvement in combat operations is associated with increased risk for posttraumatic stress disorder (PTSD), and U.S. Air Force (USAF) aviators are commonly deployed to war zones. PTSD has been consistently linked to neurocognitive changes, emotional disturbance, and functional impairment in both civilian and military populations. However, knowledge regarding the potential long-term impact of PTSD on high-functioning individuals such as USAF aviators is relatively sparse. Aviators with a diagnosis of PTSD evaluated at the Aeromedical Consultation Service (ACS) for waiver consideration were followed over time, with re-assessments and waiver renewal occurring at several designated times. **TOPIC:** USAF aviators with a diagnosis of PTSD were assessed at the ACS with planned follow-up at 1 year, 2 years, 5 years, and 10 years from original waiver date for re-evaluation and for waiver renewal. The evaluations consist of clinical interviews by psychology and psychiatry and administration of measures of intellectual functioning (MAB=II), neurocognitive functioning (MicroCog), personality assessment (NEO-PI-3) and psychopathology/psychological distress (MMPI-2; MMPI-2-RF). Data collected from aviators diagnosed with PTSD from 2013 to 2020 will be analyzed to investigate potential predictive factors associated with initial recommendations for waiver and return to flying status. For those aviators that have completed follow-up evaluations, the relationship between demographic, neurocognitive, and personality factors and longitudinal outcomes, (i.e., recurrence of symptoms, persistent subclinical symptoms, functional/occupational impact, or subsequent DNIF/DQ due to psychiatric symptoms) will be explored. **APPLICATION:** Examination of factors associated with recurrence/persistence of psychiatric symptoms and functional/occupational impact in aviators diagnosed with PTSD will allow for greater understanding of risk/protective factors to inform clinical decision-making in this population. Additionally, this information should increase recognition of unique variables associated with PTSD in the aviator population and increase understanding of operational impact associated with the diagnosis.

#### Learning Objectives

1. The participant will learn about predictive factors associated with initial recommendations for waiver/return to flying status in USAF aviators who have been diagnosed with PTSD.
2. The participant will be able to understand the relationship between demographic, neurocognitive, and personality factors and outcomes in aviators who have been diagnosed with PTSD.

### [22] TRAUMA- AND STRESSOR-RELATED DISORDERS IN USAF AVIATORS – CONSIDERATIONS FOR DISQUALIFICATION (DQ)

Justin Bunn<sup>1</sup>

<sup>1</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

#### (Education - Tutorial/Review)

**INTRODUCTION:** Trauma- and stressor-related disorders include adjustment disorders, acute stress disorder, and posttraumatic disorder (PTSD). These disorders are disqualifying for all classes of flying in the U.S. Air Force. Therefore, they have a significant impact on individual and mission readiness. **TOPIC:** Posttraumatic Stress Disorder (PTSD) can be a chronic and debilitating diagnosis that can cause clinically significant impairment depending on the length, severity, and functional impact. Within the aviator community, it is essential to closely track and diagnose PTSD because of the severity of symptoms and the negative impact they can have on pilot performance. If symptoms are not treated with empirically-supported treatments, such as Cognitive Processing (CPT) and/or Prolonged Exposure (PE) therapies, aviators may become severely impaired psychologically, emotionally, and physiologically to the extent that a disqualification from flying may be warranted. This presentation discusses the possible disqualification of aviators due to the impact of PTSD symptoms, specifically examining the process and conditions leading to disqualification. **APPLICATION:** PTSD is a prevalent condition among military members and can lead to disqualification from flight duties for USAF aircrew. Many of the symptoms of PTSD can interfere with flying safety and mission completion with severe anxiety symptoms leading to significant impairment in the aviators ability to focus and concentrate. More severe symptoms, such as flashbacks, may be acutely incapacitating, which can interfere with the operational elements of flight and mission safety, as well as threatening the safety of the aviator themselves. Excellent evaluation and treatment can reduce negative psychological impact to the aviator, however at times symptom chronicity and severity can lead to aeromedical risk that cannot be managed and therefore disqualification from flying duties is necessary. This presentation will highlight these concepts and describe when disqualification is needed. This is primarily applicable to USAF flight surgeons, but it also has utility for other military services and civilian flight medicine. Example cases will also be presented. **RESOURCES:** 1. Heacock, K.F., Van Syoc, D., and Gregory, D. Post-Traumatic Stress Disorder (PTSD) (January 2020). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2019.

#### Learning Objectives

1. Participants will learn the process of how PTSD can become disqualifying for AF aviators.
2. Participants will be able to identify specifics of how PTSD can cause significant impairment in aviator functioning.

### [23] TRAUMA- AND STRESSOR-RELATED DISORDERS IN USAF AVIATORS – WAIVER CONSIDERATIONS

Ryan Peirson<sup>1</sup>

<sup>1</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

#### (Education - Tutorial/Review)

**INTRODUCTION:** Trauma- and stressor-related disorders include adjustment disorders, acute stress disorder, and posttraumatic disorder (PTSD). These disorders are disqualifying for all classes of flying in the U.S. Air Force. Therefore, they have a significant impact on individual and mission readiness. **TOPIC:** The diagnosis of PTSD, especially in the combat environment, is fraught with difficulty. Flight surgeons and mental health providers need to consider the length, severity, and functional impact of PTSD symptoms along with the situationally-induced nature and accompanying stressors that triggered the condition. This presentation discusses the treatments for PTSD along with its waiver potential following treatment and stabilization of the aviator. When managed well, PTSD may not require waiver. **APPLICATION:** PTSD is a prevalent condition among military members and is potentially waiver-eligible in USAF aircrew. Residual symptoms after treatment may remain and not impair the member from performing assigned duties. Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can minimize DNIF



periods, and can enhance resilience to avoid recurrence. This presentation will highlight these concepts and describe effective management strategies for trauma- and stressor-related disorders. This is primarily applicable to USAF flight surgeons, but it also has utility for other military services and civilian flight medicine. Example cases will also be presented. **RESOURCES:** 1. Wood J, Heaton J, and Van Syoc D. Post-Traumatic Stress Disorder (PTSD) (June 2017). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2019.

2. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*, 5<sup>th</sup> edition. Arlington (VA): American Psychiatric Association; 2013: 265-290.

#### Learning Objectives

1. The participant will understand the necessary criteria for waiver consideration of USAF aircrew.
2. The participant will be able to describe decision elements necessary to make good clinical judgment about local determination for waiver need.

**Monday, 08/30/2021**  
**Plaza P**

**10:30 AM**

### [S-07]: SLIDE: CLINICAL CASE PRESENTATIONS AND AEROMEDICAL DECISION MAKING

**Chair: Carol Ramsey**  
**Co-Chair: Carlos Navarro**

#### [24] AEROMEDICAL DECISION MAKING: RETAINED RENAL CALCULI

Sri Hari Enakal<sup>1</sup>

<sup>1</sup>Institute Of Aerospace Medicine, Benagaluru, India

(Education - Case Study)

**INTRODUCTION:** Nephrolithiasis in aircrew can cause sudden incapacitation in flight and the pilots are assessed unfit for flying till the aviators are completely stone free. The calculi in renal parenchyma, renal cyst, or calyceal diverticulum which are long standing, stable and retained have minimal possibility of migrating into the collecting system thus having a remote chance of causing sudden incapacitation in flight. However, there is dilemma on disposal of such pilots due to the following challenges:

- Duration to be observed before assessing fit for flying;
- Imaging studies required and its frequency to assess the size and position of calculi;
- Metabolic and renal function tests and its frequency;
- Aeromedical evaluation by exposure to high G forces and vibration stress.

**MATERIAL & METHODS:** A case (Fighter pilot) of retained renal calculi was followed up for a duration of 24 months and aeromedical evaluation policies of different countries were analyzed. **DISCUSSION:** This paper shows the challenges faced in ADM of pilots with stable retained renal calculi and outlines the role of Renal Stone Risk assessment index score and the average mean values of the solutes in 24 hr urine collection, imaging studies and the aeromedical evaluation in assessing the aircrew for flying.

#### Learning Objectives

1. The participants will understand the role of Renal Stone Risk assessment index score in evaluating the aircrew with impacted or long standing retained renal calculi and thus helps in Aeromedical Decision making of such aircrew by Aerospace Medicine Specialists.
2. The participants will understand the role of Average mean values of the solutes in 24 hr urine collection and correlation with the imaging studies in evaluating the aircrew with impacted or retained renal calculi in the Aeromedical Decision making of aircrew by Aerospace Medicine Specialists.
3. The participants will understand the role of aeromedical evaluation by High Performance human centrifuge and Vibration simulator platform in evaluating the aircrew with impacted or retained renal calculi which plays a pivotal role in the Aeromedical Decision and insight into the aeromedical policies of different countries.

#### [25] PILOT WITH TESTICULAR CANCER AND HORMONE THERAPY

William Valencia<sup>1</sup>, Ann Tsung<sup>1</sup>

<sup>1</sup>University of Texas Medical Branch at Galveston, Galveston, TX, USA

(Education - Case Study)

**INTRODUCTION:** Gender dysphoria refers to discomfort or distress that is caused by a discrepancy between a person's gender identity and that person's assigned sex at birth. Reports suggest that 0.3 to 0.6% of the adult population is transgender. **BACKGROUND:** The diagnosis of gender dysphoria should be made by medical providers who understand the diagnostic criteria and have experience with assessing the mental health issues that might confound the diagnosis. Transgender patients typically have high rates of mental health diagnoses and screening is recommended for depression, anxiety and other mental health illnesses. Feminizing hormone therapy complications could include VTE, breast cancer, cardiovascular disease, cerebrovascular disease, HTN. Transgender females undergoing gender-affirming therapy should be evaluated every 3 months in the first year and then one to two times per year for adverse reactions. **CASE PRESENTATION:** A 30-year-old transgender female (natal male) with history of testicular cancer presented for a special issuance initial exam. In 2005, pt presented to her PCM with persistent cough. CXR revealed bilateral lung masses and further evaluation found metastatic testicular cancer which was treated with chemotherapy followed by right thoracotomy with right lung resection. Pt was followed regularly with tumor markers for 10 years and continued to undergo scheduled imaging surveillance. Pt reports symptoms of gender dysphoria since she was 3-4 years old. She began her hormonal transition in 2016 with oral estradiol and spironolactone. Her current regimen is subcutaneous estradiol and topical progesterone, started in 2018. She denies any side effects from medications. She plans to undergo penile inversion surgery in 2 years. **DISCUSSION:** A FAA CACI (conditions airmen can issue) and AME Assisted Special Issuance exist for testicular cancer. Consideration factors include current status report, treatments, time frame, and presence of metastasis. An FAA CACI is available for gender dysphoria which includes timeframe, hormonal replacement, surgery, and any mental health issues. A Gender Dysphoria Mental Health Status Report is required from the AME. Oral hormonal replacement is not disqualifying for medical certification and will depend on existence of adverse effects. Air Force, Navy and Army standards are also reviewed.

#### Learning Objectives

1. The audience will understand the aviation clinical considerations and certification requirements for hormonal therapy and gender dysphoria.
2. The audience will learn about the requirements for the FAA CACI protocol for testicular cancer.

#### [26] AIRCREW HIV – DEPRESSION CHALLENGES IN SUB-SAHARAN AFRICA

Alexander Mkwizu<sup>1</sup>, Japhet Ndegwa<sup>2</sup>

<sup>1</sup>Muhimbili University of Health and Allied Science, Dar es Salaam, United Republic of Tanzania; <sup>2</sup>MOI University, Nairobi, Kenya

(Education - Tutorial/Review)

**INTRODUCTION:** Mandatory HIV testing can be perceived as a brutal way of carrying out aviation medical examination, nevertheless critical in aviation safety when it comes to airmen in areas of high - HIV prevalence such as Sub-Saharan Africa (SSA). Identified HIV positive airmen should regularly and properly get screened for psychiatric manifestations particularly mood disorders such as depression using appropriate agreed tools. **TOPIC:** Estimates reported by the World Health Organisation (WHO) suggests an approximately 36.9 million people worldwide were living with HIV/AIDS in 2017, of which 19.6 million (53%) lived in sub-Saharan Africa (SSA) alone. Depression, one of the most common psychiatric disorders, is 2-3 times more prevalent in people living with HIV (PLWHIV) compared to general population in many geographical settings, yet is remains neglected in SSA. WHO and UNAIDS do not support mandatory or compulsory HIV testing of individuals on public health grounds; insisting that HIV testing, no matter how it is delivered, must always respect personal choice and

adhere to ethical and human rights principles. Several challenges lie ahead of us; how can we identify HIV positive aircrew with heightened likelihood of concealing their HIV status or shun from testing as a result of depression and Stigma? Are we not closing our eyes to a possible next Germanwings disaster in SSA by simply relying on voluntary HIV testing by our airmen? **APPLICATION:** Mandatory HIV testing should be adopted and supported by ICAO, subject to local HIV prevalence of the State concerned. Any known HIV positive Airmen should be evaluated in accordance with agreed HIV protocol accommodating comprehensive, tested diagnostic tools in depression. **RESOURCES:** 1. World Health Organization. 10 Facts on HIV/AIDS. 2017. 2. Roy KF, Andriote JM. HIV and Clinical Depression Fact Sheet. *American Psychiatric Association*. [www.psychiatry.org/AIDS](http://www.psychiatry.org/AIDS). 3. Simoni JM, Safren SA, Manhart LE, Leyda K, Grossman CI, Rao D, Mimiaga MJ, Wong FY, Catz SL, Blank MB, DiClemente R, Wilson IB. Challenges in Addressing Depression in HIV Research: Assessment, Cultural Context and Methods. *National Center for Biotechnological Information, US National Library of Medicine*, ncbi.nlm.nih.gov, 24 April 2012, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3335263>. 4. WHO/UNAIDS. HIV Testing Services: New opportunities and Ongoing Challenges. *Joint United Nations Programme on HIV/AIDS*. 2017

#### Learning Objectives

1. The participant will be able to determine that Depression attributed to HIV/AIDS is relatively high for Airmen in areas of high HIV prevalence.
2. The participant will understand that even in high HIV prevalent areas, HIV screening is not mandatory, providing a leeway for HIV positive Airmen to avoid tests, further increasing the already available incapacitation risk.
3. The participant will be aware that, a significant gap exists of which ICAO must act immediately to address the legislation behind mandatory HIV testing to Airmen including inclusion of agreed diagnostic tool targeting depression for HIV positive Airmen.

#### [27] JAW PAIN IN AN ARMY AVIATOR

Robert Gingerich<sup>1</sup>, Simmons Emily<sup>1</sup>

<sup>1</sup>School of Army Aviation, Fort Rucker, AL, USA

#### (Education - Case Study)

**INTRODUCTION:** This case describes an Army aviator with jaw pain caused by Burkitt Lymphoma, a rare and aggressive non-Hodgkin B-cell lymphoma. It is more common in children than adults, although adults have a worse prognosis. There are endemic and sporadic forms, and it has been associated with infections such as EBV, malaria, and HIV. The typical presentation is a rapidly growing tumor and potentially abnormal labs, such as elevated LDH. Tumor locations vary between the endemic and sporadic forms; tumors in the jaw are most commonly seen in the endemic form. **CASE DESCRIPTION:** The subject aviator is a 28 year old white male who presented with left-sided jaw pain and paresthesias, without a mass or systemic symptoms. The initial workup included evaluations by a dentist and otolaryngologist, radiographs, and an MRI of the head and face, and was non-diagnostic. A subsequent blood count revealed a significantly elevated WBC with immature cells, and the patient rapidly developed classic B symptoms. The diagnosis of Burkitt Lymphoma was made by lymph node biopsy. PET scan revealed diffuse lymphadenopathy, and bone marrow biopsy demonstrated massive infiltration. He is currently undergoing an aggressive chemotherapy regimen. **DISCUSSION:** Because this was a relatively mild initial presentation and appeared isolated to the jaw, malignancy was not high on the list of differential diagnoses. Medical providers must consider a broad differential, including rare conditions, particularly when symptoms are persistent, unusual, or not well explained by the initially suspected diagnosis. There are both short-term and long-term aeromedical considerations associated with lymphoma. In the short term, pain may distract the aviator from cockpit duties, and may be exacerbated by the wear of protective equipment. Some lymphomas can affect the central nervous system, leading to incapacitation. Long term considerations include sequelae of chemotherapy and the risk of recurrence or secondary malignancy. All military services and the Federal Aviation Administration consider active chemotherapy or radiation therapy disqualifying. The FAA may

consider a Special Issuance following successful treatment of lymphoma. The military services generally require a determination of fitness to remain in the military prior to considering a return to flight status.

#### Learning Objectives

1. The audience will understand the clinical presentation of Burkitt Lymphoma.
2. The audience will understand the aeromedical implications and return to flight considerations of malignancies including Burkitt Lymphoma.

#### [28] BEHCET'S DISEASE PRESENTING AS PANUVEITIS AND RETINITIS IN A C-130 PILOT, IN REMISSION WITH ADALIMUMAB, AND TOPICAL BRIMONIDINE

Mathew Koshy<sup>1</sup>

<sup>1</sup>BAE Systems, Dhahran, Saudi Arabia

#### (Education - Case Study)

**INTRODUCTION:** This case report describes a C-130 pilot with Behcet's disease presenting with panuveitis and retinitis.

**BACKGROUND:** Behcet's disease is a generalized inflammatory condition of unknown cause with vasculitis as its primary pathology. It is most common in countries along the ancient silk route and can affect any part of the body. It is most commonly seen in the 20 to 30 yrs age group and seems to have a greater incidence in those with HLA B-51. Environmental factors also seem to play a role in triggering the disease. Common presentation includes eye symptoms, oral and genital ulcers, skin rashes, pathergy, musculoskeletal problems and vascular problems. Treatment is usually with immunosuppressive drugs and locally acting drugs as per presentation. **CASE PRESENTATION:** Subject pilot was a 26-yr old C-130 pilot who presented with discomfort and redness in the right eye. The ophthalmologist diagnosed panuveitis and noticed he had oral and genital ulceration. Rheumatology assessment followed and Behcet's disease was diagnosed. Eye symptoms were treated with topical steroids, dorzolamide and timolol while systemic treatment was commenced with oral steroids and colchicine. He subsequently developed secondary glaucoma. Visual acuity in right eye was 20/400 and IOP was over 30 mmHg in both eyes. Right eye had +3 cells in the anterior chamber, cells in the vitreous and a small retinitis spot near the macula. Symptoms settled and acuity returned to 20/20 in both eyes. Treatment was changed to Adalimumab and topical steroids were stopped. He has since stayed in remission. Regular follow up continues under the ophthalmologist and rheumatologist. He was temporarily grounded during the acute phase and upgraded as fit to fly UAVs 9 months after initial presentation. After further review, he was upgraded as fit to fly as co-pilot only, 16 months after initial presentation.

**DISCUSSION:** Aeromedical concern in this case included defective vision and possible complications of immunosuppressive therapy. In this case recovery was quick and he remained in remission on biologics and topical eye drops. He had no psychological sequelae and was keen to return to flying duties. This was done in a phased manner by initially awarding him fitness to fly UAVs followed by limited flying fitness roughly equating to OML. This was done to minimize the risk of subtle incapacitation and he remains under regular follow up.

#### Learning Objectives

1. Understand the common presenting symptoms of Behcet's disease and treatment modalities, including complications of treatment. This pilot developed secondary glaucoma as a result of topical steroid treatment for his uveitis and this could have worsened the prognosis for his affected eye.
2. Regular follow up is required for this condition to monitor for flare ups and possible side effects of medications. Return to flying duties should be in a phased manner and in this case was finally limited to flying as copilot only, in order to minimize risk of subtle incapacitation.
3. Our experience with Adalimumab was limited and the decision to upgrade to flying duties took a lot of consideration. In the end, his lack of recurrent symptoms, side effects and enthusiasm to return to flying duties helped in the decision making process. His command was also supportive.

**[29] CAN YOU HEAR ME NOW?**Douglas Hogoboom<sup>1</sup>, Matthew Cooper<sup>1</sup><sup>1</sup>U.S. School of Army Aviation Medicine, Fort Rucker, AL, USA*(Education - Case Study)*

**INTRODUCTION:** Hearing is essential in the aviation environment for safe operations. As such, all Army aircrew members undergo annual hearing examinations as part of the flight physical. Air crew members with significant threshold shifts are referred to an audiologist for further testing and evaluation to ensure that they are able to meet the flight standards. Unfortunately, many medical conditions affect hearing, some are reversible and some aren't. Here, we present a case of a flight medic who developed unilateral ear pain with hearing loss. Subsequent evaluation established the diagnosis of Bullous Myringitis (BM). **BODY:** The patient is a 39 year old male flight medic who had an insidious onset of right ear pain associated with subjective ipsilateral hearing loss and tinnitus. Evaluation at the flight medicine clinic was notable for vesicles on the tympanic membrane without evidence of effusion, concerning for BM. Audiogram was notable for mild loss at 500 Hz and mild to moderate loss from 4,000 to 8,000 Hz. He was placed on Augmentin twice daily for ten days and given a temporary restriction from flight duties. Additionally, given the rarity of the condition, he was referred to an otolaryngologist for confirmation. **DISCUSSION:** BM is an infectious condition of the tympanic membrane that may mimic acute otitis media (AOM). It can be both viral and/or bacterial in nature with similar pathogenicity as AOM. The main aeromedical concern with BM is the potential for sensorineural hearing loss (SNHL). Hearing loss is common in this condition with an average sensorineural hearing loss of 28 dB at the higher frequencies in the affected ears. Close monitoring of the patient's hearing is needed for all aircrew with a diagnosis of BM as the SNHL could be permanent. BM has also been associated with transient vestibular dysfunction, which can also present aeromedical concerns. Given the propensity for the aviation environment to cause spatial disorientation, any dysfunction of the vestibular system could gravely incapacitate a crewmember. Luckily, for our patient, he did not have vestibular symptoms and the hearing loss fully recovered to his pre-infection baseline.

**Learning Objectives**

1. The audience will learn about a case of an uncommon cause of ear pain; including pathophysiology, signs and symptoms, differential diagnosis, treatment, and complications
2. The audience will understand the importance of being familiar with a disease processes pathophysiology in order to better evaluate the ramifications for the aviation environment

**Monday, 08/30/2021****10:30 AM****Plaza D/E****[S-08]: SLIDE: RISKY BUSINESS IN SPACE****Chair: Amanda Lippert****Co-Chair: Ronald Robinson****[30] COUNTERMEASURES FOR SPACEFLIGHT ASSOCIATED NEURO OCULAR SYNDROME: AN INVESTIGATION OF ARTIFICIAL GRAVITY**Allison Anderson<sup>1</sup>, Joseph Butterfield<sup>1</sup>, Prem Subramanian<sup>3</sup>, Torin Clark<sup>1</sup><sup>1</sup>University of Colorado Boulder, Boulder, CO, USA; <sup>2</sup>University of Colorado School of Medicine, Aurora, CO, USA*(Original Research)*

**INTRODUCTION:** The origin of the spaceflight associated neuro-ocular syndrome (SANS) has not been determined conclusively, but long-term exposure to microgravity appears to contribute to ocular changes not present on Earth. Mimicking gravitational loading through artificial gravity (AG) may mitigate these negative adaptations. In our prior work we performed an experiment to investigate two AG

conditions. We briefly review these results and identify alternative mechanisms that may affect intraocular pressure (IOP) during AG.

**METHODS:** Seventeen subjects (9M, 8F, 18-32 years) completed the experiment. Experimental conditions were: 1) Supine, 2) Standing, 3) center of rotation at the eye (ECAG), 4) 2G's at the feet (2GAG, causing the eye to be off the center of rotation). In both AG conditions, subjects were spun to produce 1G at their center of mass. Data collected included self-administered intraocular pressure (IOP, Tonopen AVIA), and cardiovascular parameters. **RESULTS:** IOP showed a main effect ( $F(3,48)=11.0$ ,  $p<0.0005$ ), with Standing significantly lower than Supine ( $p=0.0009$ ), AGEC ( $p=0.002$ ), and AG2G (0.036). Supine, AGEC, and AG2G were not statistically different. Cardiovascular parameters were lower in Supine compared to all other postures ( $p=0.002$  to  $p<0.0005$ ), but there were no differences between Standing, AGEC, and AG2G. **DISCUSSION:** Cardiovascular parameters behaved as hypothesized, as did IOP in the supine and standing positions. In both AG conditions, though, IOP was elevated above standing values. Since IOP is driven by cardiovascular parameters and fluid shift, this is contrary to the initial hypothesis. This indicates there are additional unconsidered factors influencing IOP in AG. We propose that either venous pressures were elevated or choroidal blood volume was increased in AG beyond what was expected. Potential mechanisms include systemic vasoconstriction in the legs, enhanced venous return due to leg muscles, increased thoracic pressures due to tissue weight, and/or elevated choroidal blood flow. These mechanisms are being evaluated through a series of experiments. This study was the first to investigate IOP during short radius centrifugation, informing its use as a proposed countermeasure to mitigate SANS. Our results inform the potential for future designs of AG systems in microgravity, which will likely be an intermittent, short-term exposure of centrifugation.

**Learning Objectives**

1. Participants will understand the potential utility of artificial gravity to mitigate the spaceflight associated neuro-ocular syndrome.
2. Participants will know how intraocular pressure changes with changes in posture and artificial gravity.

**[31] A META-ANALYSIS TO INFORM ARTIFICIAL GRAVITY CONCEPTUAL DESIGNS TO MITIGATE SPACEFLIGHT-INDUCED PHYSIOLOGICAL DECONDITIONING**Kathrine Bretl<sup>1</sup>, Torin Clark<sup>1</sup><sup>1</sup>University of Colorado Boulder, Boulder, CO, USA*(Education - Program/Process Review)*

**INTRODUCTION:** Artificial gravity (AG) has the potential to provide a comprehensive countermeasure, mitigating spaceflight deconditioning of multiple physiological systems concurrently. Despite this promise and decades of research investigating the potential benefits and feasibility of AG, there remains a lack of optimized AG architecture. Here we quantitatively integrate the findings from available ground-based studies to assess the efficacy of using AG as a spaceflight countermeasure. Specifically, through a meta-analysis, we integrate our own findings with ground-based analog tests to identify the most effective AG design and protocol. **METHODS:** Twenty-five unique publications were identified for the meta-analysis. Each study investigated human response to centrifugation during bedrest campaigns (5 to 21 days, with recent studies continuing for 60 days). We have compiled and pooled outcome metrics by physiological subsystem (e.g., cardiovascular, musculoskeletal, etc.). To capture the degradation of analog deconditioning, we compute a relative (percent) change from pre to post-bed rest in both the control condition (bedrest only) and the treatment condition (bedrest with AG, or in some cases, bedrest with exercise during AG). **RESULTS:** Analysis was performed for cardiovascular, musculoskeletal, neurovestibular, endocrine, and immune systems. For example, we found cardiovascular metrics after bedrest differed from pre-test values by 19.4% (95% confidence interval (CI): 13.4-25.3%), representing the deconditioning from the ground-based analog. When an AG countermeasure was applied during bedrest, cardiovascular measures only changed from pre-test by 10.1% (95% CI: 7.9-12.3%), suggesting an effective mitigation of 48% of the deconditioning changes. Musculoskeletal system measures also benefitted from AG, as the treatment reduced bedrest-induced physiological changes by 55%. Our statistical analysis includes factors to identify potential trends in efficacy of different AG exposure prescriptions



or loading levels. **DISCUSSION:** The results of this meta-analysis suggest that AG protects physiological function during disuse, and different AG loading levels result in various levels of protection. Findings from the analysis will assist in directing future efforts to determine an optimized AG conceptual design for use in mitigating astronaut physiological deconditioning during long-duration space exploration.

#### Learning Objectives

1. Participants will learn about the effectiveness of artificial gravity in mitigating physiological deconditioning in spaceflight analogs.
2. Participants will learn how to perform a meta-analysis that quantitatively integrates findings from several studies and groups the findings to inform design.

### [32] WHAT IS A SAFE ELECTRICAL CURRENT TO CONDUCT THROUGH AN ASTRONAUT?

Doug Hamilton<sup>1</sup>

<sup>1</sup>University of Calgary, Calgary, Alberta, Canada

#### (Original Research)

**INTRODUCTION:** Research conducted over the last 15 years shows that astronauts performing intra- and extra-vehicular activities may be exposed to undesired electrical hazards. Experiments conducted in the 20th century on humans determined the physiological responses to the magnitude of electrical current being externally conducted through them and their severity (muscle contraction, ventricular fibrillation, burn etc.). With the exception of burn and tissue destruction, most of the physiological responses of living systems to electrical shock are due to the electric field (E-Fields) stimulating nerves and/or muscle. In order to quantify these effects, NASA used computational models to characterize the typical impedance the human body presents to an electrical hazard and its resultant physiological response. **METHODS:** Using a supercomputer, a multiresolution variant of an admittance method, along with a magnetic resonance image millimeter resolution model of a male human body, were used to calculate the induced E-Fields secondary to a standard 15-volt exposure over multiple parts of the body. **RESULTS:** Neurons in the human body respond to local spatial and temporal E-Field magnitude and variations by initiating electro-potential discharges which will propagate E-Field changes along the neuron resulting eventually in neuro-transmitter release to another neuron or an end-effector (muscle, gland, etc). These modeled exposures were found to be significant enough to cause involuntary neuromuscular activity caused by either large diameter peripheral nerve activation or reflex activity from cutaneous afferent stimulation. The calculated E-Fields are scalar and therefore can be extrapolated to almost any voltage exposure. **DISCUSSION:** Under realistic exposure conditions using a 15V source, current density magnitudes and total current injected are well above previously reported startle reaction thresholds. In the past, these voltage exposures were considered safe, thus abrogating the need for very expensive hazard controls, however this is not always the case inside a spacecraft or spacesuit. This new methodology presents and alternative means to mitigate electrical hazards by utilizing Probability Risk Assessment to quantify the severity of the electrical shock as opposed to always controlling its likelihood. This could provide significant Mass, Power and Volume savings for Lunar and Mars missions and would further ameliorate electrical hazards on Earth.

#### Learning Objectives

1. The participant will understand the current dogma used to control electrical hazards for spaceflight.
2. The participant will understand the physiology and pathophysiology of electrical shock during an extravehicular activity.
3. The participant will understand the means by which large computers can be used to model human electrical exposures during spaceflight and their resultant hazard risk.

### [33] A QUALITATIVE SYSTEMATIC REVIEW OF ELEVATED AMBIENT CARBON DIOXIDE ON PHARMACEUTICAL STABILITY: IMPLICATIONS FOR HUMAN SPACEFLIGHT

Emily Stratton<sup>1</sup>, Rochelle Velho<sup>2</sup>, Anthony Yuen<sup>3</sup>, Michelle Demetres<sup>3</sup>, Jonathan Laws<sup>4</sup>, Bryce Christensen<sup>5</sup>, Keval Patel<sup>6</sup>, Benjamin Easter<sup>7</sup>, Kris Lehnhardt<sup>7</sup>

<sup>1</sup>Mayo Clinic, Rochester, MN, USA; <sup>2</sup>University Hospitals Birmingham NHS Trust, Birmingham, United Kingdom; <sup>3</sup>Weill Cornell Medicine, New York, NY, USA; <sup>4</sup>University of Northumbria, Newcastle upon Tyne, United Kingdom; <sup>5</sup>Brooke Army Medical Center, San Antonio, TX, USA; <sup>6</sup>Johns Hopkins University, Baltimore, MD, USA; <sup>7</sup>NASA Johnson Space Center, Houston, TX, USA

#### (Original Research)

**INTRODUCTION:** Pharmaceuticals are an essential component of the medical system for crewed missions. Current research has identified decreased stability in space-flown pharmaceuticals compared to ground controls, and this presents a significant risk for future exploration-class missions where resupply will be limited. While the cause is not known, the elevated ambient carbon dioxide (CO<sub>2</sub>) in the spacecraft atmosphere has been postulated as a potential contributing factor. The aim of the review was to determine the impact of higher partial pressure of carbon dioxide in the atmosphere on pharmaceutical stability from the available literature.

**METHODS:** An extensive search was conducted on the Ovid MEDLINE, Ovid EMBASE, Cochrane Library (Wiley), Web of Science Core Collections (Clarivate Analytics), PubSpace, and the NASA Technical Reports Server (NTRS) databases from the beginning of records to April 6, 2020. Abstract screening was performed on the results in a blinded manner by two authors (KP, BC) and secondary screening by full text was performed in a blinded manner by another three authors (AY, RV, ES). The Aerospace Medicine Systematic Review Group (AMSRG) quality scoring tool was used to assess the quality of included documents and NVivo 12 was used to extract data for thematic analysis. **RESULTS:** The systematic review identified a total of four publications of varying quality out of a total of 13,385 documents. There was insufficient data to complete a quantitative comparison. A thematic analysis was conducted and revealed two overarching themes: 1) Elevated levels of ambient CO<sub>2</sub> may be a precipitating factor leading to pharmaceutical degradation and 2) that pharmaceutical repackaging may lead to accelerated degradation profiles.

**DISCUSSION:** The lack of quality studies in both terrestrial and space environments affirm a literature gap in understanding the effect of elevated ambient CO<sub>2</sub> on pharmaceutical stability. Furthermore, space-flown pharmaceuticals are repackaged for missions due to operational purposes and there is terrestrial literature reporting limited stability for pharmaceuticals that were repackaged on the ground in dosage administration aids. Further studies are needed to elicit the individual impact of higher ambient CO<sub>2</sub> and repackaging on pharmaceutical stability.

#### Learning Objectives

1. The audience will learn about the impact of higher partial pressure of carbon dioxide in the atmosphere on pharmaceutical stability, and the implications for human space flight.
2. The audience will learn about the systematic review process used to capture the relevant information and qualitative synthesis of the studies.

### [34] SPACEFLIGHT MEDICAL EVACUATION RISK ASSESSMENT PRINCIPLES: A QUALITATIVE INVESTIGATION FROM SPACE AND ANALOG ENVIRONMENTS

Austin Almand<sup>1</sup>, Jonathan Laws<sup>2</sup>, Arian Anderson<sup>1</sup>, Kris Lehnhardt<sup>3</sup>, Benjamin Easter<sup>3</sup>

<sup>1</sup>University of Colorado School of Medicine, Aurora, CO, USA; <sup>2</sup>Northumbria University, Newcastle upon Tyne, United Kingdom; <sup>3</sup>NASA, Houston, TX, USA

#### (Original Research)

**INTRODUCTION:** Human space exploration beyond low Earth orbit will require innovative solutions to support the crew medically and optimize their health and performance. Challenges will include communication delays, minimal to non-existent resupply, long transfer times to definitive medical care, and significant limits on mass-power-volume-data. Included in these challenges will be assessing the risks and benefits that a complicated medical evacuation (MEDEVAC) poses to the injured crewmember, the remainder of the crew, and to accomplishing the mission. This qualitative study identifies common medical evacuation risk assessment principles used in spaceflight and other extreme environments to better inform future risk assessment tools and exploration mission concepts. **METHODS:** Semi-structured interviews focused on MEDEVACs were conducted with subject matter experts in spaceflight and appropriate analog environments, defined as domains

that present elements of operational mission requirements, evacuation complexity and limited local medical capability such as: polar research, civilian and military undersea operations, combat medicine, and alpine mountaineering. Transcripts were analyzed for recurring themes using the qualitative method of Thematic Analysis with the technique of consensus, co-occurrence and comparison. **RESULTS:** Data from initial interviews show two main recurrent themes: the risks a MEDEVAC poses to the remaining crew are considered more heavily than the medical risks to the patient, and that a patient's stability and likelihood of remaining stable for the estimated evacuation time is a prime factor in deciding whether to execute a MEDEVAC. Data also show that mission considerations were common but often secondary and assessed primarily upon the level of dedicated resources. **DISCUSSION:** Unlike standard medical practice which regards responsibility to the patient as paramount, preliminary data show that extreme environments prioritize the health and safety of the crew over that of the patient. Additionally, resource allocation and a patient's long-term stability are heavily considered when deciding whether or not to conduct a MEDEVAC in extreme environments. These factors are rarely considered in normal medical care where all resources and options are often exhausted to save a patient. These and other recurrent themes will be critical for evaluating risks and medical support plans when designing future space exploration missions.

#### Learning Objectives

1. Understand that medical support to exploration spaceflight is complex and present unique challenges to medical evacuation risk assessments and decisions.
2. Appreciate that the unique considerations used in extreme environment medical evacuations differ from conventional medical support paradigms.

#### [35] DECON IN DEEP SPACE: LESSONS FROM MICROBIAL MONITORING IN ISOLATED AND CONFINED ENVIRONMENTS

Sheyna Gifford<sup>1</sup>, Yajaira Sierra-Sastre<sup>2</sup>, Benjamin Johnson<sup>3</sup>  
<sup>1</sup>Washington University St. Louis, St. Louis, MO, USA; <sup>2</sup>Science in Space, Rockville, MD, USA; <sup>3</sup>Georgetown University, Washington, DC, USA

#### (Original Research)

**INTRODUCTION:** The significance of the human-microbe relationship is amplified in long duration space exploration (LDSE), where isolated and confined microbial environments degenerate space habitat integrity, comprise planetary protection goals, and have unknown effects on astronaut health. To investigate the effects of closed environments on microbes, a series of experiments were conducted at a Mars analog in Hawai'i. **METHODS:** The study occurred in the isolated and confined environment (ICE) of the Hawai'i Space Exploration Analog and Simulation (HI-SEAS) during two distinct time periods. At HI-SEAS Mission I (M1), leftover food samples were homogenized and cultured for pathogenic bacteria and two ATP luminometry assays were used to measure metabolic activity of microbes as a proxy for cleanliness on bathroom and kitchen surfaces. In Mission IV (M4), nasal swabs of crew members were collected fortnightly. The DNA was extracted and sequenced for 16S rRNA to determine bacterial genera present. **RESULTS:** During M1, leftover meals had low microbial loads unless stored longer than three days, when they yielded too-numerous-to-count aerobic bacteria. Rehydrated fruits exhibited *S. aureus*. Microbial burden was highest on the microwave touch panel and the hot tea handle. In the bathroom, the door handle exhibited the highest microbial burden. During M4, crew nasal microbiome trends varied widely by subject. *Corynebacterium* was found to be the most abundant microbe among crew members overall and in crew members C & D, varied inversely with *Staphylococcus*. Samples taken after release from the isolated habitat showed immediate and drastic variation from samples taken just before release. **DISCUSSION:** For successful LDSE, in-situ surveillance schemes for and countermeasures against microbial contamination need to be devised. This ICE study features extensive in-mission microbial collections as well as post-mission sampling of the analog astronauts. It characterizes the microbial loads of the habitat, food, and crew, and provides unique insights regarding food planning, inter-crew bacterial transmission, and decontamination protocols for planetary habitats with kitchens and bathrooms. Given their relative accessibility and comparatively modest cost, Earth-based analogs are invaluable for the aerospace community to

expand our understanding of microbial behavior in ICE and to apply this knowledge to mission operations on-planet before making the giant leap into deep space.

#### Learning Objectives

1. To understand the relationship between mission success and the microbiome in extended space operations.
2. To receive an introduction to the current state of space-based microbiome research.
3. To explore the benefits to human health and exploration generated by robust microbiome research in analog environments.

Monday, 08/30/2021  
 Governor's Square 14

2:00 PM

#### [S-09]: SLIDE: IN-FLIGHT FATIGUE ASSESSMENTS FOR MILITARY AND COMMERCIAL PILOTS

Chair: Kathryn Hughes  
 Co-Chair: Andrea Hanson

#### [36] MEASUREMENT OF FATIGUE AND PERFORMANCE OF OPERATIONAL RISK MATRIX IN IDENTIFYING FATIGUE – EX GREEN FLAG WEST 19-5

Ian Mollan<sup>1</sup>, Emma Smith<sup>2</sup>

<sup>1</sup>Royal Air Force, Carterton, United Kingdom; <sup>2</sup>Royal Air Force, Henlow, United Kingdom

#### (Original Research)

**INTRODUCTION:** Previously, an objective fatigue measurement in RAF Typhoon pilots on Ex GREEN FLAG 17-04 indicated sub-optimal fatigue management in around 1 in 7 sorties. A more precise measurement by actigraphy was undertaken with the primary aim to determine the level of aircrew fatigue on FLAG Exercises. **METHODS:** All Ex GREEN FLAG 19-5 aircrew were offered entry to the study; 17 out of 18 participated for the entire 3-week period. Daily sleep diaries and actigraphy were analysed using the FAST model to generate an effectiveness score. A secondary objective was to assess the performance of the Operational Risk Matrix (ORM) in identification of fatigue pre-flight. Individual pilots completed an ORM before each sortie, the responses were compared against effectiveness using ANOVA. The null hypothesis was that there was no difference in the measured mean effectiveness between ORM question responses. **RESULTS:** Participation was high; 17 out of 18 pilots took part for the entire Exercise. A total of 140 flying tasks, comprising: 96 simulated weapons release, 28 live weapons release and 18 familiarization sorties were examined. Mean effectiveness at ORM completion was  $83.9 \pm 15.8$ ; effectiveness was normally distributed. Only 5 sorties were undertaken with effectiveness less than 70. There was no difference in measured effectiveness for number of consecutive previous duties ( $p=0.91$ ), reported sleep quality ( $p=0.57$ ), reported time to adjust to current time zone ( $p=0.54$ ) or anticipated duty length ( $p=0.15$ ). There were significant differences in measured effectiveness for duty start time ( $p<0.001$ ), number of prior consecutive night duties ( $p<0.001$ ), sleep immediately prior to flight ( $p<0.001$ ), hours of rest since previous duty ( $p=0.001$ ), sleep in the previous 3 days ( $p=0.001$ ) and number of reported wakeful hours at the end of duty ( $p=0.01$ ). **DISCUSSION:** Over half of ORM questions had significant relationship with effectiveness. The ORM should be further honed and applicability to other types of military flying examined. Whilst measured effectiveness had improved compared to the previous Ex: deployment of a flight surgeon, measurement precision, pharmacological fatigue countermeasure trials and the ability to issue medications were likely factors contributing to the fatigue improvements. The ORM demonstrated usefulness in identifying fatigue pre-flight, but further work should be undertaken to create a validated scoring system to aid flight authorizers.

#### Learning Objectives

1. Understand the content of the questions asked on the Operational Risk Matrix and their relationship with measured fatigue on a fast-jet exercise.
2. Understand the confounding factors which may have influenced the measurement of fatigue on this exercise, compared with previous exercises.

### [37] DIFFERENCES BETWEEN SHORT AND LONG-HAUL PILOTS' ROSTERS, STRESS, SLEEP, FATIGUE AND MENTAL HEALTH

Marion Venus<sup>1</sup>

<sup>1</sup>University of Bern, Venus Aviation Research, Training & Support, Maur, Switzerland

(Original Research)

**INTRODUCTION:** This research was set out to compare short haul (SH) and long haul (LH) pilots regarding sleep restrictions and fatigue risks on flight duty, sleep problems, fatigue-severity, wellbeing and mental health. **METHOD:** 406 international SH and LH pilots completed the cross-sectional online survey. Pilots' sleep restrictions and fatigue-risk profiles (e.g. time-pressure, late arrivals, minimum rest), sleep problems, fatigue-severity, wellbeing, symptoms of depression, anxiety and common mental disorders (CMD) were measured and compared for SH and LH pilots. **RESULTS:** Although SH and LH pilots were scheduled for only 51.4% to 65.4% of the legally allowed duty and flight hours, 44.8% SH pilots reported severe fatigue (FSS $\geq$ 4), additional 31.7% high fatigue (FSS $\geq$ 5), compared with 34.7% and 37.3% LH pilots. Considerable sleep problems in  $\geq$ 8 nights/month were reported by 24.6% SH vs. 23.5% LH pilots. Positive depression screenings were reported by 18.1% SH and 19.3% LH pilots. Positive anxiety screenings were reported by 9.6% SH and 5% LH pilots. 20% of all investigated pilots reported significant symptoms of depression or anxiety, 7.23% had positive depression and anxiety screenings. LH pilots reported significantly better wellbeing than SH pilots. **DISCUSSION:** Our results show that even far less duty and flight hours than legally allowed according to FTL lead to high levels of fatigue, sleep problems and significant mental health issues among pilots. SH pilots were even more affected than LH pilots. Pilots' fatigue should be considered as immediate threat to aviation safety and pilots' fitness to fly by promoting fatigue and burnout.

#### Learning Objectives

1. Understand that on average three of four pilots report severe fatigue, and that short haul pilots are more affected by severe fatigue than long haul pilots, even though their flight and duty hours are 49% to 35% below the legal limits (FTL).
2. Understand that short haul pilots' sleep, wellbeing and health is more affected by more demanding rosters, sleep restrictions, fatigue risks on flight duty, compared with long haul pilots.
3. Understand that although short haul pilots were significantly younger than long haul pilots, short haul pilots reported more symptoms of common mental disorders, more impaired wellbeing and more sleep problems.

### [38] DIFFERENCES IN FATIGUE AND PERFORMANCE MEASURES AMONG AIRLINE PILOTS DURING EARLY STARTS AND LATE FINISHES

Erin Flynn-Evans<sup>1</sup>, Lucia Arsintescu<sup>2</sup>, Kevin Gregory<sup>1</sup>, Cassie Hilditch<sup>2</sup>, Sean Pradhan<sup>3</sup>

<sup>1</sup>NASA Ames Research Center, Moffett Field, CA, USA; <sup>2</sup>San Jose State University Research Foundation, Moffett Field, CA, USA; <sup>3</sup>Menlo College, Atherton, CA, USA

(Original Research)

**INTRODUCTION:** Pilots are limited in the number of hours they can work based on duty start time and flight duration. Current regulations in the United States and Europe allow for a longer duty day when work start occurs in the morning, while the duty day is restricted when work start occurs later in the day. However, early starts often require pilots to report for work during the window of circadian low, which has the potential to impair performance relative to later starts. Few studies have examined objective measures of performance by time of day. We hypothesized that performance on the psychomotor vigilance task (PVT) would be impaired according to both work start time and time awake during short-haul aviation operations. **METHODS:** Short-haul airline pilots completed sleep diaries over 34 days of data collection. They completed a five-minute version of the PVT and the Samn-Perelli fatigue rating scale upon waking, pre-flight, at the top of descent during each flight,

post-flight, and before bed for all duty days. Data were stratified by duty start time, with early starts defined as 05:00-06: 59, mid-morning starts as 07:00-10: 59, afternoon starts as 13:00-16: 59, and evening starts as 17:00-20: 59. The PVT was inverse transformed (1/ reaction time; response speed). Data were analyzed using linear mixed-effects models (R Studio Version 1.1.419). All *p*-values were Bonferroni corrected. **RESULTS:** One hundred pilots completed the study. Pilots reported significantly higher fatigue on the Samn-Perelli at duty end when their flight duty period (FDP) started in the afternoon (*n* = 356 FDPs) and evening (*n* = 60 FDPs) compared to early- (*n* = 423 FDPs) and mid-morning (*n* = 135 FDPs; both *p* < 0.01). Pilots' subjective fatigue scores were also significantly higher for FDPs that began in the early morning as opposed to the mid-morning (*p* < 0.05). Subjective fatigue was also significantly impacted by both prior sleep period time and time awake at duty start, whereby increased time awake and sleep periods were associated with higher reported fatigue. The results were identical for objective fatigue, as measured by PVT response speed. **DISCUSSION:** Both early starts and late finishes are associated with reduced performance relative to mid-morning starts. These findings suggest that it may not be appropriate to allow longer duty length for early starts due to the influence of the circadian rhythm on alertness during the window of circadian low.

#### Learning Objectives

1. The participant will be able to understand how time awake and circadian factors influence pilot performance during short-haul flights.
2. The participant will learn how pilot fatigue and performance are influenced by existing flight and duty time regulations.

### [39] EFFECTS OF AN 11-HR SIMULATED FIGHTER MISSION ON FLUID BALANCE, G-TOLERANCE, COGNITIVE PERFORMANCE, AND COMFORT

Mikael Grönkvist<sup>1</sup>, Ola Eiken<sup>1</sup>, Eduardo Rosa<sup>2</sup>, Johan Willander<sup>2</sup>, Roger Kölegård<sup>1</sup>

<sup>1</sup>Royal Institute of Technology, Solna, Sweden; <sup>3</sup>University of Gävle, Gävle, Sweden

(Original Research)

**INTRODUCTION:** Modern fighter aircraft with in-flight refueling capacity enable long-duration flight missions. The aim was to investigate the effects of an 11-hr simulated flight mission (FM) on comfort and physical and cognitive functions. **METHODS:** 12 subjects performed a simulated patrol mission in a dynamic flight simulator (DFS) with a gondola mock-up of the Swedish fighter 39 Gripen. Each subject was wearing complete pilot personal equipment and was provided with 1.5 L of drinking water and 6 protein/energy bars. The DFS was standing still throughout the test, apart from the first and last 45 min during which it was spinning for determination of the subjects' relaxed G-tolerance with and without anti-G suit (AGS), as well as his/her spatial orientation in terms of ability to perceive roll tilt during a simulated coordinated turn without visual cues. Every second hour, the subject performed cognitive tests and rated sleepiness, fatigue, and discomfort. Urine was collected throughout, and venous blood was sampled before and after the FM, for assessment of fluid balance. **RESULTS:** One subject discontinued prematurely due to urinary retention. FM caused a 5% reduction in plasma volume and reduced G-tolerance without AGS by 14%. FM did not affect spatial orientation nor cognitive functions, apart from a 10-15% increase in reaction time about seven hours in to the mission, coinciding with a higher rating in fatigue. FM caused moderate discomfort in the lower back and buttocks. **CONCLUSION:** It seems feasible to perform an eleven-hour flight mission in a fighter with only minor reductions of physical and cognitive performance.

#### Learning Objectives

1. An insight in the cognitive effects of an 11-hr long flight mission in a single seat fighter.
2. An insight in the physiological of an 11-hr long flight mission in a single seat fighter.



**[40] CONTROLLED REST: INVESTIGATING THE USE OF AN IN-FLIGHT SLEEPINESS COUNTERMEASURE**Cassie Hilditch<sup>1</sup>, Lucia Arsintescu<sup>1</sup>, Kevin Gregory<sup>2</sup>, Erin Flynn-Evans<sup>2</sup><sup>1</sup>San Jose State University Research Foundation, Moffett Field, CA, USA;<sup>2</sup>NASA, Moffett Field, CA, USA*(Original Research)*

**INTRODUCTION:** Sleepiness is commonly reported amongst commercial airline pilots and is recognized as a safety risk due to its impact on performance. Controlled Rest (CR) refers to a short, voluntary nap opportunity taken by pilots on the flight deck as a countermeasure to unanticipated sleepiness in flight. This study explores the profile of CR use in a long-haul commercial airline. **METHODS:** Forty-four pilots filled in an application-based sleep/work diary and wore actiwatchers for approximately 2 weeks. Complete data sets from 239 flights including sleep diaries, actigraphy, and schedules were merged and analyzed. Sleep diary entries were used to set CR intervals in the actigraphy software, which was then used to predict sleep within these intervals. All time stamps of sleep periods and flight schedules were adjusted for home-base time of the pilots. Pearson Correlations were used to assess the influence of pilot demographics on CR use. A mixed-effects logistic regression was used to analyze the impact of schedule factors on CR. **RESULTS:** Pilots reported taking CR on 46% (n=110) of observed flights. Average CR attempt duration was 43.1 ± 11.0 minutes. Eighty percent (n=106/133) of all CR attempts were estimated by actigraphy to have successfully achieved sleep with an average sleep duration during successful rest periods of 31.7 ± 12.2 minutes. Captains reported taking CR on 38% of flights (n=39/102), compared to First Officers reporting 52% (n=71/137) of flights with CR (p=0.131). Age, experience, BMI, and sleep need were not associated with the percentage of flights with CR (all p>0.244). The following schedule factors were associated with a higher frequency of CR: night (55%, n=76) vs. day flights (34%, n=34; <10h (63%, n=80) vs. >10h duration flights (27%, n=30; return (60%, n=71) vs. outbound flights (33%, n=39; and 2-pilot (69%, n=83) vs. >2-pilot flights (23%, n=27) (all p≤0.001). There was a trend for more CR on eastbound flights, but this was not significant (eastbound: 51%, n=57; westbound: 40%, n=44; p=0.059). Of note, 22% (n=26) of augmented flights (>2-pilots) contained both CR and Bunk Rest (in a designated rest facility). **DISCUSSION:** Data from this airline show that pilots commonly use CR to mitigate sleepiness in-flight, especially on flights <10h duration and during home-base nighttime flights. Future studies are required to determine generalizability of these results to other airlines.

**Learning Objectives**

1. The audience will learn about the prevalence and distribution of Controlled Rest use as a countermeasure to sleepiness in a long-haul commercial aviation operation.
2. The participant will be able to understand the importance of in-flight fatigue countermeasures for maintaining flight crew alertness and performance.

**[41] PILOT WORKLOAD IS ASSOCIATED WITH LONG DUTY DAYS AND MULTIPLE FLIGHT LEGS**Lucia Arsintescu<sup>1</sup>, Kenji Kato<sup>2</sup>, Erin Flynn-Evans<sup>3</sup><sup>1</sup>San Jose State University Foundation, Moffett Field, CA, USA; <sup>2</sup>ASRS Research and Technology Solutions, Mountain View, CA, USA; <sup>3</sup>NASA Ames Research Center, Mountain View, CA, USA*(Original Research)*

**BACKGROUND:** Pilot workload is a real danger throughout aviation, especially in short-haul operations due to short flights and multiple flight legs. Our goal was to examine the workload experienced by pilots during normal operations in a short-haul airline. **METHODS:** Thirty pilots flew a roster consisting of a cycle of five days of mid-day start time duty hours with many flight legs (baseline block) followed by four days off, five early start time duty hours followed by three days off, five mid-day time starts with many legs followed by three days off and then five early start time followed by one day off. The pilots provided evaluations of workload by scoring the six subscales of NASA-TLX (i.e., Mental Demand, Performance, Physical Demand, Effort, Temporal Demand, and

Frustration) on their duty days during each flight and once during rest days. The analyses included the raw TLX scores for each demand, the mean raw TLX, and the overall weighted TLX mean for duty days and rest days. **RESULTS:** We found that mental demand was significantly lower for each duty schedule and rest relative to baseline (early start 1st block p = 0.016, late duty p = 0.017, early start 2nd block p < 0.001, rest p < 0.001). Temporal demand was significantly lower than baseline on early duty 1st block (p = 0.02), early start 2nd block (p < 0.001), and rest (p < 0.001). Effort was significantly lower than baseline only during early start 1st block (p = 0.014) and early start 2nd block (p < 0.001). Frustration was significantly lower during early start 2nd block relative to baseline (p = 0.039). Physical demand and performance were higher relative to baseline during rest days (p < 0.001). Mean raw TLX showed significantly lower workload for early start 1st block (p = 0.011) and early start 2nd block (p < 0.001). The overall weighted TLX showed significantly lower workload for early start 1st block (p = 0.004), early start 2nd block (p < 0.001) and rest (p < 0.001). **DISCUSSION:** We found that pilots experienced higher workload on longer duty days with multiple flight legs. Pilots experienced lower mental demand, temporal demand, and effort on short duty days even their duty started earlier in the day. During days off pilots experienced higher physical demand and higher performance.

**Learning Objectives**

1. The audience will learn about workload levels experienced by pilots during short-haul operations.
2. The audience will be informed that short-haul pilots experience higher workload on long duty days with multiple flight legs.

**Monday, 08/30/2021**  
**Governor's Square 15****2:00 PM****[S-10]: SLIDE: THE APPLICATION OF EN-ROUTE DATA****Chair: Cathy Dibiase****Co-Chair: Sean Smith****[42] BENEFITS OF APP-BASED ECG ON BOARD: RESULTS FROM MHEALTH IMPLEMENTATION ON LUFTHANSA'S LONG-HAUL FLEET**Sven-Karsten Peters<sup>1</sup>, Andre Gomola<sup>2</sup><sup>1</sup>Deutsche Lufthansa AG, Frankfurt am Main, Germany; <sup>2</sup>Deutsche Lufthansa AG, Raunheim Germany, Germany*(Original Research)*

**INTRODUCTION:** This case reports results from Lufthansa after implementing a new App-based, mHealth ECG solution to its "first aid crew process" in May 2019. Cardiovascular conditions amount for 7.7% of all in-flight medical emergencies and 18% of medical diversions in 2013. This trend is expected to more than double in the near future due to the demographic change in air travel and higher purchasing power of the 50+ passenger segment. This encourages airlines to focus on improved medical care and reliable ECG diagnostics on board. However, most available diagnostic technology is too cumbersome and neither cost effective nor easily integrated into existing on-board processes. **TOPIC:** Lufthansa addressed the challenge to improve first aid care for cardiovascular conditions and decision making for medical diversions by implementing a new App-based ECG solution. The system consists of an App on the cabin crew mobile device and a cable with four electrodes, providing a 12-lead ECG. All ECGs are automatically transmitted to ground-based medical support (GBMS) and are stored on backend servers for evaluation and reporting. **APPLICATION:** In 2018 the App-based ECG was piloted on 14 A380 planes followed by a rollout to 110 long-haul planes in May 2019. Lufthansa analyzed all GBMS and crew reports since implementation to evaluate the impact and quality of mHealth on board. Since May 2019, 63 passengers were examined. Major cardiovascular diseases could be excluded in 50% of all cases. During 15 flights the system was used to continuously monitor the heart condition and therefore prevent unwarranted diversions and 5 medical diversions were based on pathological ECG data. Due to the

high quality of the 12-lead ECG data (96% of ECGs were evaluable) and the effortless implementation and minimal staff training, Lufthansa was able to increase passenger safety and flight OPS stabilization. The ECG system sees high utilization by cabin crew and integrates seamlessly into existing on board emergency procedures. Lufthansa's experience shows how mHealth can provide high quality medical diagnosis for in-flight first aid crew processes of civil aviation.

#### Learning Objectives

1. The participant will be able to learn about the potential of mHealth used by medical non professionals, providing high Quality results for both medical diagnosis and flight ops decision making.
2. App based mHealth products can be a safe tool to create inflight safety in commercial passenger transfer.

#### [43] FACTORS AFFECTING MEDICAL INCIDENTS ON-BOARD COMMERCIAL AIRCRAFT, INCLUDING THE USE OF INFLIGHT TELEMETRY/CARDIAC MONITORING DEVICES

Kapil Ojha<sup>1</sup>, Justin Flatt<sup>2</sup>, Micheal Harrigan<sup>2</sup>, Linda Porter<sup>3</sup>, Stephen Houston<sup>2</sup>, Ashvini Keshavan<sup>4</sup>

<sup>1</sup>Civil Aviation Authority (UK), London, United Kingdom; <sup>2</sup>British Airways Plc., London, United Kingdom; <sup>3</sup>Virgin Atlantic Airways Ltd., Crawley, United Kingdom; <sup>4</sup>University College London, London, United Kingdom

#### (Original Research)

**INTRODUCTION:** 4.3 billion passengers travel by air annually, with medical incidents reported for 1 in every 14,000 passengers. The advent of ground-to-air medical services (GAMS) and inflight telemetry devices (IFTD) aimed to improve passenger safety but few studies have examined their impact on outcomes. **METHODS:** This study examined two large European carriers recording 1,239 medical incidents in 240 million passengers over four years. Databases and flight operation records were reviewed; medical conditions, volunteer healthcare professional (HCP) involvement, GAMS involvement, AED and IFTD use were documented alongside demographic and geographical data. Three outcomes were examined: medical diversion, death on-board and transportation to hospital. **RESULTS:** Carrier A and Carrier B had 1.27 incidents and 46 incidents per million passengers respectively. Multivariate logistic regressions showed AED use was significantly associated with outcomes ( $p < 0.0001$ ). Cardiologist presentations were associated with less frequent diversion (log odds ratio -2.522) but more frequent transport to hospital (1.330) and were linked to AED use. GAMS involvement was associated with lower odds of death on-board (Carrier A, -7.116) and higher odds of a medical diversion (Carrier B, 1.748). HCP involvement decreased the odds of diversion in Carrier A (-1.939) but increased them in Carrier B (1.913). Geographical sector (in both carriers) and IFTD use (in carrier B) had no significant effect on outcomes. **DISCUSSION:** AED, GAMS and HCP involvement could help carriers mitigate risks associated with medical incidents. Objective physiological data from IFTDs may support flight operations and clinical care but large-scale prospective studies are required to assess efficacy.

#### Learning Objectives

1. Establish if there are any predictors of major outcomes of a medical incident; namely medical diversion, death on-board or transport to hospital.
2. Establish if there is an association between the involvement of ground-to-air medical services and outcomes.
3. Establish if the use of inflight telemetry devices can influence outcomes.

#### [44] FOXTROT - FORWARD OPERATING BASE EXPERT TELEMEDICINE RESOURCE UTILIZING MOBILE APPLICATION FOR TRAUMA

Jennifer Stowe<sup>1</sup>, William Gensheimer MD<sup>1</sup>, Gary Legault<sup>1</sup>, Kyle Miller<sup>1</sup>, Jennette Little<sup>2</sup>

<sup>1</sup>U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, Enterprise, AL, USA; <sup>2</sup>TATRC, Fort Gordon, GA, USA

#### (Education - Program/Process Review)

**BACKGROUND:** During Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), 10-15% of combat-related trauma injuries involved the eye. There were 170 ocular trauma cases reported in 2018 occurring in deployed locations. The military ophthalmologist's primary mission is to be prepared to manage ocular trauma, especially in an austere environment; however with deployments across the globe, access to ophthalmic care is not easily accessible. The primary purpose of our research is the development of an operationally secure, Health Insurance Portability and Accountability Act (HIPAA) compliant, mobile application (mApp) to provide ophthalmic care to any remote deployed location through a teleophthalmology called FOXTROT - Forward Operating Base EXpert Telemedicine Resource Utilizing MOBILE Application for Trauma. The development of this application will effect the Aerospace Medical community by reducing the number of MEDEVACs needed in theater operations. In addition, future buildout of this application will involve developing a platform for aviation flight physicals. Currently in the military, we have one primary method for teleophthalmology involving pagers and non-secure or secure Defense Switched Network (DSN) phone, satellite phone, or cellular phone if Wi-Fi is available.

**OVERVIEW:** 1. Developed FOXTROT teleophthalmology mApp for ocular trauma utilizing the mobile healthcare environment. 2. Test and evaluate FOXTROT teleophthalmology. Develop a standardized and reproducible protocol for deploying FOXTROT. **DISCUSSION:** FOXTROT is currently being fielded in Afghanistan field hospitals. Based on an independent assessment, FOXTROT could potentially save the Military \$2.4M by preventing costly medical evacuations out of theater. There is currently limited access to ophthalmic care at forward-operating bases, especially with ocular trauma. Teleophthalmology is currently limited in the military and in the civilian sector. FOXTROT teleophthalmology mApp will improve and extend ophthalmic trauma care in remote deployed environments. In addition to field hospitals, it could be utilized for ocular trauma in any remote or austere environment, including ships at sea, disaster areas, and humanitarian missions. It could also be integrated into any medical treatment facility (MTF) or emergency department without an in-house ophthalmologist. FOXTROT would enhance the safety and quality of patient care and lower costs by avoiding some referrals.

#### Learning Objectives

1. Understand the importance telehealth can play in austere environments
2. Approx. how much money in the reduction of medical evacuation could the FOXTROT
3. Understand the requirements of virtual health with regards to protection of patient's personal information.

#### [45] AEROMEDICAL EVACUATION LINE OPERATIONS SAFETY AUDIT (LOSA) - THREAT AND ERROR MANAGEMENT WITHIN EN ROUTE CARE OPERATIONS

Daniel Wyman<sup>1</sup>, Kathleen Flarity<sup>2</sup>, Stephen Powell<sup>1</sup>

<sup>1</sup>Synsensus, LLC., Peachtree City, GA, USA; <sup>2</sup>University of Colorado School of Medicine, Aurora, CO, USA

#### (Education - Program/Process Review)

**BACKGROUND:** The Line Operations Safety Audit (LOSA) is a proactive safety assessment process developed by the FAA and implemented across aviation to improve safety and enhance performance. During normal operations, peer-to-peer observations are conducted using the Threat and Error Management (TEM) framework to collect/analyze LOSA data for trends and opportunities for improvement. USAF Air Mobility Command (AMC) has conducted LOSAs across multiple different aircraft/crew positions. In 2019/2020 AMC conducted the first-ever LOSA within the Aeromedical Evacuation (AE) environment. Since 2001, more than 32,000 patients have been transported through the AE system. Today's contingency operations continue to be challenging and require radical innovation as AE professionals continually seek new and creative ways to improve survival and quality of life for those entrusted to their care. This presentation will describe the stages of AE LOSA and highlight the results. **OVERVIEW:** The AE LOSA began with the formation of a

Steering Committee with members from AMC Safety, Operations, Command Surgeon, AOC and Synensys (Contractor) to develop the goals and provide project oversight. During the initial TEM development phase, Threats, Errors, and Undesired States (US) were codified into a TEM Matrix. Selected AE nurse/technician total force observers were then trained to conduct AE operational observations using TEM software. These observations were reviewed in real-time for data integrity, then validated via a subject matter expert roundtable. Finally, the aggregated data was analyzed and presented using descriptive techniques, comparisons, and trends. Upon AE LOSA completion, we determined the prevalence of Threats, Errors, and USs and examined effective management strategies within current USAF AE operations. Additional CRM, crew fatigue, mission complexity, and AE demographic data were collected. **DISCUSSION:** LOSA is a well document powerful tool applied by the aviation community to proactively highlight and correct safety and performance issues. Numerous En Route Care forums have identified the need for a better understanding of patient safety within the AE environment. The first-ever AE LOSA provided foundational safety management information regarding the Threats, Errors, and USs within USAF AE operations and highlighted effective management tactics, techniques, and procedures, thus paving the way for future AE operations in a contested environment.

#### Learning Objectives

1. The audience will learn about the Line Operational Safety Audit (LOSA) process and its value as a proactive safety assessment process which was developed by the FAA in 2005 and implemented across aviation organizations to improve safety and enhance performance.
2. The audience will learn about the Threats, Errors and Undesired States within Aeromedical Evacuation operations and Aeromedical Evacuation crew management strategies.

#### [46] EN ROUTE CARE RESEARCH REPOSITORY: RAPID ACCESS TO EVIDENCE

Derek Haas<sup>1</sup>

<sup>1</sup>Air Force Research Laboratory, Dayton, OH, USA

#### (Education - Program/Process Review)

**BACKGROUND:** Research and evidence-based practice initiatives are highly dependent upon access to existing literature. Most major universities across the U.S. and internationally maintain digital research repositories for both data and documents. However, there currently exists no repositories for ERC research and evidence-based practice. Thus, an ERCRR will promote the dissemination of relevant mission and clinical research findings. Therefore, the purpose of this session is to: 1. Provide examples from a market review of existing research repositories; 2. Delineate the value of an ERC Research Repository for key stakeholders;

3. Describe how an ERC Research Repository can be utilized by researchers and clinicians. **OVERVIEW:** The federal government's Science Portal (Science.gov Alliance) is a conglomerate constituted by the research repositories of fifteen federal agencies including the National Institutes of Health, National Library of Medicine (PubMed). Commercially, Elsevier is a science, technology, and health evidence bank. In the United Kingdom, 34 institutions of higher learning have partnered to form the research repository known as SHERPA. The benefits of an ERCRR include, but are not limited to the following: knowledge, efficiency, focus, currency, and collaboration. Knowledge implies the sharing of research and evidence-based practice information dissemination. Efficiency suggests the ERC research Repository is a one-stop resource for rapid access to ERC related evidence. Focus proposes that it is unique to joint service en route care. A living systematic review (LSR) methodology begets currency of the repository. Lastly, the ERCRR would encourage investigators to connect with colleagues (collaboration). **DISCUSSION:** Clinically, a cloud-based repository would offer caregivers and unit educators a mechanism to obtain up-to-date information which informs best clinical practice. For leadership, the ERC research repository would minimize competing efforts and disparate research and subsequently, optimize funding. Given all of these qualities, an ERCRR

would benefit not only scientists, but clinicians and commanders. However, perhaps the greatest beneficiary of the ERCRR will be the patient.

#### Learning Objectives

1. Provide examples from a market review of existing research repositories.
2. Delineate the value of an ERC Research Repository for key stakeholders.
3. Describe how an ERC Research Repository can be utilized by researchers and clinicians.

#### [47] PROSPECTIVE RISK ANALYSIS USING BOWTIE METHODOLOGY TO IMPROVE THE SAFETY MANAGEMENT OF IN-FLIGHT MEDICAL EMERGENCIES AND GUIDE AEROMEDICAL DATA USAGE

Peter Wallace<sup>1</sup>, Apurva Bharucha<sup>2</sup>, Stuart Mitchell<sup>3</sup>, Peter Hodgkinson<sup>2</sup>

<sup>1</sup>University of Cambridge, Cambridge, United Kingdom; <sup>2</sup>King's College London, London, United Kingdom; <sup>3</sup>Civil Aviation Authority, London, United Kingdom

#### (Education - Program/Process Review)

**BACKGROUND:** In-flight medical emergencies (IFMEs) are an important consideration for flight safety and can adversely affect aircrew and passengers. Annual commercial flights are predicted to double within the next two decades and so too the opportunities for IFMEs. Effective tools are therefore required to manage these risks and associated mitigation options. This work presents Bowtie methodology as a means of prospective risk assessment and safety management.

**OVERVIEW:** Bowtie methodology is well established in the fields of aerospace operations and medicine but has received limited consideration in aerospace medicine. We have undertaken a literature review and developed a bottom-up guide on how to produce an aerospace medicine Bowtie diagram supplemented by exemplar diagrams involving three key scenarios within the commercial aviation sphere. Based on these exemplar diagrams a review of current aeromedical data will be presented to demonstrate the practical application and potential benefits of Bowtie methodology in aerospace medicine. **DISCUSSION:** Risk management underpins aerospace medicine practice and the Bowtie provides a novel tool to support this work. The examples presented demonstrate its potential to inform efforts to mitigate the risk of a clinically significant incident in-flight and reduce the impact of such incidents where these efforts do fail. The Bowtie provides a framework for identifying and visualizing measures at all stages of event progression, from IFME prevention through to outcome mitigation. Critically it also provides a framework to review and direct the collection of aeromedical data at each of these stages as well as highlighting potential gaps in current data. Such applications of the Bowtie in aerospace medicine provide a framework for critical analysis of safety management systems around IFMEs, allowing their continuous monitoring and improvement through systematic aeromedical data collection and utilization. Whilst qualitative methods are presented in this work, the Bowtie diagram lays the foundation from which more robust quantitative models can be developed. These evidence-informed probabilistic risk assessment and machine learning-based optimization models would provide data driven risk management strategies, further enhancing safety management within aerospace medicine.

#### Learning Objectives

1. To understand and appreciate the unique benefits of applying Bowtie methodology in the prospective risk analysis and safety management of in-flight medical emergencies at all stages of event progression, from incident prevention through to outcome mitigation.
2. To review current aeromedical data collection and usage in improving the safety management of in-flight medical emergencies.
3. To learn how to construct a Bowtie diagram for aeromedical applications.



**Monday, 08/30/2021**  
**Plaza A/B**

**2:00 PM**

## **[S-11]: PANEL: ENABLING PROGRESSIVELY AUTONOMOUS MEDICAL OPERATIONS FOR SPACE EXPLORATION**

**Chair: Kris Lehnhardt**  
**Co-Chair: Sharmila Watkins**  
**Co-Chair: Michael Barratt**

**PANEL OVERVIEW: INTRODUCTION:** As NASA and its International Partners prepare to expand human space exploration beyond the International Space Station (ISS) to the Moon (and ultimately Mars) with the Artemis missions, the importance of evolving space medical operations in an Earth independent fashion becomes increasingly clear. Continuous human presence on the ISS for 20 years has demonstrated the successful development and execution of medical operations in low Earth orbit. However, this paradigm of medical operations is dependent upon continuous real-time communications, frequent resupply missions, and the availability of rapid evacuation options. As the distance and time away from Earth increase, all of these dependencies will no longer be available. In addition, future surface operations and dynamic flight events in deep space will incur medical risks beyond current ISS activities. As a result, the paradigm of space medicine operations will need to become more autonomous and less dependent upon mission support personnel on Earth. **TOPIC:** To successfully shift the space medicine operational paradigm, all relevant crew health and performance stakeholders must work together towards this common goal. The first step involves a deep understanding of how medical operations are currently executed, which includes the training of astronauts as ISS Crew Medical Officers and the role of ground-based mission support personnel. The next step is an analysis of how this operations concept aligns with the realities of providing medical care in the spaceflight environment and identifying where the challenges of exploration spaceflight will exceed the parameters of this operations concept. Subsequently, it will be crucial to address two fundamental issues: how can astronauts be aided by technology solutions to make informed medical decisions in an autonomous fashion and what capabilities are needed on exploration missions to enable astronauts to perform complex medical tasks or procedures without real-time ground support? Finally, all of this information must be synthesized into a plan for developing Exploration Crew Medical Officers and vehicle systems that are capable of maintaining progressively Earth-independent astronaut health. **APPLICATION:** This panel will provide detailed examples of past, present, and future NASA efforts in each of these key areas, including research, technology development, and operations.

## **[48] CREW MEDICAL OFFICER TRAINING AND ROLE OF GROUND SUPPORT FOR INTERNATIONAL SPACE STATION (ISS) OPERATIONS**

Rachel Richardson<sup>1</sup>, Steven Piper<sup>2</sup>, Ronald Moomaw<sup>3</sup>, Melinda Hailey<sup>1</sup>

<sup>1</sup>KBR, Houston, TX, USA; <sup>2</sup>NASA Johnson Space Center, Houston, TX, USA;  
<sup>3</sup>UTMB, Galveston, TX, USA;

(Education - Tutorial/Review)

**INTRODUCTION:** Medical systems supporting exploration-class missions to the Moon and Mars will require greater inflight medical decision-making autonomy. An understanding of current ISS training regimens for Crew Medical Officers (CMOs) as well as the role of ground support personnel in medical operations is needed to identify the starting point from which exploration medical system design must evolve in order to achieve inflight medical autonomy. **TOPIC:** Pre-mission assignment, NASA astronauts do not complete any medical training, outside of standard first aid and cardiopulmonary resuscitation. However, physician astronauts may elect, with permission from their management, to maintain clinical skills through outside engagement with healthcare facilities but this is not mandatory and is difficult given their already demanding schedules. Upon ISS mission assignment, all astronauts begin an intensive training program in the two years leading up to launch

during which approximately 15 hours total is spent on CMO training. When compared to terrestrial training standards for other healthcare providers (paramedic, nurse, psychologist, physician), the CMO training regimen and duration is not equivalent to any one role or curriculum but is intended to enable the CMO to be an extension of the ground based interdisciplinary medical team. Due to the availability of near-real-time communications between Mission Control and ISS, clinical decision support for inflight medical and behavioral events is provided by an interdisciplinary team of ground specialists. As a result, CMO training is focused only on familiarization and exposure to spaceflight-specific medical tasks, knowing that ground specialists will provide real-time guidance and troubleshooting in mission. For tasks needed in emergent events, experiential learning takes place on the ground through the use of high-fidelity simulations. Inflight, computer-based training is provided to help maintain learned skills, in addition to live instruction for any needed just-in-time training. **APPLICATION:** Insight into the current medical training regimen and operations concept will enable exploration medical system designers and mission planners to build a new concept of operations for missions where clinical decision making shifts from a ground-based to flight-based paradigm

### **Learning Objectives**

1. The audience will be able to recognize where primary clinical decision making occurs for medical event management on ISS.
2. The audience will learn how crew medical training is optimized to take advantage of ground-centric medical expertise when addressing inflight medical events.

## **[49] MEDICAL CARE IN SPACEFLIGHT: CHALLENGING TODAY AND ONLY GETTING HARDER**

Serena Aunon-Chancellor<sup>1</sup>, Amy Krekes<sup>2</sup>, Ronald Moomaw<sup>2</sup>, Ben Easter<sup>1</sup>

<sup>1</sup>NASA Johnson Space Center, Houston, TX, USA; <sup>2</sup>UTMB, Galveston, TX, USA;

(Education - Tutorial / Review)

**INTRODUCTION:** Medical care in spaceflight poses unique challenges. The International Space Station (ISS) is well equipped to provide medical care given its frequent resupply from visiting vehicles, large volume to accommodate medical resources, and proximity to Earth for evacuation. In contrast, exploration missions will have little to no resupply, small volume, and limited to no opportunity for evacuation in the event of a medical emergency. Exploration spaceflight will necessitate both more comprehensive and more autonomous medical care. **TOPIC:** The spaceflight environment poses unique challenges to medical care, many of which can be attributed to microgravity. These range from difficulty restraining supplies during a procedure to changed or absent hallmark terrestrial physical exam findings. Air-fluid levels do not form and bubbles do not rise, so even the simple act of drawing up a medication from a vial is difficult. In-flight care on ISS is a combination of autonomous care provided by the Crew Medical Officer (CMO) and guidance from flight surgeons through ground communication. In addition to urgent communications, ground-based care can occur through Private Medical Conferences (PMCs) and Private Psychological Conferences (PPCs) that are scheduled at regular intervals for all crewmembers. Diagnostic techniques on ISS include medical history taking, physical examination, and ultrasonography, all of which can be augmented through communication with the ground. However, these methods are largely reliant on near real-time and continuous communication. This telemedicine will be complicated by significant communication delays on exploration missions and will necessitate a shift in decision-making from ground to crew. The Crew Medical Officer (CMO) is responsible for helping to deliver medical care inflight. Nominally, any crewmember can be trained to serve as CMO as there is no requirement that a physician be present for ISS missions. However, physician-astronauts are likely to be the CMO for their crews, and although they receive similar training in the CMO role, they are expected to carry a higher degree of medical expertise as well as more autonomous diagnostic and treatment capability. **APPLICATION:** Although medical care in Low Earth Orbit is challenging, increasing distance from Earth on exploration missions will present new challenges, necessitating increased autonomy for the crew.

**Learning Objectives**

1. The participant will become familiar with the unique challenges of providing medical care in spaceflight due to operational and physical constraints.
2. The participants will become familiar with the role of the inflight care provider and their dependencies on the ground medical system to support inflight care.

**[50] AUGMENTING CREW AUTONOMOUS MEDICAL DECISION MAKING ON EXPLORATION MISSIONS USING CLINICAL DECISION SUPPORT**

Michael Krihak<sup>1</sup>, Brian Russell<sup>1</sup>, Sandeep Shetye<sup>2</sup>, Dana Levin<sup>3</sup>, Tianna Shaw<sup>2</sup>

<sup>1</sup>Universities Space Research Association, Columbia, MD, USA; <sup>2</sup>NASA Ames Research Center, Moffett Field, CA, USA; <sup>3</sup>NASA Johnson Space Center, Houston, TX, USA

(Education - Tutorial / Review)

**INTRODUCTION:** Exploration spaceflight, with its distance from Earth and communication delays, will place new demands on crew autonomy. Crewmembers operating during such missions require a clinical decision support system (CDSS) that enhances autonomy by augmenting their knowledge, skills and abilities in different medical scenarios. **TOPIC:** We augment inflight autonomous medical decision-making by (i) describing use of ideal systems through a Concept of Operations (ConOps), (ii) outlining vehicle and human systems interfaces, and (iii) aligning technology and user interfaces with acuity and severity of conditions. The CDSS's role is to assist the crew in prevention, detection, diagnosis, and treatment of countless medical conditions that could arise in spaceflight, exacerbated by known decrements in sleep, cognition, nutrition, and exercise. While such demands exist today on the ISS, near real-time communications allows the burden on decision-making to remain on the ground. This will shift to the crew during exploration flights, and the CDSS is intended to support and optimize that process. The CDSS ConOps describes a vision for the system and outlines scenarios of how it might augment crew capability. The need for the CDSS to increase autonomy results in new practices and the inclusion of what is stereotypically non-clinical data from other human and vehicle domains. A CDSS will be a single integrated system that encompasses the crew health and performance (CHP) domain and interfaces with vehicle systems for information and context using advanced analytics. The system includes software, crew and resources, where the software is operating with a 'human in the loop'. The ultimate goal of an ideal aerospace CDS system is to include both core and advanced features incorporating work from collaborators and flexible for new technology in the future.

**APPLICATION:** The ideal CDSS acts as an assistant to the crew and aids by guiding decision support based on the context of the scenario, such as those described above. Benefits of a CDSS are found in applications such as emergency assistance, alerts and notifications, prevention, training, guidance for exam procedures, monitoring crew performance and diagnosis of symptoms.

**Learning Objectives**

1. Attendees will be able to identify a minimum of three functions associated with an augmented clinical decision support system for deep space missions.
2. Attendees will be able to describe some augmented clinical decision support system example use cases for different acuity and severity.

**[51] MEDICAL TASK SUPPORT FOR AUTONOMOUS SPACE EXPLORATION MISSIONS**

Marlei Walton<sup>1</sup>, Doug Ebert<sup>1</sup>, Vicky Byrne<sup>1</sup>, Ashot Sargsyan<sup>1</sup>

<sup>1</sup>KBR, Houston, TX, USA

(Education - Tutorial / Review)

**INTRODUCTION:** Successful performance of medical tasks during missions beyond low Earth orbit (LEO) will require novel solutions to replace real-time Earth-based support since communication delays increase as astronauts travel farther from Earth. Key factors to consider when developing autonomous medical support tools for crew use during

exploration missions include: self-tailored applicability for users with varied medical experience, task familiarity, and learning styles; modularity and flexibility for incorporation with other medical system elements; commonality with training materials; and extensibility to a wide range of tasks. **TOPIC:** To address the need for autonomy beyond LEO, the Autonomous Medical Officer Support (AMOS) software tool was developed. AMOS shifts the emphasis from pre-flight training and real-time guidance (the current International Space Station [ISS] standard) to a new exploration paradigm of in-flight, just-in-time instruction with little to no ground support, enabling crew medical autonomy. AMOS is an intuitive, easily deployed, browser-based application, and introduces a streamlined skill management system for both medical and non-medical tasks, allowing users with different experience levels to access information as needed. In April 2020, two ISS crewmembers participated in a technology demonstration (TD) using AMOS training and guidance modules for urinary bladder and kidney ultrasound examinations. A non-physician astronaut Operator performed ultrasound exams on another astronaut Subject using the AMOS modules in a fully autonomous fashion; crewmembers also had no prior exposure to the software. AMOS tracked software use and incorporated a user experience survey. Captured images were later analyzed using 8 criteria to rate image quality from 0 (poor) to 3 (excellent). The AMOS TD yielded a positive user experience and successful image collection. Seventeen bladder imaging instances were acquired; all were rated '3' in all 8 rating elements. Twenty-five kidney imaging instances were acquired; image quality averaged 2.6 in all 8 rating criteria. However, as the Operator gained experience, kidney instances collected later in the TD were rated '3' across all criteria. **APPLICATION:** The AMOS platform is an example of a novel autonomous technology solution that provides training and in-mission support using a single training and procedure tool for all phases of medical skill management including acquisition, retention, and application.

**Learning Objectives**

1. Learn about training and guidance capabilities that will be needed to support successful execution of complex medical tasks in an Earth-independent, space-based autonomous fashion
2. Learn about the Autonomous Medical Officer Support (AMOS) software tool, a recent example of a novel autonomous technology solution that provides training and in-mission support

**[52] THE EXPLORATION CREW MEDICAL OFFICER OF THE FUTURE**

Moriah Thompson<sup>1</sup>, Ben Easter<sup>1</sup>, Rachel Passmore<sup>2</sup>, Sharmi Watkins<sup>1</sup>, Steven Piper<sup>1</sup>

<sup>1</sup>NASA Johnson Space Center, Houston, TX, USA; <sup>2</sup>KBR, Houston, TX, USA

(Education - Tutorial / Review)

**INTRODUCTION:** The current paradigm for Crew Medical Officer (CMO) credentials and training in Low Earth Orbit medical operations is likely to be insufficient for exploration-class missions. Long duration lunar surface stays and Mars missions will require increasing levels of autonomy of the CMO. This presentation will investigate the roles and responsibilities of the CMO of the future, including a discussion of clinical competency and training needs. **TOPIC:** Future exploration missions to Mars will be of longer duration and involve notable communication delays. Additionally, evacuation to obtain definitive medical care is not plausible for such exploration missions. Resupply will be limited, and the medical system will have notable mass and volume constraints. Given these realities, the responsibilities of and decision-making burden on the CMO will likely increase, requiring additional skillsets and autonomy. The current training pathway for the CMO will need to expand. Increased emphasis will need to be placed on autonomous evaluation, diagnosis, and treatment of conditions based upon likelihood and severity. The current operational concept of Private Medical Conferences (PMCs) and Private Psychological Conference (PPCs) will need to change as these become asynchronous. In addition, during emergency scenarios, the CMO will need to be able to respond and initiate care in autonomous fashion without initial assistance or cognitive offloading from the ground. Accordingly, the CMO will likely need additional medical and behavioral health training to better support the crew. According to NASA-STD-3001, a planetary mission requires that at least one physician be included on the crew. Many physician astronauts are practicing clinically in some

fashion prior to selection. However, training within the Astronaut Corps strongly favors other skillsets (e.g., EVAs) and may not allow physicians to maintain clinical skills in the way that, for example, a pilot astronaut maintains flight proficiency with T-38 training. **APPLICATION:** This presentation will discuss the various needs of the CMO for exploration missions of the future. An in-depth overview of the additional training elements and methods of maintaining clinical competency will be included.

#### Learning Objectives

1. Compare and contrast the demands of the ISS Crew Medical Officer of today with the exploration Crew Medical Officer of the future.
2. Understand the differences in training required for a Crew Medical Officer to act in autonomous fashion.

**Monday, 08/30/2021**

**2:00 PM**

**Plaza D/E**

### [S-12]: PANEL: FAA AEROMEDICAL RISK ASSESSMENT OF NEUROCOGNITIVE IMPLICATIONS OF HIV SEROPOSITIVITY – UPDATE ON INTEGRATING CURRENT RESEARCH AND KNOWLEDGE ABOUT HIV EFFECTS ON NEUROCOGNITIVE FUNCTION

**Chair: James DeVoll**

**Panel Overview: INTRODUCTION:** The FAA has evaluated and certificated airmen who are seropositive for human immunodeficiency virus (HIV) for over 2 decades. HIV+ was previously considered debilitating and frequently evolving into acquired immune deficiency syndrome (AIDS) that was often fatal. Current antiretroviral therapies and other treatment has transformed HIV to a chronic, stable condition in many patients with few, if any, clinical symptoms and favorable long-term prognosis. The FAA's current protocol for evaluating HIV+ airmen focuses on evidence of viral suppression, adequate immune function, absence of any significant clinical manifestations of HIV/AIDS, and no evidence of neurocognitive deficiencies. As such, cognitive testing is central in evaluating HIV+ airmen for initial special issuance medical certification and recertification (annually for commercial pilots and air traffic controllers, and every 2 years for private pilots). In light of the overall clinical success in controlling HIV+, frequently the most critical question for aeromedical regulators is the rationale for neurocognitive testing and understanding how that testing informs aeromedical decision-making. **TOPIC:** The FAA's current evidence-based risk assessment (EBRA) approach focuses on finding a path to "Yes" by leveraging current medical literature, generally accepted clinical guidelines, and experts in a variety of medical disciplines. The purpose of this panel is to bring together expertise to update review this topic. The first presentation will provide an overview of HIV infection with specific attention to neurologic issues, followed by presentations on the status and utility of neuroimaging and a review of aeromedically-relevant medical literature. The last two presentations will focus on HIV+ neurocognitive testing results and the application of neurocognitive testing to aeromedical certification. **APPLICATION:** Because the safe performance of pilot duties so heavily depends on intact neurocognitive functioning, it is important to examine what we currently know about cognitive effects of HIV+ and how best to effectively evaluate and efficiently integrate neurocognitive testing into evidence-based risk assessment of HIV+ airmen.

#### [53] HIV INFECTION AND CNS IMPLICATIONS: 2021 UPDATE

**Richard Roth<sup>1</sup>**

<sup>1</sup>Gulfstream Aerospace Corporation, Savannah, GA, USA

#### (Education - Tutorial / Review)

HIV infection has impacted individuals worldwide. The aviation population has not been immune to these effects. As HIV retroviral therapies have advanced the longevity of HIV patients has improved concordantly. Early in the HIV epidemic, clients died from opportunistic infections such as Pneumocystis, Toxoplasmosis and invasive Kaposi's sarcoma. In today's practice environment these infections are quite rare

due to the advances of HIV highly active antiretroviral therapies. Unfortunately, data supports that as the survivorship of the HIV populations grows so does the central nervous system injurious effects of HIV inside the blood brain barrier which may act as a sanctuary for the virus avoiding the serum levels of HIV medications. With this said, although HIV clients have shown MRI and global cognition test scores independent of CD4 counts and ultrasensitive viral load detection that are worse than normative tests for cognition and executive functioning. In the assessment process of an airman pursuing medical certification this data supports that cognitive and potentially imaging modalities may be needed at more stringent intervals than prior parameters with special attention to the long-term survivors of HIV even with well controlled HIV viral loads and acceptable CD4 cellular quantification. HIV independent of cognitive impairment has been shown to have mental health impacts such as depression, anxiety and other mood disorders which directly impact the medical certification of aviators. The approach to the medical certification of HIV infected applicants warrants concern that solely relying on HIV virologic and cellular immunologic quantification in aviators taking well tolerated highly active combination antiretroviral interventions requires reassessment of both the frequency and the spectrum of the evaluation of long-term infected individuals.

**REFERENCES:** Brain Sci. 2019 Feb; 9(2): 37. Br. Med. Bull. 2018; 127: 56-68. Immune Defic. Syndr. 2016;73: 374-383. Lancet Infect. Dis. 2015;15: 810-818.

#### Learning Objectives

1. HIV impacts to the CNS Secondary opportunistic infectious events in well controlled HIV patients are rare due to the blood brain barrier protections. HIV neurologic sequelae long term are potential hazards to aviation in HIV clients with poorly suppressed HIV viral loads.
2. Outcomes of HIV in the aviator can significantly impact crew member performance capacity.

#### [54] NEUROIMAGING OF STRUCTURAL AND FUNCTION EFFECTS OF HIV SEROPOSITIVITY, AND THE RELATION TO TREATMENTS, CO-MORBIDITIES, AND COGNITION

**Erin O'Connor<sup>1</sup>**

<sup>1</sup>University of Maryland School of Medicine, Baltimore, MD, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** Twenty-six to sixty percent of treated HIV infected individuals experience mild cognitive dysfunction, sometimes symptomatic and sometimes asymptomatic[1]. The source of the cognitive dysfunction remains unclear. Possible sources include pretreatment HIV injury, persistent central nervous system (CNS) viral reservoirs, chronic inflammatory cascades, neurotoxic antiretroviral therapy (ART) effects, and age related comorbidities common in HIV patients. Mechanisms responsible for neurological impairment in treated HIV infection are debated and identification of patients at risk for progressive neurologic impairment remains a diagnostic dilemma. **TOPIC:** Because HIV associated cognitive impairment is prevalent, non-invasive reliable biomarkers are needed. Nevertheless, HIV associated brain structural effects have diminished with time possibly related to widespread use of ART[2]. This has motivated researchers to investigate if advance neuroimaging methods are more to sensitive macrostructural, microstructural and physiological brain differences in chronic treated HIV infection. While numerous studies report HIV associated brain differences using high resolution sMRI, dMRI, fMRI and ASL, many of these studies are confounded by co-morbidities and clinical features common in the HIV population. In addition to cohort characteristics, variation in image acquisition and analysis techniques may also contribute to study outcome heterogeneity. **APPLICATION:** Here we review the potential effects of these confounds on detection of HIV infection effects and discuss strategies used by investigators to avoid or mitigate the effects of these confounds. We then present a systematic approach to measurement, design and analysis in HIV neuroimaging studies, combining both experimental and statistical control techniques to determine if HIV infection effects persist or worsen in groups achieving viral suppression from ART. **REFERENCES:**

1. Heaton RK, Franklin DR, Ellis RJ, et al. HIV-associated neurocognitive disorders before and during the era of combination antiretroviral therapy: differences in rates, nature, and predictors. J Neurovirol 2011;



17(1): 3-16. 2. O'Connor EE, Zeffiro TA, Zeffiro TA. Brain Structural Changes following HIV Infection: Meta-Analysis. *AJNR Am J Neuroradiol* 2018; 39(1): 54-62.

#### Learning Objectives

1. The audience will learn about the change in serostatus effects on brain structure over time, and the relation to anti-retroviral treatment.
2. The audience will learn about HIV associated brain differences detected by current neuroimaging techniques.
3. The audience will learn about the confounding effects of clinical characteristics and co-morbidities in the HIV neuroimaging literature, and how to control for these confounds.

### [55] EXAMINING POLICY AND AIRMAN EXPERIENCE; MANAGING NEUROCOGNITIVE DEFICIT AMONG HIV-POSITIVE AIRMEN

Thomas Chidester<sup>1</sup>

<sup>1</sup>Federal Aviation Administration, Oklahoma City, OK, USA

#### (Education - Program / Process Review)

**BACKGROUND:** In 2016, airmen and Aviation Medical Examiners (AMEs) expressed concern about annual screening of HIV+ airmen for neurocognitive deficit. Policy making requires weighing stakeholder interests, expert neuropsychological opinion and experience reflected in data. **OVERVIEW:** Airmen and AMEs concerned about policy cited several favorable studies (Sacktor, et al, 2002; Skinner, et al, 2009; McArthur, et al, 2010; Crum-Cianflone, et al, 2013), and Pebody's (2017) conclusion: "Cognitive impairment caused by HIV is usually mild in people taking HIV treatment." In contrast, Eggers, et al (2017) cautioned that neurocognitive dysfunction caused by HIV increases over time with infection and could be as frequent as 20 to 50% of cases. This began a discussion within the Office of Aerospace Medicine to determine an optimal policy for screening HIV+ airmen. **DISCUSSION:** Skaggs, et al (2018) assessed the impact of waiving annual screening for up to the five-year length of Special Issuance for airmen conforming to Centers for Disease Control A-1 status. Analyses revealed that this alternative would have missed 4.5% of failed neurocognitive screening, but only 2 cases (1%) that would have changed the certification outcome. Rather than being reassuring, this highlighted cases where FAA had accepted neuropsychologist dismissal of screening without further testing. An additional concern was attrition of airmen from certification. Skaggs, Norris, and Chidester (2020) followed from 2009-2019 the cohort of active airmen certificated prior to 2009. Attrition was routine; retention over five years of those with no reported pathology was 45.6%. Retention fell to 26.8% after 10 years. Of 208 HIV-positive airmen who sought certification, 179 (86%) received a special issuance. Of those issued, retention at five years was 46.9%, and 16.2% at 10 years. This is comparable to retention among 89,792 applicants and airmen with hypertension (98% issued, 47.1% retained at five years, 16.4% at 10 years). Attrition was lower among airmen with brain and spinal conditions or valvular heart disease and higher among those with arrhythmia, atrial fibrillation, myocardial infarction, or diabetes. To evolve policy, the Office of Aerospace Medicine must weigh stakeholder interests, expert opinion, and data reflecting airmen experience.

#### Learning Objectives

1. Understand issues and data involved in policy-making for HIV-positive airmen.
2. Understand data available to assist government policy-makers in aerospace medicine and methods for analysis.

### [56] QUESTIONING THE PREVALENCE AND CAUSES OF HIV-ASSOCIATED NEUROCOGNITIVE DISORDER

Andrew Levine<sup>1</sup>

<sup>1</sup>University of California, Los Angeles - David Geffen School of Medicine, Los Angeles, CA, USA

#### (Education - Program / Process Review)

**INTRODUCTION:** HIV-associated neurocognitive disorders, or HAND, describe the spectrum of neuropsychological deficits presumed to be due to HIV infection. HAND has been reported to occur with an

estimated prevalence of approximately 50%, with the vast majority of cases presenting with mild deficits that do not affect day-to-day functioning. However, these estimates were derived largely from studies without HIV-uninfected controls, or in which control groups were not similar to the HIV+ participants. Recent findings from well-designed cohort studies and those applying improved statistical methods call into question whether HIV, in the current era of combination antiretroviral therapy, causes significant neuropsychological impairment among most individuals. These findings are bolstered by the frontline (clinical) experience of the presenter. **TOPIC:** The assumption that HIV leads to neuropsychological impairment is scrutinized in this presentation. In particular, methodologies of studies that do and do not conclude a higher prevalence of neuropsychological impairment in HIV are compared. Results of recent analyses employing advanced statistical approaches that point to other causes of neuropsychological impairment in people living with HIV (PLWH) are discussed. Finally, an examination of the presenter's experiences of PLWH in clinical settings is discussed. **APPLICATION:** With a greater understanding of neuroHIV in the current era, FAA policy makers will be better informed when developing screening and monitoring protocols for PLWH.

#### Learning Objectives

1. The participant will gain a better understanding of HIV-associated neurocognitive disorder, including characteristics, prevalence, and course.
2. The participant will gain a better understanding of the co-morbid medical conditions that likely contribute to neuropsychological deficits in PLWH
3. The participant will be better able to judge the importance of cognitive screening and monitoring pilots who are HIV+

### [57] FAA HIV NEUROPSYCHOLOGICAL EVALUATION SPECIFICATIONS

Randy Georgemiller<sup>1</sup>

<sup>1</sup>Federal Aviation Administration, Washington, DC, USA

#### (Education - Program / Process Review)

**SUMMARY:** Based on archival data at the Civil Aviation Medical Institute, consultation with experts in the field, and an updated literature review, the original HIV Neuropsychological Evaluation Specifications were revised. Special Issuance Medical Certification was first granted in 1997 after the introduction of Combination anti-Retroviral Therapy (cART). After considering the current state of HIV treatment and evaluation, the frequency, timing, and content of aeromedical neuropsychological evaluations with PLWH (people living with HIV) were reconsidered by the FAA. **BACKGROUND:** Despite stabilization with cART as demonstrated by biomarkers such as values for CD4 and plasma viral load, milder forms of HIV associated neurocognitive disorder (HAND) may persist. Prior estimates of the prevalence of HAND were as high as 40% to 50% of PLWH. More recent research with larger samples and better controls have led to much lower estimates and intimate that medical comorbidities and accelerating aging are more likely explanations for cognitive diminution. When present, HAND may impact aeromedically relevant cognitive skills such as executive functioning, speed of information processing, attention, working memory, learning, memory, and motor speed/coordination. While the ideal clinically indicated frequency of cognitive screening may vary by individual case, for regulatory purposes a uniform schedule is preferable for monitoring and tracking purposes. Review of published clinical practice guidelines did not find a recommendation for the frequency of neuropsychological testing and/or screening.

Based upon an updated protocol, after detection of seropositive status and reporting to the FAA, a baseline neuropsychological evaluation will be conducted when the airman is immunologically stable with full viral suppression. Given the potentially progressive nature of the disease process and impact on safety sensitive aeromedically significant cognitive functioning, the current frequency of cognitive screening employing a standardized neuropsychological measure was recommended for all medical certification classes. At such time if there is a failed cognitive screening, the full baseline neuropsychological test battery will be re-administered.

**Learning Objectives**

1. Attendees will learn about the cognitive domains to be measured with standardized neuropsychological measures for PLWH.
2. Attendees will learn about proposed changes to the FAA HIV Neuropsychological Specifications as they relate to timing, frequency, and content of the examinations.
3. Attendees will learn about the use of internal archival data gathering in the decision making process for updating specifications for neuropsychological specifications.

**Monday, 08/30/2021**  
**Governor's Square 12**

**2:00 PM**

### **[S-13]: SLIDE: PROFESSIONAL DEVELOPMENT, ETHICS & MENTAL HEALTH**

**Chair: Roger Hesselbrock**  
**Co-Chair: Elizabeth Eekhoff**

#### **[58] THE BOLDFACE, APPLYING AVIATION CORE PRINCIPLES TO BETTER PREPARE RESIDENT PHYSICIANS TO PERFORM AND TROUBLESHOOT CRITICAL PROCEDURES FACED IN TRAINING**

**Edmond Fenton<sup>1</sup>**

<sup>1</sup>USAF, Perrysburg, OH, USA

*(Education - Program / Process Review)*

**INTRODUCTION:** In the emergency department performing critical procedures, namely rapid sequence intubation (RSI), is a core skill most medical residents learn to perform. The RSI is a high risk procedure with significant potential for adverse outcomes. Everyday in military aviation pilots utilize routine checklists as well as the "Bold Face" for almost all critical actions in flight. Studying and applying such concepts and mindset to medical training can provide greater levels of success in new medical trainees performing critical procedures with greater success. **TOPIC:** The checklist largely contributes to why modern aviation both in the military and civilian settings has such a low mishap rate with such highly complex operations taking place on a daily basis. From day one, the student aviator is taught the critical importance of the checklist. For the most critical phases of flight emergencies, pilots are taught "the boldface." The medical field is equally faced with procedures that are highly invasive with potential deadly consequences if not performed correctly, especially when being performed by novice doctors in residency training programs. Often, the most life and death critical procedure faced is the rapid sequence intubation (RSI). Performing endotracheal intubation, while routinely done in operating rooms every day, poses a significant potential for adverse outcomes. A previous study looking at the application of an observer-timed checklist during RSI increased adherence to the RSI protocol (from 55% to 90%) and improved first pass success rate from 86% to 90%. There have been a handful of similar studies looking at checklists in emergency medicine and trauma procedures; however, there has not been a study looking at applying key concepts of military aviation and applying them to graduate medical training for high-risk procedures. **APPLICATION:** The goal of this talk and current ongoing study is to implement aviation principles of the "boldface" and checklist mentality to graduate medical education. Working in the world of aerospace medicine not only allows us to apply medical concepts to the aviator, but it can also allow us to use aviation principles to better train future physicians. While the study currently being performed focuses on the rapid sequence intubation in medical teaching, these and other aviation concepts can be further applied to numerous other scenarios of medical education.

**Learning Objectives**

1. The audience will learn about the history and culture of medical education and error rates in procedures and patient safety in a wide range of medical fields and procedures.
2. The audience will learn how the culture and concepts of the checklist in aviation can be applied to medical residency training programs and the potential for improved execution of high risk procedures and decreased adverse events.

#### **[59] THE UNIQUE ETHICAL SITUATION OF TRIPLE AGENCY IN THE ROLE OF MILITARY FLIGHT SURGEONS**

**Jonathan Beich<sup>1</sup>, Ryan Peirson<sup>2</sup>**

<sup>1</sup>Wright State University, Dayton, OH, USA; <sup>2</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

*(Education - Tutorial / Review)*

**INTRODUCTION:** The concept of *dual agency* in the context of medicine describes the divided roles of simultaneously serving the best interests of a patient and of a forensic investigation. An even more complicated situation of *triple agency* may occur when the provider is a military flight surgeon who additionally has an obligation to a unit commander and their mission. In matters of ethical uncertainty and unclear or confusing boundaries, it behooves the physician to carefully consider ahead of time how they will satisfy their responsibilities to patients, the law, the military mission, and their own conscious. **TOPIC:** Quandaries arising from triple agency may present the flight surgeon with a source of difficulty and frustration. Currently, there is little to no published work that might be consulted in these potentially delicate situations. There exists a need for accurate, current, and straightforward guidance for military flight surgeons. This work defines the triad components of triple agency, describes potential conflicts (actual and perceived), and suggests methods for physicians to confidently arrive at their own conclusions and courses of action. Practical example scenarios will be provided as exercises. The overall intent is to provide a framework that invites the reader to think deeply on initial consideration, and can serve as a quick reference for just-in-time knowledge refreshment out in the squadrons and clinics. **APPLICATION:** While the career of a military flight surgeon is niche, it is not rare with several hundred specially-trained men and women serving across all branches of the U.S. military. It is inevitable for this population that situations will arise that make them feel "caught in the middle" of competing professional military and medical values and principles. The intent of this work is to 1) assist in clarifying roles and responsibilities of the players in a triple agency situation and 2) to stimulate self-directed reflection of how a provider may carry out their Hippocratic duties in equilibrium with legal requirements and loyalty to the military mission. The scope of this work is intentionally limited to the unique role of military flight surgeons which would likely include those of any service branch or nationality, but may have extended significance to providers within or associated with commercial or civil aerospace institutions.

**Learning Objectives**

1. The audience will learn about unique multi-agency roles that flight surgeons may find themselves in.
2. The audience will learn about how flight surgeons can satisfy their responsibilities to patients, the law, the military mission, and their own conscious.

#### **[60] WRONGFUL AEROMEDICAL DECISIONS: AEROMEDICAL EXAMINER GETS JAIL SENTENCE**

**Ulrich Werner<sup>1</sup>**

<sup>1</sup>German Military Aviation Authority, Cologne, Germany

*(Education - Case Study)*

**INTRODUCTION:** An accident investigation team had to look at the crash scene after a midair collision of 2 GA-aircraft with 8 casualties. Prescriptions and tools were found on scene which indicated, that one pilot suffered Insulin treated diabetes. Civil european aviation law does not allow waivers for Insulin treated type 1 diabetes. The district attorney immediately accused the AME of negligent homicide. **BACKGROUND:** The accident investigation revealed, that the pilots medical condition was not the cause of the accident, but dead reckoning of the two aircraft tracks. Thus negligent homicide was no longer accused. Nevertheless, wrongful medical certification in very many cases was still suspected. Wrongful medical certification is a case of prosecutable charge. German law impends up to 2 years jail sentence in such cases. A criminal trial was opened. **CASE PRESENTATION:** All medical files of the AME were sequestered and given to an expert witness by the prosecutor. Many files, a 3-digit number, looked suspicious. 117 of those cases were taken to court. Examples of accused cases were (aeromedical certificate given regardless of): Malign arrhythmia with ICD implantation; Brain infarction, arteria carotis bypass,

prostate malignoma; Insulin treated diabetes type 1. The prosecutor considered it to be telltale, that some of the AME's customers came from afar to his office. Medical confidentiality ends in conjunction with a criminal trial. All accused cases were read aloud at court, following the code of criminal procedure. The court sentenced the AME to 1 ½ year jail on probation, which he immediately appealed. The appellate court confirmed the former decision in principal but reduced the sentence to 1 year on probation. Again, the defendant appealed to the higher court, who disallowed the petition. Following this, the sentence became effective. **DISCUSSION:** Criminal accusations of physicians of wrongful medical certifications are rare cases. But AME's must be aware, that correct work in this field of medical practice is particularly enforced by penalty.

#### Learning Objectives

1. The participants will understand the juridical classification of aeromedical assessment
2. The audience will learn about the stakes an examiner takes in case of wrongful action

### [61] SMARTPHONES AS A MENTAL HEALTH SCREENING TOOL: WHAT'S IMPORTANT FOR AEROSPACE MEDICINE?

Diederik De Rooy<sup>1</sup>, Laura Müller<sup>2</sup>

<sup>1</sup>Transparant Mental Healthcare / Leiden University Medical Center, Leiden, Netherlands; <sup>2</sup>Leiden University Medical Center, Leiden, Netherlands

#### (Education - Program / Process Review)

**BACKGROUND:** The current COVID-19 pandemic is a major source of mental distress among air crews, and mental disorders of airline pilots may cause a substantial threat to aviation safety. There is increasing evidence that smartphone data may be used to detect mental disorders. Theoretically, smartphone data may help to predict or screen for mental disorders in pilots. **OVERVIEW:** Smartphone and wearable data may be used to collect information on physiological and behavioral functions. Social media content and internet search entries may be analyzed to predict behavioral problems. This may be used in clinical practice for predicting and monitoring the onset and course of mental disorders. However, there is a risk that commercial parties will develop unreliable tools that are being used without proper testing. At this moment, there is not yet regulation on the application of data from smartphone use in daily clinical practice, or to prevent that data are used by commercial parties for non-clinical purposes. **DISCUSSION:** Likely, in a few years it will be possible to detect mental disorders by smartphone data. It might seem attractive to ask pilots to share their smartphone data in order to detect mental disorders early. Still, important practical and ethical barriers exist. There is the chance of false positive results. Also, it is questionable whether people will be able to make a free consent if their employer or aeromedical examiner asks them to share smartphone data. Sharing these data has a massive impact on someone's privacy. It is debatable whether this huge infringement of the privacy of so many, is justified. Given the speed of technological advances, the aeromedical community should consider developing technical and ethical guidelines together with other stakeholders, such as pilots and their unions. **REFERENCE:** Martinez-Martin N, Insel TR, Dagum P, Greely H, Cho MK. Data mining for health: staking out the ethical territory of digital phenotyping. NPJ Digit Med 2018;1. pii: 68.

#### Learning Objectives

1. In a few years' time, data obtained from smartphone use may be used to screen for mental disorders in aerospace medicine, but this comes with several practical and ethical challenges.
2. The aeromedical community should consider developing technical and ethical guidelines to deal with the developments in using smartphone data for diagnosing mental disorders.
3. The developments in digital phenotyping may be accelerated by the current COVID-19 pandemic.

Monday, 08/30/2021  
Plaza F

2:00 PM

### [S-14]: SLIDE: NEW LESSONS IN AIRCREW TRAINING

Chair: Ernest Prochazka

Co-Chair: Ryan Peirson

### [62] AEROSPACE PHYSIOLOGY (AP) TRAINING TIMELINE BASED ON U.S. AIR FORCE (USAF) HUMAN FACTORS (HF) & PHYSIOLOGICAL TRENDS

Vikas Kumar<sup>1</sup>, Michael Luby<sup>1</sup>, Michael Armstrong<sup>1</sup>, Nicole Djanbatian<sup>1</sup>

<sup>1</sup>U.S. Air Force, Kirtland AFB, NM, USA

#### (Original Research)

**INTRODUCTION:** Since 2002, the USAF has used the Department of Defense (DoD) HF Analysis & Classification System (HFACS) based on James Reason's Accident Causation Model to analyze human error patterns in aviation mishaps. DoD HFACS are divided into four levels & 17 additional Tier 1 categories or "bins". USAF AP courses are divided into six refresher tracks based on the aircraft mission design series (MDS). Each refresher track curriculum addresses nine Tier 1 categories or "bins" from the Acts and Preconditions levels in a four-hour academics block once every five years. The goal of this review was to identify DoD HFACS/physiological trends in aviation mishaps and determine the AP training currency requirements for different MDSs and aircrew. **METHODS:** Air Force Safety Automated System was utilized to analyze USAF aviation flight mishap data from fiscal years 2000 – 2020. Physiological events were identified in class A-E mishaps. These events were further identified by the Event Type Tier 1 (physiological, smoke & fumes, laser strike, etc.). Additionally, individual physiology training dates were scrutinized to establish time-gap and trends, if any. **RESULTS:** Trend analysis were relatively the same in each airframe for the past 20 years. Areas of concerns were found to be in performance-based errors, judgement/decision making errors, mental awareness & sensory perception. In regards to specific MDSs, it was found that fighter/attack airframes had the most incidences of sensory misperceptions compared to tanker/transport airframes. **DISCUSSION:** Currently, each flyer receives relatively the same curriculum regardless of their crew position, airframe, & level of expertise. The analysis reveals that the USAF AP refresher training would benefit from tailoring academics as well as targeted frequency for each of the MDSs.

#### Learning Objectives

1. Explain the DoD HFACS trends in USAF Aviation mishaps in a 20-year review.
2. Understand the USAF Aerospace Physiology refresher training requirements and its correlation with Air Force Safety program

### [63] SPECIFIC PSYCHOLOGICAL SKILLS USED DURING TRAINING IN STUDENT PILOTS

Edward Ofori<sup>1</sup>, John Gassaway<sup>2</sup>, Justin Foster<sup>3</sup>

<sup>1</sup>Arizona State University, Phoenix, AZ, USA; <sup>2</sup>Luke AFB, Litchfield Park, AZ, USA; <sup>3</sup>Bering Straits, Litchfield Park, AZ, USA

#### (Original Research)

**INTRODUCTION:** Specific psychological factors may influence performance, especially in the fighter pilot community. We sought to examine whether there are associations between pilots adapted Athletic Coping Scale Inventory and Test of Performance Strategies in student pilots (SPs). It is suggested that the more athletes use mental skills the more they experience flow or peak performance. We aim to test whether this can apply to SPs during training. **METHODS:** Twenty-four SPs were given the ACSI and TOPS questionnaires. The ACSI is a measure of sport coping skills and psychological competencies. The ACSI consists of seven-factors to include: coping with adversity, peaking under pressure, goal setting/mental preparation, concentration, freedom from worry, confidence and achievement, and coachability. The TOPS is a measure of usage of psychological skills and strategies in



practice. The TOPS subscales are activation, automaticity, emotional control, goal setting, imagery, relaxation, and self-talk. Both scores are used to understand the individual's utilization of mental tools. Between-survey Pearson correlations were computed among subscales. Further, a principal component analysis was conducted to determine key factors that explained a majority of the variance in the survey data.

**RESULTS:** Moderate to strong correlations were found among ACSI-peaking and TOPS-activation ( $r=0.59$ ,  $p=0.003$ ), ACSI-goal setting and TOPS-goal setting ( $r=0.753$ ,  $p=0.000022$ ), and ACSI-coping with adversity and TOPS-emotional control ( $r=0.62$ ,  $p=0.001$ ). The PCA revealed 4 factors that accounted for 65% of the variance in the data. TOPS-Peaking and TOPS-Goal setting were loaded 0.82 and 0.83 on factor 1. TOPS-Coping w/Adversity and TOPS-Confidence were loaded on 0.71 and 0.77 on Factor 2. TOPS-Freedom from Worry and ACSI-emotional control were loaded 0.65 and 0.68 on Factor 3 and ACSI-Relaxation and ACSI-Self Talk were loaded on Factor 4. These factors may correspond to constructs of "a goal achievement" factor, an "emotion regulation factor", an "instructional feedback" factor, and a "self-motivation factor". **DISCUSSION:** TOPS and ACSI scores in the SP population assess different psychological factors that may be useful indicators of flight training and performance. Further, these results may inform practitioners on which psychological skills (from TOPS) help derive improvements in the areas of sport coping skills (ASCI) for better targeting program development.

#### Learning Objectives

1. The audience will learn about ways to assess psychological factors in SPs
2. The audience will learn how these factors may be useful in training.

#### [64] PERCEPTUAL COGNITIVE TRAINING IMPROVES MOTOR COORDINATION IN STUDENT PILOTS

Justin Foster<sup>1</sup>, Edward Ofori<sup>2</sup>, John Gassaway<sup>3</sup>

<sup>1</sup>Bering Straits, Litchfield Park, AZ, USA; <sup>2</sup>Arizona State University, Phoenix, AZ, USA; <sup>3</sup>Luke AFB, Litchfield Park, AZ, USA

#### (Original Research)

**INTRODUCTION:** The ability to make accurate decisions and react quickly under pressure is an important skill for performance in the fighter pilot community. We examined retrospectively whether perceptual-cognitive training in student pilots (SPs) improved stimulus processing and mental focus. **METHODS:** Fifty-five Basic course SPs were included in this retrospective cohort study. Twenty-five SPs underwent their normal course education series and strength & conditioning training, whereas 30 SPs had perceptual-cognitive training in addition to course education and strength & conditioning training. SPs were separated by assigned by airframe. Both groups attended Basic courses for F-16 or F-35 airframes at a U.S. Air Force base. SPs were tested on their processing speed with a simple reaction time task and mental focus was assessed with a visual scanning task. SPs were tested pre- and post B-course academic training. Outcome measures were also assessed while SPs underwent physiological stressors, via a Watt bike test, for pre- and post-testing. We also examined whether assigned airframe had an effect on our measures.

**RESULTS:** A main effect of the training group was found on the visual scanning and reaction time scores ( $p$ -values  $< 0.05$ ). For visual scanning, the perceptual-cognitive training group resulted in a decrease in visual scanning scores, but this was due to incongruence in stress testing results ( $p=0.001$ ). A main effect for training group was found on reaction times ( $p<0.001$ ) resulting in faster reaction times in the training group following a physiological stressor. There was also a training group x airframe interaction and training group x stress interaction. The training group had a greater effect on reducing reaction times in F-35 SPs (350 vs 300 milliseconds) than F-16 SPs (340 vs. 315 ms) ( $P<0.003$ ). **DISCUSSION:** Perceptual-cognitive training may be useful in improving information processing and mental focus. These findings suggest perceptual-cognitive training may enhance perceptual-cognitive skills needed for skilled pilot performance.

**Disclaimer:** The authors of this abstract are responsible for the study design, analysis of results, discussions, views, and recommendations provided. The opinions and assertions expressed herein are those of the authors and do not necessarily reflect the official policy or position of the US Air Force, the 56th Fighter Wing, or the Department of Defense.

#### Learning Objectives

1. The audience will learn how to assess perceptual-cognitive training effects
2. The audience will understand the utility of perceptual-cognitive training

#### [65] AVIATOR TRAINING NEXT: DEMOGRAPHIC ANALYSIS AND PHYSIOLOGICAL EFFECTS OF VIRTUAL REALITY EXPOSURE

Claire Goldie<sup>1</sup>, Clay Woody<sup>2</sup>, Kevin O'Brien<sup>1</sup>, Chris Aura<sup>1</sup>, Cristina Delgado-Howard<sup>1</sup>

<sup>1</sup>U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; <sup>2</sup>ORCEN, West Point, West Point, NY, USA

#### (Original Research)

**BACKGROUND:** Aviator Training Next (ATN) was recently introduced into the U.S. Army's Initial Entry Rotary Wing training curriculum and sought to compare the effectiveness of part-virtual reality (VR) flight training against traditional training methods. Students were semi-randomly allocated to either a control (non-VR) or experimental (VR) group. In support, USAARL developed and analyzed data from 3 flight student questionnaires, designed to gather demographic information about the students in each group, determine any correlations between demographic characteristics and flight performance, and compare physiological responses to VR and live flying between the 2 groups. **METHODS:** Raw questionnaire data were processed and encoded using Python code developed at the USAARL. The data were then split into VR and non-VR groups for comparative analysis. Various statistical tests were applied to the data, depending on data type and normality. The outputs were then used to generate descriptive demographic and physiological response statistics for each group, check for group differences and, using Spearman's correlation, test for any associations between the demographic or physiological variables and flight performance. **RESULTS:** A total of 361 non-VR and 300 VR students were included in the analysis. Demographically the 2 groups were generally split equitably and none of the demographic or physiological variables showed any significant correlation with performance. Sickness reporting rates were low in both groups but the VR group reported earlier onset and greater severity for eye strain and nausea. They also declared more prolonged symptoms ( $>1$  hour) after VR flight. Both groups appeared to show adaptation with a longitudinal reduction in reporting rates. Female students reported more (non-significant) symptoms during training but there was no difference in performance outcomes by gender. **DISCUSSION:** Individual demographic variables did not impact the observed performance scores for either group, suggesting that those who meet the selection criteria for flight school are likely to succeed, irrespective of individual characteristics. This highly selected population also shows low physiological response rates to aviation-related motion stimuli. However, VR appears to generate more symptoms in some, and these may be more severe and last longer. Nonetheless, students appear to adapt well over time to VR, with little difference in training outcomes between the 2 groups.

#### Learning Objectives

1. The audience will learn basic facts about the U.S Army's Aviator Training Next program
2. The audience will learn about the physiological effects of repeated VR exposure during flight school (ATN)

#### [66] EFFECTS OF AMBIENT LIGHTING ON PERFORMANCE AND LEARNING OF HELICOPTER UNDERWATER ESCAPE SEQUENCES DURING SIMULATION TRAINING

Stefanie Martina<sup>1</sup>, Gal Ziv<sup>2</sup>, Elizabeth Sanli<sup>3</sup>, Heather Carnahan<sup>1</sup>

<sup>1</sup>Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada; <sup>2</sup>Wingate University, Netanya, Israel; <sup>3</sup>Marine Institute, Memorial University of Newfoundland, St. John's, Canada

#### (Original Research)

**INTRODUCTION:** There are currently no universal standards concerning ambient lighting for civilian helicopter underwater escape training. We evaluated the effects of training in the light, dark, or with both conditions on learning and performance of simulated helicopter escape sequences. **METHODS:** Thirty-eight participants were randomized to practice a standardized helicopter escape sequence six times (two

times in each of three different seat positions) either in the light, dark, or in the light for three trials and then dark for three trials (graduated). Participants had up to a 60-minute break, followed by retention testing in the dark and then in the light. Dependent measures included accuracy and movement time. All procedures were approved by the MUN Interdisciplinary Committee on Ethics in Human Research. To assess learning, dependent measures were analyzed with separate ANOVAs with repeated measures on the trial (practice trials conducted in the stroked seat; dark retention test; light retention test) factor. **RESULTS:** For accuracy, a significant main effect of trial was found ( $F(2, 58) = 6.012, p = .004, 2p = .172$ ). Least Significance Difference (LSD) post hoc revealed that accuracy during the dark retention trial (mean = 4.9 points) was significantly better than during practice trials (mean = 4.4 points;  $p = .006$ ) and the light retention trial (mean = 4.6;  $p = .033$ ). For completion time, a significant main effect of trial was also found ( $F(1.839, 53.335) = 5.911, p = .006, 2p = .169$ ). LSD post hoc indicated that participants took significantly longer during the practice trial (mean = 44.5 s) than during the light retention trial (mean = 39.2 s;  $p = .001$ ). No other significant effects were found. **DISCUSSION:** Ambient lighting during training did not appear to impact performance in the light or in the dark. Regardless of training condition, participants performed more accurately during the dark compared to the light retention trial. This could be due to increased arousal elicited by performance in the dark or, alternatively, may suggest that performance of helicopter escape sequences is not visually mediated. Of note, average accuracy across groups for retention tests was five points out of a maximum of seven. Arguably, any score less than seven could have severe consequences in the real-world. Based on findings, it appears that training in the light is suitable for potential performance in the dark. Further research is warranted.

#### Learning Objectives

1. The audience will learn about how light levels during helicopter escape training affects performance.
2. The audience will learn about stress levels during helicopter escape training as correlated with performance.

**Monday, 08/30/2021**  
**Governor's Square 14**

**4:00 PM**

### [S-15]: PANEL: WHAT AND WHO KILLED KOBE BRYANT: A MODELING PERSPECTIVE

**Chair: Chris Brill**

**Co-Chair: Angus Rupert**

**PANEL OVERVIEW:** Spatial Disorientation (SD) has been responsible for the aviation-related deaths of many athletes and entertainment celebrities. The January 2020 helicopter crash taking the life of Kobe Bryant and others was typical of so many SD mishaps occurring in a degraded visual environment (DVE). Since the DoD has experienced many SD mishaps occurring in DVE, considerable research funding has been directed to model SD mishaps with the view that modeling may provide insights towards developing the best SD countermeasures. The first presentation will compare the Kobe Bryant mishap to a remarkably similar Army mishap for which extensive data were available, including voice recordings establishing the cause as SD. The perceptual modeling of both mishaps will be presented. The second presentation will discuss data from in-flight experiments on perceptual detection thresholds for linear acceleration during translational flight under operational conditions experienced in helicopters. This presentation will demonstrate how this new sensory threshold information applies to the issue of whether acceleration is perceived as drift or tilt, as in the Kobe Bryant mishap. The third presentation will present updates to the model as compared to data from the second presentation along with an implementation and ground-based validation of using a computational model of pilot spatial orientation perception in real-time to trigger an active SD countermeasure. The fourth presentation will present in-flight data demonstrating a technology to continuously maintain spatial orientation as a tool for SD mitigation in DVE. The fifth presentation will introduce the various failure points in delayed acceptance of innovation in aviation to set up a discussion of where responsibility should lay for continued SD mishaps when

technologies such as the Automatic Ground Collision Avoidance System (AGCAS) and tactile cueing are available. The panel will conclude with discussion of prepared and audience questions facilitated by the panel chair.

#### [67] PERCEPTUAL MODELING OF N72EX MISHAP

Braden McGrath<sup>1</sup>, John French<sup>1</sup>, Bruce Mortimer<sup>2</sup>, Chris Brill<sup>3</sup>, Angus Rupert<sup>1</sup>

<sup>1</sup>Embry-Riddle Aeronautical University, Daytona Beach, FL, USA; <sup>2</sup>EAL, Casselberry, FL, USA; <sup>3</sup>USAF AFMC 711, Dayton, OH, USA

#### (Original Research)

**INTRODUCTION:** Aircraft mishaps involving spatial disorientation (SD) in commercial and military aircraft remains a significant hazard during air operations. Over the past 25 years, we have developed several mathematical models to predict the orientation and motion perception of a pilot when subjected to the acceleration environment of flight. Our modelling solution is based on the deployment of a nonlinear observer and fuzzy logic concepts and is an extension of the MIT observer family of models. The vestibular core is based on Merfeld's topology with the addition of Newman's structural modifications to account for visual cues. Recently, the model was extended to include tactile cueing, 3D sound, and expanded fuzzy-logic concepts. On January 26, 2020, a Sikorsky S76-B helicopter, N72EX, was destroyed in an accident. The pilot and eight passengers were fatally injured, and SD was suspected as a causal factor.

**METHOD:** The model was used to predict the perceived orientation of the pilot during the final phase of the N72EX flight. The helicopter was equipped with ADS-B system that recorded the time, latitude and longitude, altitude, and speed. Data was processed, and along with communications data, video footage, and crash scene data was inputted into the system to calculate the perceived pitch and roll attitude of the pilot. **RESULTS:** Estimated roll and pitch attitude angles during the final minute of the flight, showed that the pilot could have misperceived both pitch and roll angles. Specifically, the model predicted a somatogravic illusion with the pilot perceiving a pitch up during the final minute, when in reality, the helicopter was pitching down. The N72EX mishap was similar to a 2018 Army H-60 mishap in terms of initial altitude, flight profile, and flight conditions. The H-60 was equipped with data and voice recorders and was confirmed as a somatogravic illusion from pilot conversations, so we compare the two mishaps to examine the dynamics of time course of the positive feedback process of the somatogravic illusion. **DISCUSSION:** These result from this mishap analysis indicate that SD remains an important causal factor in aviation mishaps, especially for fatal rotary wing operations. Accurate modelling on the involvement of SD is critical in the development of safety technologies that that will be discussed in following presentations have the highest and most cost-effective potential for further reducing mishaps.

#### Learning Objectives

1. The participant will be able to understand the use of mathematical models to predict the orientation and motion perception of a pilot when subjected to the acceleration environment of flight.
2. The participant will be learn about the comparison of two helicopter mishaps to examine the dynamics of time course of the positive feedback process of the somatogravic illusion, with particular focus on whether linear acceleration is perceived as a translation perception or as a tilt perception.

#### [68] WHETHER LINEAR ACCELERATION IS PERCEIVED AS TILT OR TRANSLATION IN HELICOPTERS

Angus Rupert<sup>1</sup>, John Brill<sup>2</sup>, Bradden McGrath<sup>3</sup>, Bruce Mortimer<sup>4</sup>

<sup>1</sup>DRIP, Pensacola, FL, USA; <sup>2</sup>USAF, Dayton, OH, USA; <sup>3</sup>Embry Riddle Aeronautical University, Daytona, FL, USA; <sup>4</sup>Engineering Acoustics Inc, Casselberry, FL, USA

#### (Original Research)

**INTRODUCTION:** The Kobe Bryant mishap has been described by analyses conducted by the previous speaker and the NTSB mishap investigation as a somatogravic illusion. Linear acceleration can be

perceived as tilt or translation depending in part on the duration of the stimulus. We will examine three fatal class A mishaps in which linear acceleration played an important role – two U.S. Army Class A mishaps and the Kobe Bryant mishap. In the first Army mishap, despite significant forward linear acceleration neither tilt or translation appears to have been perceived likely due to the masking effects of noise and vibration. In-flight experimental data was collected to demonstrate the reduced perception in the presence of typical noise and vibration present in helicopters. While collecting in-flight data to establish reduced perception of linear acceleration during horizontal translation, a subset of pilots were exposed to an acceleration profile to replicate the initiating event of a fatal 2017 Class A H-60 Black Hawk mishap in which both pilots experienced spatial disorientation.

**METHODS:** Four of twelve visually-restricted instructor pilots participating in threshold linear translation studies were provided a transition from normal cruise flight to a forward linear acceleration combined with a mild bunt maneuver. The blindfolded pilots provided continuous verbal reports of orientation as well as videotaped hand maneuvers to indicate their pitch and roll perceptions. Aircraft accelerations both linear and angular were monitored with a Systron Donner SDI500 tactical grade inertial measurement unit. **RESULTS:** Although each pilot reported the expected (model predicted) pitch up sensation the perceptual reports of pitch up were not consistent in that not all forward accelerations evoked verbal reports and hand maneuvers to indicate pitch changes. **DISCUSSION:** There are many factors involved in pitch perception including the role of expectation. Although pilot perceptions matched the direction predicted by the model it is likely that the ambient noise and vibration partially masked the perceptions as seen in short duration linear translations. The difference in acceleration duration will be related to model predictions of translation or pitch perception in the three selected fatal mishaps. In all of these mishaps and during the in-flight experiments there are additional vestibular canal angular acceleration contributions affecting the final perception.

#### Learning Objectives

1. The participant will understand the factors determining whether linear acceleration is perceived as tilt or translation in the rotary wing environment.
2. The participant will understand the relative roles of angular and linear acceleration in the determination of pitch in rotary wing aircraft.

### [69] IN-FLIGHT SPATIAL ORIENTATION CUEING TO MITIGATE SPATIAL DISORIENTATION

Bruce Mortimer<sup>1</sup>, Jon French<sup>2</sup>, Bradden McGrath<sup>2</sup>, Angus Rupert<sup>3</sup>  
<sup>1</sup>Engineering Acoustics, Inc., Casselberry, FL, USA; <sup>2</sup>Embry Riddle Aeronautical University, Daytona Beach, FL, USA; <sup>3</sup>DRIP, Pensacola, FL, USA

#### (Original Research)

**INTRODUCTION:** Spatial orientation during flight is achieved primarily through visual information. During visual flight the horizon and celestial references are enough to inferring aircraft orientation. During degraded visual conditions, flight instruments must be scanned and interpreted. However, cross checking instruments can be complicated by workload, distraction, and situations where the vestibular and proprioceptive systems may provide false but concordant orientation information. We describe the in-flight performance of a tactile orientation system that can mitigate spatial disorientation (SD).

**METHODS:** Two tactile array designs were tested; a full array of 60 (torso and seat) or a reduced array of 12 (seat only) tactors. We tested the performance of the tactile array designs by measuring the perceived orientation using a group of 12 experienced flight instructor participants during a series of flight maneuvers under various sensory conditions. The flight maneuvers were selected to induce well known perceptual illusions. Flights were conducted at night. Participants access to flight instruments visual cues were controlled and compared to tactile array cues. Participants were trained for at least 4 hours in a flight simulator using the tactile array prior to their flight test. During maneuvers, the participants provided an indication of their perceived orientation by using their hand (camera sensor) and with a verbal response.

**RESULTS:** Without visual or tactile orientation cues, participants were not able to reliably determine the aircraft orientation. Both tactile array

designs were effective in maintaining participant spatial orientation over all conditions tested. Pilots reported less disorientation with the seat and belt array across all conditions for visual and combined visual and tactile cues compared to no cues ( $p > 0.0001$ ). With the seat array, more pilots felt less disorientation for the combined tactile and visual cues compared to the no cue condition ( $p > 0.02$ ). **DISCUSSION:** Continuous tactile orientation maintains participant orientation even under conditions of reduced vision and illusory conditions. With appropriate pilot training, the tactile cues may mitigate loss of orientation awareness due to visual distraction during degraded visual environments. We have previously described a perceptual model that can predict perceived orientation during SD. These tests show the need for a tactile/somatosensory channel in an updated model.

#### Learning Objectives

1. Understand the use and effectiveness of tactile displays as a tool for spatial disorientation (SD) mitigation.
2. Understand what factors pilots use to construct a percept of spatial orientation.

### [70] DEVELOPMENT AND AN EXPERIMENTAL VALIDATION METHOD FOR A MODEL-BASED SYSTEM TO DETECT PILOT SPATIAL DISORIENTATION IN REAL-TIME

Jordan Dixon<sup>1</sup>, Tristan Endsley<sup>2</sup>, Torin Clark<sup>1</sup>

<sup>1</sup>University of Colorado Boulder, Boulder, CO, USA; <sup>2</sup>The Charles Stark Draper Laboratory, Cambridge, MA, USA

#### (Original Research)

**INTRODUCTION:** While pilot spatial disorientation (SD) remains a leading cause of Class A mishaps and fatalities, current mitigation relies predominantly on training. To intervene appropriately *during* an SD event, a system is needed to detect pilot SD in real-time. Computational models of human orientation perception have offered a methodological approach for verifying SD as a factor in accidents. Past approaches are limited to post-hoc analysis, however, as they require expert analysis and association with specific SD "illusions". We propose a real-time system for detecting SD: a novel modeling framework that is not constrained to a preset stimuli-to-SD database, and a linked experimental methodology for parameter identification. **METHODS:** We leverage the state-of-the-art 'Observer' model in sequence with algorithms we have developed to capture the impact of orientation misperception, over time, on the experience of SD. Critically, these algorithms combine each multidimensional orientation state (e.g. acceleration, angular velocity, etc.), and create a unidimensional metric of SD to be used as a trigger for active countermeasures (CM). We use a new experimental methodology where participants experience various motion stimuli and rate the magnitude of SD using a visual analog scale. This provides the data needed to determine the optimal algorithm and fit free parameters. **RESULTS:** Simulated motion stimuli based on SD-related flight data was used in the development of the SD algorithms. Our simulation results demonstrate the utility of capturing all state parameters related to orientation perception which enables the system to capture the continuum of SD involving misperceptions of a variety of different stimuli (e.g. slow banked turns, somatogravic tilts, etc.), common illusions and inter-individual differences. A human subject experiment can validate the model's SD metric based upon the motions experienced within a particular domain (e.g. fast jet in transit). **DISCUSSION:** An appropriately fitted algorithm can be used in conjunction with real-time CM interventions (e.g. tactile cueing) to assist pilots through SD events *only when* it is truly needed. As a pilot's attentional resources are strained with other flight- or mission-related activities, it is crucial that interventions aimed at reallocating attention meet this criterion. The evidence-based tuning of our proposed system permits applicability to various environments, airframes, and operating theatres.

#### Learning Objectives

1. The audience will learn about a novel computation modeling strategy linked with an experimental paradigm, that together provide a framework for developing systems capable of detecting pilot spatial disorientation in real-time.
2. The audience will understand the potential for performance and safety enhancement with the integration of a spatial disorientation detection system as a trigger for active countermeasures in the cockpit.
3. The audience will understand why and how the new modeling framework enables application to any airframe or domain, e.g. high performance jets, cargo freighters, spacecraft, SCUBA, etc.



## [71] THE TECHNOLOGIES AVAILABLE TO PREVENT ROTARY WING SPATIAL DISORIENTATION MISHAPS

Peter Mapes<sup>1</sup>, Angus Rupert<sup>2</sup>, Bradden McGrath<sup>3</sup>, Bruce Mortimer<sup>4</sup>, John Brill<sup>5</sup>

<sup>1</sup>Self Employed, Oscoda, MI, USA; <sup>2</sup>DRIP, Pensacola, FL, USA; <sup>3</sup>Embry Riddle Aeronautical University, Daytona, FL, USA; <sup>4</sup>Engineering Acoustics Inc., Casselberry, FL, USA; <sup>5</sup>USAF, Dayton, OH, USA

(Education - Tutorial / Review)

**INTRODUCTION:** A number of entities have long recognized the need to augment perception for the purpose of increasing situational awareness and decreasing mishaps due to spatial disorientation. Controlled flight into terrain (CFIT) and midair collisions remain two of the costliest mishap categories in DoD, just as they were in the Defense Safety Oversight Council DoD Rotorcraft Mishap review from 1985 through 2005. The FAA has required Helicopter Terrain Awareness Warning System (HTAWS) technology on medical evacuation helicopters for over six years. The US Army (Safety Center) has estimated that a technology like tactile cueing tied to a technology like HTAWS could prevent 24% of Army mishaps and 46% of Army aviation fatalities. The USAF has installed HTAWS and active traffic detection in its UH-1N fleet but the Army and the Navy have avoided installation of HTAWS and traffic detection technology to date. Technologies like the Automatic Ground Collision Avoidance System (Auto-GCAS) are not appropriate for rotary wing vehicles but technologies using salvation technology not dependent on stored kinetic energy, such as vertical escape, could be instituted in a generation of rotary wing vehicles with integrated digital electronic fly-by-wire technology (none currently exist in the DoD inventory except for the CV-22 and MV-22 Tiltrotors). Examination of the topic "Who Killed Kobe Bryant" is a rooted in the pilot training and certification, regulations, currency and technology equipping rotorcraft. The mishap could have been prevented at any point in the mishap chain by the proper insertion of due diligence, compliance, oversight, training, currency or technological equipage. **TOPIC:** This discussion will examine the available prevention strategies for this type of VFR into IMC mishap. **APPLICATION:** Why have all of the aforementioned organizations except the USAF and the FAA (In the case of medical evacuation rotorcraft) failed to adopt rotorcraft safety technologies to prevent controlled flight into terrain and midair collisions? Military manufacturers ignore many safety technologies because military departments do not require them. Why is safety relegated to a low priority by military acquisition? Since most military rotorcraft are not equipped with modern, state of the art safety technologies, most military aviators are out of touch with available technologies? These and other possibilities will be raised in advance of the discussion period.

### Learning Objectives

1. The participant should be able to identify at least two organizations responsible for delayed acceptance of innovation in aviation.
2. The participants should be able to explain why acquisition of safety related technologies is not a high priority for military acquisition.

Monday, 08/30/2021

4:00 PM

Governor's Square 15

## [S-16]: SLIDE: TAKE A DEEP BREATH, PROTECT YOUR HEARING AND MAKE A CLEAN ESCAPE

Chair: Anthony Tvaryanas

Co-Chair: Douglas Boyd

## [72] EJECTION OUTCOMES: A RETROSPECTIVE STUDY OF MODERN ESCAPE SYSTEMS

Kathryn Hughes<sup>1</sup>, Camille Bilger<sup>1</sup>, Matthew Lewis<sup>2</sup>

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(Original Research)

**INTRODUCTION:** DoD Airworthiness Certification requirements for Escape System Safety include the dynamic response index in the Z-axis

(DRIz) associated with spinal injury rates. Previous research in crew escape systems have addressed survival and injury outcomes in legacy escape systems (Lewis 2006, Newman 2013). This presentation updates research by evaluating the Martin-Baker Aircraft Company (MBA) ejection database to determine if new technologies and design enhancements on modern escape systems have improved ejection survival rates and spinal injury rates. **METHODS:** An analysis was conducted using MBA's ejection database of over 8,000 ejections to establish the historical ejection numbers and fatality rates along with the contributing causes of these fatalities. The analysis identified 228 ejections using modern escape systems (Mk14 and Mk16 series), these data were analyzed for rates of fatality and spinal injury and contributing factors for fatality and classification of reported injuries. **RESULTS:** The ejections resulted in a survival rate of >90% with most fatalities being either out-of-envelope ejections or post-ejection causes. Ejection seats design has evolved to meet ever-diminishing DRIz limits, with a legacy DRI value of 21 in Mk10A seats, and even higher DRI values for older seats. Modern escape systems are now designed to meet a DRIz <18 (NACES and Mk16s) or a DRIz <16 (US16E). This equates to a reduction of predicted spinal injury risk from 26% to 3% (Mk16) and <1% (US16E). This low DRIz is achieved while still ensuring fin and terrain clearance and accommodating a large anthropometric range. The present analysis indicated that actual spinal injury rates have decreased from 29.4% (Lewis, 2006) to about 3% using the Mk14 and Mk16 ejection seats. For in-envelope ejections there were no fatalities attributable to the ejection sequence itself. **DISCUSSION:** The latest MBA modern escape systems demonstrate improved survival outcomes, with higher rates of injury-free ejections and lower spinal injury rates compared with historical ejections with legacy escape systems. The study identified the need for greater standardization of injury reporting, such as using the Abbreviated Injury Scale. The analysis of modern escape systems live ejection data is of great importance to inform the development of injury risk functions, and therefore help the aeromedical community work towards a set of airworthiness criteria that better predicts ejection injuries.

### Learning Objectives

1. The participant will learn about technical enhancements of modern escape systems, and about Martin-Baker's efforts to utilize in-experience mishap data to continuously work towards design safety enhancement of future escape systems that will ensure compliance with the latest safety and airworthiness requirements.
2. The participant will learn about the increased safety outcomes of ejections using Martin-Baker ejection seats over the past 25 years.
3. The audience will understand the need for creating an international standard of injury classification using the full Abbreviated Injury Scale (AIS) system.

## [73] A CASE REPORT OF A HAWK AIRCRAFT EJECTION ACCIDENT AND MODELLING OF THE EJECTION SEQUENCE.

Matthew Lewis<sup>1</sup>

<sup>1</sup>RAF Centre of Aviation Medicine, Henlow, United Kingdom

(Education - Case Study)

**INTRODUCTION:** This case report describes the events of a twin seat RAF Hawk aircraft accident in which there was one successful ejection, but the second crew (passenger) failed to eject safely. This case also reviews the safe ejection envelope and demonstrates how the latest ejection seats, compared with the older Mk10B seats fitted in the Hawk, could increase the safe survivable ejection envelope. **BACKGROUND:** The Hawk is a training aircraft and flown typically with the experienced instructor in the rear seat and the student in the front seat. Hence, the command ejection system is set to ON: rear seat ejects front and rear seats, or front seat ejects independently. In this accident the experienced pilot was in the front seat and the inexperienced passenger was in the rear seat, hence the command system was set to OFF: the occupants had to each eject independently. **CASE PRESENTATION:** The pilot was conducting a practice engine failure after take-off maneuver. On approach to the runway the pilot assessed that the aircraft had entered an irrecoverable attitude and initiated ejection at approximately: IAS 148 kts, 11.6 m (38 ft) AGL, 4.6° pitch nose up, 21° right AOB and a descent rate of 22.2m/s (73 ft/s). The pilot ejected but sustained major injuries. The rear seat occupant remained in the aircraft and did not survive the ground impact. **DISCUSSION:** As the command ejection

system was set to OFF the investigation was aimed at firstly, determining if the rear seat occupant would have had sufficient time to initiate his own ejection before ground impact following the pilot's "eject-eject-eject" call, and secondly, if the ejection was initiated would the ejection have been within the safe ejection envelope. Ejection simulation modelling was conducted using the parameters identified from the ADR. The simulations predicted that if the rear seat had been initiated within 0.5 s of the front seat, the passenger would have just survived. The ejection would have been on the edge of the safe ejection envelope, and the passenger would have been at a high risk of sustaining major parachute landing injuries. Further simulations demonstrated that the survivability would be enhanced if the aircraft was configured with an ejection system where the front seat pilot could command initiate the rear ejection. Additional simulations also showed that the performance of the latest generation of ejection seats could have also increased the safe ejection envelope.

#### Learning Objectives

1. Understand the importance of ejection simulation modeling to deliver improvements in aircraft assisted escape systems.
2. Understand how ejection system modelling can deliver improvements in injury outcome.

#### [74] AIRCREW NOISE EXPOSURE AND HEARING PROTECTION ASSESSMENT ISSUES.

Susan James<sup>1</sup>, Sara Rubio<sup>1</sup>

<sup>1</sup>QinetiQ, Farnborough, United Kingdom

(Original Research)

**INTRODUCTION:** With the introduction of double hearing protection systems to meet noise exposure legislation it is not possible to make direct measurements of aircrew noise exposure in-flight, so a reliable prediction method is required. The accuracy of predictions is reliant on the quality of the supporting data and the method adopted to combine it. A small inaccuracy can have a large impact on calculations of flying hour limitations necessary for compliance with the legislation. Of particular concern are anomalies identified in helmet attenuation data produced to British Standards by different UK Test Houses. This has raised questions about the robustness of the Real Ear Attenuation at Threshold (REAT) technique adopted. The aim of this work is to provide an understanding of whether more reliable attenuation measurements may be achieved by combining REAT and Head and Torso Simulator (HATS) measures. **METHODS:** To provide an understanding of the shortfalls in attenuation data measured using the REAT technique a comprehensive dataset of helmet attenuation was reviewed. A study was then conducted using test house data and measurements made on a HATS to understand whether some of the shortfalls identified could be addressed by combining the most reliable attenuation data from the two test techniques. **RESULTS:** Analysis of existing test house data showed differences in attenuation measurements of 5-6dB, both within and between test houses, for a given hearing protector. A lack of low frequency attenuation data was also identified. Review of the HATS data showed that reliable measurements can be made at lower frequencies and more consistent measurements can be provided in the mid-frequency range where REAT data is known to be unreliable. By combining the low/mid frequency HATS data with REAT data above 2kHz a more comprehensive attenuation spectrum was produced that offered additional allowable flying hours in five different cockpit noise fields. **DISCUSSION:** Scrutiny of the attenuation data considered has shown that data measured to the current British Standard may compromise calculations of aircrew noise exposure and introduce inaccuracies that may result in unnecessary limitations on flying hours. This study suggests that combining REAT and HATS measures may offer a more reliable and repeatable assessment of the attenuation of a double hearing protection system and it is recommended that further verification work is conducted to validate the technique.

#### Learning Objectives

1. To understand how limited data can affect predictions of aircrew noise exposure and how more accurate measures may be achieved.
2. The audience will learn about the shortfalls in the standard techniques currently used for measuring hearing protection attenuation performance.

#### [75] AQUA LUNG® PORTABLE HELICOPTER OXYGEN DELIVERY SYSTEM (PHODS) IN THE ALTITUDE CHAMBER: CEREBRAL BLOOD OXYGEN SATURATIONS

Leonard Temme<sup>1</sup>, Robert Eshelman<sup>1</sup>, Bobby Bowers<sup>1</sup>, Amanda Hayes<sup>1</sup>, Chad Adaway<sup>1</sup>, Paul St. Onge<sup>1</sup>, Aaron McAtee<sup>1</sup>, Frank Petrassi<sup>2</sup>, Dennis Ard<sup>2</sup>, Steven Murty<sup>2</sup>, Claire Goldie<sup>1</sup>

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

<sup>2</sup>U. S. Army School of Aviation Medicine, Fort Rucker, AL, USA

(Original Research)

**INTRODUCTION:** The Portable Helicopter Oxygen Delivery System (PHODS) provides supplemental oxygen (O<sub>2</sub>) to Army personnel in unpressurized aircraft up to 18K feet (ft.) above mean sea level (MSL). The PHODS delivers a predetermined bolus of nearly 100% O<sub>2</sub> via a flexible nasal cannula or face mask attached to the user's helmet. Initial PHODS testing used conventional pulse oximetry to monitor peripheral blood O<sub>2</sub> saturation (SpO<sub>2</sub>). The present test assesses the PHODS using a near infrared transcranial spectroscopic (NIRS) device to measure regional cerebral blood O<sub>2</sub> saturation (rSO<sub>2</sub>). **METHODS:** The U.S. Army School of Aviation Medicine altitude chamber enabled the PHODS evaluation at ground level, 14K, and 17.8K ft. above MSL. At each altitude, twenty-one Army aircrew volunteers used the PHODS as prescribed in the user manual to assess its performance during 10 minutes (min) of reaction time (RT) measures, 5 min of scripted speech (SS) to challenge the PHODS nasal cannula, and 2 min of self-paced squats as a surrogate physical workload (WL) task. A commercial, off-the-shelf, NIRS device monitored rSO<sub>2</sub> in parallel with standard SpO<sub>2</sub>. **RESULTS:** Of the 21 datasets, 2 were removed; 1 due to equipment failure and 1 due to noise. The analysis calculated the slope of the rSO<sub>2</sub> and SpO<sub>2</sub> over the duration of each task at each altitude. Thus, the figure of merit was the slope for the 5 min of SS, the 10 min of RT, and the 2 min of WL at each altitude. A 2-factor analysis of variance compared slopes. The rSO<sub>2</sub> slope was significantly affected by task,  $F(2, 155)=67.88$ ,  $p<0.05$  and by altitude,  $F(2, 155)=3.93$ ,  $p<0.05$ . Specifically, rSO<sub>2</sub> slope was essentially flat over the SS and RT for the three altitudes, but was significantly affected by altitude during WL,  $F(2, 37)=13.77$ ,  $p\leq 0.05$ . Notably, SpO<sub>2</sub> slope was flat over all tasks. **DISCUSSION:** While PHODS maintained rSO<sub>2</sub> over the duration of the SS and RT for the 14K and at 17.8K ft. altitude, it progressively decreased during WL whereas SpO<sub>2</sub> was unaffected. This is a statistical finding—its operational importance remains to be determined, but clearly, SpO<sub>2</sub> did not predict rSO<sub>2</sub>.

#### Learning Objectives

1. The audience will learn about the Portable Helicopter Oxygen Delivery System as a hypoxia countermeasure.
2. The audience will learn about the test and evaluation of the Portable Helicopter Oxygen Delivery System (PHODS) in the altitude chamber using conventional pulse oximetry to monitor peripheral blood O<sub>2</sub> saturation (SpO<sub>2</sub>) and near infrared transcranial spectroscopic (NIRS) measures of regional cerebral blood O<sub>2</sub> saturation (rSO<sub>2</sub>).

#### [76] ASSESSMENT OF OUTBOARD LEAKAGE FROM OXYGEN MASKS IN PERSONNEL WITH FACIAL HAIR

Nicholas Green<sup>1</sup>, Joseph Britton<sup>1</sup>

<sup>1</sup>RAF Centre of Aviation Medicine, Henlow, United Kingdom

(Original Research)

**INTRODUCTION:** For cultural and other reasons, there are increasing demands for aviators to be permitted to wear facial hair. Previously published evidence from aviation, occupational health and industrial sources suggests that significant inboard and outboard leaks from masks may occur when used by bearded individuals, and qualification evidence for aircraft oxygen systems has relied on a fully effective mask seal. In order to guide UK MOD policy, an equipment assessment was conducted to assess the effects of facial hair on the sealing performance of fast jet oro-nasal oxygen masks. **METHOD:** A test of outboard aircrew mask leakage was conducted using standard unit-level test equipment. Royal Air Force P/Q type masks were fitted to 8 non-aircrew participants by qualified and experienced Survival Equipment Technicians. Outboard mask leakage was assessed at rest and whilst performing head movements representative of pilot lookout and instrument checks, using the flowmeter built into the test equipment. The pass/fail threshold was set at an outboard flow of more than 5L.min<sup>-1</sup>. Each participant was assessed on 3 occasions: twice at an

interval while wearing facial hair of between 2.5 and 25.5mm in length, and on a further occasion when clean-shaven. **RESULTS:** It was not possible to achieve an adequate mask seal in 6 participants with facial hair, and in the remaining 2 individuals a mask seal was only achieved on one out of 2 occasions. When the same participants were clean-shaven, an adequate mask seal was achieved in all individuals at rest and in 7 of the 8 individuals during head movements. Interval testing showed variability in sealing with regard to beard length, with some leaks improving and others worsening. Technicians reported that fitting of masks to participants with facial hair was found to be more challenging due to the obscuration of anatomical landmarks. **DISCUSSION:** The findings suggest that P/Q masks worn by personnel with facial hair may provide reduced protection from hypoxia compared to clean-shaven individuals. Leakage is unpredictable and variable. Outboard leakage may compromise mask cavity pressure, reduce the endurance of emergency oxygen supplies and any associated inboard leakage may lead to hypoxia by admixture of cabin air and vulnerability to smoke and fumes toxicity. These results support the view that an adequate oro-nasal mask seal for safety critical functions cannot be guaranteed in the presence of facial hair.

#### Learning Objectives

1. The audience will learn about the influence of facial hair on aviator oxygen mask sealing properties.
2. The audience will learn about the hazards associated with poorly fitting oxygen masks.

### [77] DESIGNING RESTRAINT FOR SIMULATING LATERAL ACCELERATION

PARUL GOEL<sup>1</sup>, ANUPAM AGARWAL<sup>1</sup>

<sup>1</sup>Indian Air Force, New Delhi, India

#### (Original Research)

**INTRODUCTION:** Super maneuverable aircraft are capable of executing maneuvers involving multiaxial acceleration. Consequentially further studies are being done involving multiaxial acceleration. However, the restraint systems available in the centrifuge seat are designed primarily for Gz acceleration and are largely ineffective in preventing sideways movement of the torso, as well as neck snap under lateral (Gy) acceleration. Thus additional restraints are needed for participants undergoing lateral acceleration. **METHODS:** The present study was conducted on High Performance Human Centrifuge (HPHC). 28 healthy male volunteers participated in the study. A restraint was designed specifically for this acceleration profile. A combined acceleration profile +Gz/+2Gy was utilized to test the newly designed restraint system. Effectiveness of the restraint was tested both subjectively and objectively. **RESULTS:** All subjects were found to be comfortable with the new restraint and it was found to be very effective in restraining subjects while undergoing lateral acceleration. **DISCUSSION:** The study brings out a new effective system for restraining subjects during lateral acceleration simulation in centrifuge. The operational significance of installing a restraint system in addition to the five-point harness in aircraft capable of executing significant Gy is also highlighted.

#### Learning Objectives

1. The participants will be able to learn as to how to study multiaxial acceleration
2. The audience will learn about the modifications done in existing restraint system to simulate lateral acceleration
3. The audience will learn of the challenges faced on simulating multiaxial acceleration profiles

Monday, 08/30/2021

Plaza A/B

4:00 PM

## [S-17]: PANEL: WOMEN'S HEALTH CONSIDERATIONS FOR EXPLORATION SPACEFLIGHT

Chair: Rebecca Blue

Co-Chair: Jonathan Steller

**Panel Overview:** With future missions planned for long-duration spaceflight outside of low-Earth orbit, NASA and its international partners

have focused on medical risk mitigation. Gynecological considerations constitute one facet of medical risk for female astronauts. This panel will discuss historical challenges for women in spaceflight, current gynecological and reproductive considerations for long-duration spaceflight, exploration vehicle design constraints and medical resource architecture, and practical aspects of living onboard a space station.

### [78] HISTORICAL CHALLENGES FOR WOMEN IN AVIATION AND SPACE

Richard Jennings<sup>1</sup>, Rebecca Blue<sup>1</sup>, Serena Aunon<sup>1</sup>

<sup>1</sup>University of Texas, Medical Branch, Galveston, TX, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** Women have made and continue to make important contributions in the aerospace field. Historically, their participation has been limited secondary to preconceived biases regarding physiological and psychological limitations and perceived lack of tolerance to aerospace-related stressors. This presentation reviews certain historical biases and more recent data of residual on-going limitations. **TOPIC:** Sex-related concerns have been raised regarding women's capabilities within the aerospace environment since the early days of aviation. Concerns regarding tolerance to physiological stressors such as acceleration or motion sickness or limitation related to sex-based anthropometry and strength differences have been prevalent in the aerospace community for decades. Additional limitations were historically placed on women given concerns regarding the risks of menstruation, gynecological disease states, and the potential for pregnancy. As women have subsequently demonstrated their ability to succeed in the aerospace environment, such concerns have largely been ameliorated. This presentation will address these historical concerns, and on-going sex-based biases in the aerospace performance environment will be considered. **APPLICATION:** Identifying historical sex-based concerns allows the aerospace medical community to examine and address historical and institutional biases within the aerospace medical field. This further allows practitioners to act as advocates for their patients, independent of sex, for future flight operations.

#### Learning Objectives

1. Describe historical medically-related impediments that have hindered the timely participation of women in aviation and space activities
2. Apply lessons learned from historical and ongoing limitations that affect female participants in aerospace operations and reduce sex or gender-related bias for current and future aerospace activities.

### [79] GYNECOLOGICAL CONSIDERATIONS FOR LONG-DURATION SPACEFLIGHT

Jon Steller<sup>1</sup>, Rebecca Blue<sup>2</sup>, Roshan Burns<sup>3</sup>, Tina Bayusse<sup>4</sup>, Erik Antonsen<sup>5</sup>, Varsha Jain<sup>6</sup>, Michele Blackwell<sup>7</sup>, Richard Jennings<sup>2</sup>

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<sup>4</sup>KBR, Houston, , USA; <sup>5</sup>Baylor College of Medicine, Houston, , USA; <sup>6</sup>King's

College London, London, United Kingdom; <sup>7</sup>Independent, Houston, TX, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** With future missions planned for long-duration spaceflight outside of low-Earth orbit, NASA and its international partners have focused on medical risk mitigation. Gynecological considerations constitute one facet of medical risk for female astronauts. This presentation will address topics of consideration for gynecological risk mitigation during future exploration missions and gaps in knowledge or treatment options that offer high-yield opportunities for future study. **TOPIC:** Long-duration exploration spaceflight will introduce new challenges for maintenance of gynecological and reproductive health. The impact of the space environment outside of low-Earth orbit on gynecological concerns remains unknown, with factors such as microgravity and increased particle radiation exposure adding complexity and potential risk. While the most effective means of minimizing the impact of gynecologic or reproductive pathology for female astronauts is screening and prevention, gynecological concerns can arise unpredictably as they do on Earth. Careful consideration of gynecological risks and potential adverse events



during spaceflight is a critical component to risk analysis and preventive medicine for future exploration missions. This presentation will discuss topics in women's health, including considerations for preflight risk mitigation and in-flight management of selected conditions such as abnormal uterine bleeding, ovarian pathologies, iron deficiency, anemia, and others. **APPLICATION:** With the push for exploration missions to the moon and Mars featuring an increasing percentage of female astronauts, addressing gynecological risk and the potential for in-flight medical concerns is of increasing importance. This presentation reviews contemporary gynecologic considerations in the space environment including the management of abnormal uterine bleeding, anemia, ovarian cysts, endometriosis, and osteopenia, as well as health maintenance.

#### Learning Objectives

1. The audience will learn about preflight risk mitigation and management considerations of selected gynecologic conditions such as abnormal uterine bleeding, ovarian pathologies, iron deficiency, anemia, and others.
2. The audience will learn about in-flight risk mitigation and management considerations of selected gynecologic conditions such as abnormal uterine bleeding, ovarian pathologies, iron deficiency, anemia, and others.

#### [80] REPRODUCTIVE CONSIDERATIONS IN FEMALE ASTRONAUTS

Jon Steller<sup>1</sup>, Rebecca Blue<sup>2</sup>, Roshan Burns<sup>3</sup>, Tina Bayuse<sup>4</sup>, Erik Antonsen<sup>5</sup>, Varsha Jain<sup>6</sup>, Michele Blackwell<sup>7</sup>, Richard Jennings<sup>2</sup>

<sup>1</sup>University of California, Irvine, Orange, CA, USA; <sup>2</sup>University of Texas, Medical Branch, Galveston, , USA; <sup>3</sup>Stanford University, Palo Alto, , USA; <sup>4</sup>KBR, Houston, , USA; <sup>5</sup>Baylor College of Medicine, Houston, , USA; <sup>6</sup>Kings College London, London, , USA; <sup>7</sup>Independent, Houston, YX, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** Fertility and reproductive concerns remain an important consideration for female astronauts and their care givers. As 50% of astronaut candidates are females of reproductive age, contraception, menstrual suppression, family planning, and fertility concerns are important considerations to include in the full spectrum of care for astronauts. This presentation will address modern fertility concerns for our current astronauts and future concerns regarding the risks of the space environment on pregnancy, as well as discussing current contraceptive methodologies and associated risks and benefits. **TOPIC:** Appropriate pre-flight counseling regarding future fertility desires, screening for pregnancy, and patient-centered contraceptive management for individualized astronaut goals are essential topics for a comprehensive approach to women's health in spaceflight. Some astronauts voluntarily choose to suppress menstruation for convenience during flight, utilizing combined oral contraceptives, intrauterine devices, and other hormonal modalities. Choosing the most appropriate contraceptive for each individual desiring hormonal supplementation must consider factors such as prevention of pregnancy, induction of amenorrhea, preservation of bone mineral density, and reduction of the risks of abnormal bleeding, venous thromboembolism, and ovarian cyst production. Further, many female astronauts choose to delay pregnancy until after spaceflight, with the average age among female astronauts at time of first pregnancy ~35y. Advanced maternal age is associated with increased risk of reduced ovarian reserve, infertility, miscarriage rates, and aneuploidy. While pregnancy is an absolute contraindication for space travel, there is a paucity of animal research evaluating the risks to both the mother and fetus in the setting of space radiation or altered gravitational force. As there is a non-zero risk that pregnancy could occur in future spaceflight, this presentation will further introduce ongoing research exploring the effects of the spaceflight environment on pregnancy. **APPLICATION:** With the push for exploration missions to the moon and Mars featuring an increasing percentage of female astronauts, addressing reproductive concerns should be encouraged and destigmatized, allowing aerospace practitioners to respectfully explore and individualize a reproductive management plan with female astronauts.

#### Learning Objectives

1. Understanding the various risks, benefits, and alternatives to hormonal or non-hormonal contraceptive modalities pre-flight, in-flight, and post-flight.
2. Understanding reproductive considerations for astronauts pre-flight and post-flight as it relates to maternal age and possible impact of the space environment.

#### [81] THE CASE OF THE UNEXPECTED SPECULUM AS A STUDY OF SPACEFLIGHT HUBRIS

Rebecca Blue<sup>1</sup>, Erik Antonsen<sup>2</sup>, Jonathan Steller<sup>3</sup>

<sup>1</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>2</sup>Baylor College of Medicine, Houston, TX, USA; <sup>3</sup>University of California Irvine, Irvine, CA, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** Exploration vehicle design constraints will impose limits on onboard mass, volume, and power allowances to support medical resource architecture. One possible approach to address onboard resource limitations is through use of additive manufacturing for medical equipment that otherwise might be excluded from onboard medical kits, such as gynecological speculums. We will discuss the process of additive manufacturing of a gynecological speculum, lessons learned, and where/how physicians can appropriately influence the integration of medical system capabilities throughout a system design process. **TOPIC:** To demonstrate the challenges inherent to the use of additive manufacturing for specialized medical tools, we utilized additive manufacturing to construct a gynecological speculum. This process provided insights into challenges that can arise when physicians make assumptions about post-hoc medical capability inclusion late in engineering life cycles of spacecraft systems, including insufficient analysis of risk, vehicle hardware and software architecture impacts, underestimation of cost, and inadequate consideration of the ethics involved in informing crews of the realities and uncertainties of exploration spaceflight. We will review common faulty assumptions, risks those assumptions carry, and engineering system language and approaches that physicians should be familiar with when engaging in system design efforts. Solutions including Probabilistic Risk Assessment, appropriate Concept of Operations definition, and basic Human Systems Integration Architecture and are discussed within the context of a typical engineering life cycle for space vehicle and mission development. **APPLICATION:** Medical system capabilities in human spaceflight endeavors have lagged behind other engineering subsystems when interfacing with systems engineering and requirements provision for new missions and vehicles. Complex systems like space vehicles have concept and design phases that start many years prior to launch and system checkout. As designs mature, system flexibility decreases and the cost to include late changes increases exponentially. Recognition of the utility and the limitation of additive manufacturing technology provides insight into how it may, or may not, be able to address medical needs. This case serves as a prime example of how medical and engineering teams can continually work together to improve innovative technologies in the space environment.

#### Learning Objectives

1. Participants will understand the challenges inherent to the use of additive manufacturing in printing a specialized medical tool.
2. Participants will learn about challenges that can arise when physicians make assumptions about post-hoc medical capability inclusion late in the engineering life cycle of spacecraft systems

#### [82] PRACTICAL ASPECTS OF LIVING ONBOARD A SPACE STATION

Serena Aunon-Chancellor<sup>1</sup>

<sup>1</sup>NASA, UTMB/LSU, Baton Rouge, LA, USA

#### (Education - Tutorial / Review)

**INTRODUCTION:** Despite some of the challenges described in this panel, women continue to live and work onboard space vehicles. The practical aspects of women's health and hygiene in spaceflight are rarely discussed. Here, we will describe some of the many aspects of life aboard

space vehicles, particularly as they affect women's health considerations. **TOPIC:** As both men and women live and work in space, the practical aspects of basic human health and hygiene have been managed as a part of daily life. Life onboard transit vehicles, such as the Soyuz, or onboard the International Space Station carry unique, vehicle-specific challenges and require adjustments to many aspects of activities of daily life. Here, the unique challenges of health, hygiene, and other concerns will be discussed in the context of a long-duration flight in low-Earth orbit. Practical considerations for waste management, menstrual considerations, and similar will be examined. **APPLICATION:** Open discourse regarding human health and hygiene considerations in spaceflight is essential to encourage supportive development of medical system architecture and other vehicle design considerations for future space-flight. Providing a practical and experience-based understanding of daily challenges allows aerospace physicians to advocate for supportive and unbiased system architecture to enable spaceflight for all astronauts.

#### Learning Objectives

1. Participant will learn about the practical aspect of women's health on board ISS
2. Participant will learn about the unique challenges women face regarding waste and hygiene activities on board ISS

**Monday, 08/30/2021**

**4:00 PM**

**Plaza D/E**

### [S-18]: PANEL: AERONEUROSCIENCE – WHAT'S THE EVIDENCE?

**Chair: Roger Hesselbrock**

**Co-Chair: Aven Ford**

**PANEL OVERVIEW:** Historically, neurologic conditions were incompatible with flight training, and few aviators with neurologic conditions were cleared for return to flying activities. This conservative approach reflected early aviation medicine practice, as neurologic conditions could produce sudden incapacitation or cause aeromedically-incompatible impairments, and little effective management was available. Severely restrictive aeromedical standards for neurologic conditions continued until roughly after the Second World War. Advances in medical knowledge and practice coupled with expanding clinical evidential information then allowed for cautious opening of the aviation service aperture for some neurologic conditions. This trend has continued to expand, and today many neurologic conditions that formerly were considered permanently unfitting can be safely recommended for medical certification, both in military and civilian settings. While some neurologic disorders have well-established evidence-based data that are directly applicable to aviators, continuing challenges exist for many neurologic conditions that have minimal or non-applicable cohort-specific evidence-based information, with resulting difficulties in determining suitability for initial or continued aviation service. This panel will present information on advances in aeromedical evaluation and dispositions for several neurologic conditions or managements commonly encountered in aviators. Topics to be covered include the role of screening EEG in pilot applicants, traumatic brain injury, sleep disorders and cognitive impairment in long duration space flight, altitude-exposure associated white matter hyperintensities, and use of monoclonal antibodies and biologic agents in neurologic conditions. Current research and clinical evidence data and future trends will be presented. Audience participation and discussion are highly encouraged.

### [83] SLEEP DISORDERS AND COGNITIVE IMPAIRMENT IN LONG DURATION SPACE FLIGHT

**Christopher Skinner<sup>1</sup>**

<sup>1</sup>University of Ottawa, Ottawa, Ontario, Canada

(Education - Program / Process Review)

Sleep disorders in long duration space flight have been implicated as a major cause of cognitive dysfunction impairing day to day operations as well as resulting in potentially serious aeromedical events compromising flight safety. This presentation will review the history and research into the impact of sleep disorders in space on cognitive impairment and

discuss the principle mitigating strategies that have been researched and developed over time and are currently in use. The presentation will outline the various mitigation strategies and countermeasures for remediation the specific underlying causes of sleep deprivation in space and the need for a multi-disciplinary approach. The different research and management approaches used by the ISS partners, and Chinese space travellers will be highlighted.

#### Learning Objectives

1. To understand the major factors causing sleep deprivation in space flight
2. To review the research related to cognitive impairment due to sleep deprivation in space flight
3. To review the mitigating strategies employed as counter-measures to improve sleep quality in space flight

### [84] TRAUMATIC BRAIN INJURY IN THE AEROMEDICAL SETTING

**Aven Ford<sup>1</sup>**

<sup>1</sup>Aeromedical Consultation Service at USAFSAM, U.S. Air Force, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

**INTRODUCTION:** Traumatic brain injury (TBI) is a constantly evolving topic. As imaging has improved we have learned more about how structural changes lead to long-term impairment and negative outcomes. This talk will use cases to discuss aeromedical decision making in TBI. **TOPIC:** TBI is one of the most common neurologic injuries that in seen in aviators and may carry significant long-term risks. Traumatic brain injury may be especially prevalent in the younger, military aviator population. The aeromedical risks associated with traumatic brain injury are the risks of performance decrement that may occur associated with the cognitive and physical posttraumatic symptoms as well as the increased risk in sudden incapacitation from seizures that is present following a more severe TBI.

**APPLICATION:** TBI is classified into levels of severity based on clinical and radiographic findings. The Air Force and civilian aviation use slightly different categorization schema, both of which will be reviewed. Most cases of mild TBI, in which there is no loss, or only brief loss, of consciousness and head imaging is normal, recovery is rather quick, with most symptoms resolving within 2-4 weeks and with no significant increased risk of seizure. In patients with moderate or severe TBI, symptoms can linger for some time and more concerning, there can be subtle decrements in performance that may not be evident to the aviator, as well as an increased risk of seizures that persists for years. Imaging, particular magnetic resonance imaging (MRI) of the brain has greatly improved the diagnostic categorization of TBI and allowed for more accurate risk assessment regarding return to flight. To illustrate this, I will present two cases. First, a historical case for reference. Second, a recent case in which radiographic findings changed the level of severity and changed management, helping to ensure the safety of the pilot and mission.

**RESOURCES:** 1. Davis, JR et al (Eds). Fundamentals of Aerospace Medicine, 4th Edition; Lippincott Williams & Wilkins, 2008. 2. Gradwell D, Rainford D (Eds). Ernsting's Aviation and Space Medicine, 5th Edition, CRC Press, 2006.

#### Learning Objectives

1. The participant will be able to accurately classify traumatic brain injury and understand the aeromedical implications of traumatic brain injury and the current evidence for the recommended restrictions, evaluation, and management.
2. The participant will understand the historical evolution of care and flying restrictions following a brain injury.

### [85] ALTITUDE ASSOCIATED WHITE MATTER HYPERINTENSITIES

**Frank Weber<sup>1</sup>, Carla Ledderhos<sup>1</sup>**

<sup>1</sup>German Air Force Center of Aerospace Medicine, Fuerstenfeldbruck, Germany

(Education - Tutorial / Review)

**INTRODUCTION:** Since McGuire's seminal studies on the prevalence of WMH in the brain of active duty U2-pilots WMH came into the center of interest in aerospace neurology. **TOPIC:** In general, WMH are unspecific and frequent findings in MRIs of the brain. Their occurrence is positively correlated with age, possibly they are part of the normal ageing process. On the other hand, they can be sign or part of many CNS disorders, e.g.

inflammatory disorders or disorders that affect the CNS secondarily like small vessel disease due to chronically elevated arterial blood pressure. While it is an established finding that hypobaric hypoxia can lead to WMH, we could recently show that WMH induced by a single exposure to hypobaric hypoxia in mountaineers are transient and reversible within months at lowland (Kühn et al. HAM 2019). To answer the question, whether repeated exposure to hypobaria without hypoxia produces a high WMH load we currently do a study on military altitude chamber workers. Preliminary results show no increased WMH load in this chamber personal compared to the controls (Ledderhose 2021) This might be a consequence of the numbers of expositions and of the altitude (McGuire AnnNeurol 2014). Older own studies with a 1.0 T MRI showed no WMH in German fighter pilots (Weber, Goriup ASEM 2007). A more recent 1.5 T MRI study on fighter pilots showed an increased WMH load only in those pilots with right-to-left shunt via PFO (Kang ClinNeurolNeuroSurg 2014). **APPLICATION:** We conclude that WMH in fighter pilots cannot be attributed to altitude exposure alone and need a thorough assessment in each individual case. **RESOURCES:** 1. Kang KW, et al: Patent foramen ovale and asymptomatic brain lesions in military fighter pilots, ClinNeurolNeuroSurg 2014;124: 9-14. 2. Kühn S, et al: An Observational Cerebral Magnetic Resonance Imaging Study Following 7 Days at 4554 m; HIGH ALTITUDE MEDICINE & BIOLOGY 2019, DOI: 10.1089/ham.2019.0056. 3. McGuire SA, et al. White matter hyperintensities on MRI in high-altitude U-2 pilots. Neurology 2013;81: 729-735. 4. McGuire SA, et al: White Matter Hyperintensities and Hypobaric Exposure, ANN NEUROL 2014;76: 719-72. 5. Ledderhose C, et al: WMH in altitude chamber workers, ASMA 2021. 6. Weber F, Goriup A: Prevalence of right-to-left shunts in active fighter pilots; ASEM, 2007;78: 135-136.

#### Learning Objectives

1. The audience will understand prevalence and pathophysiology of WMH in the brain
2. The audience will understand the effects of hypobaric hypoxic exposure on the brain

#### [86] "NEW" THERAPIES IN NEUROLOGICAL DISEASE: AEROMEDICAL CONSIDERATIONS

Edwin Park<sup>1</sup>

<sup>1</sup>Naval Aerospace Medical Institute, Pensacola, FL, USA

(Education - Tutorial / Review)

**INTRODUCTION:** New therapies in neurological disease include the monoclonal antibodies (mAb) for autoimmune disorders, such as multiple sclerosis, and prevention or acute treatment in migraine. Gepant and ditans for acute treatment of migraine. The mAbs were developed using hybridoma technology, the process first described in the 1970s. Today, mAbs are produced using newer technologies and have expanding indications for the diagnosis and treatment of many types of medical disorders, including cancers, autoimmune disorders, infectious diseases, and in the management of organ transplant. Gepants are calcitonin gene-related peptide receptor antagonist drugs. Ditans are similar to triptans but with more specific activity that may be better tolerated in certain patients. Several drugs with a variety of mechanisms of action have been FDA approved for the treatment of relapsing-remitting and secondarily progressive forms of multiple sclerosis since 2010. **TOPIC:** This presentation will describe these new therapies, their mechanisms of action, their indications and the evidence supporting or discouraging their use in flight personnel to date. **APPLICATION:** The presentation will continue by outlining the aeromedical considerations for certification of individuals who are using or may wish to use these agents.

#### Learning Objectives

1. Be familiar with the range of new treatment modalities for selected neurological diseases now potentially available to trained or prospective flight personnel.
2. Understand the aeromedical considerations for certification of personnel using or wishing to use these therapies.

#### [87] SMALL FINDINGS IN EEG DURING SELECTION PROCESS WITH OBSERVED EPILEPTIC SEIZURE DURING FLIGHT

Denis Bron<sup>1</sup>, Frank Weber<sup>2</sup>

<sup>1</sup>Aeromedical Centre, Dübendorf, Switzerland; <sup>2</sup>Zentrum für Luft- und Raumfahrtmedizin der Luftwaffe, Fuerstenfeldbruck, Germany

#### (Education - Case Study)

The selection procedure for Swiss military pilots includes a routine EEG screening. Aspirants with epilepsy or certain EEG abnormalities (e.g. epileptiform patterns) are automatically disqualified from the process. Hereafter is a description of a patient's case, which took place during the years 2016-2018. The 20 year old glider pilot has had his first generalized tonic-clonic seizure in July 2016, thought to be triggered by paint fumes. His pilot license was revoked to be re-evaluated at the earliest in one year. Over the course of said year, he was neurologically examined twice, in accordance with his wish to regain his pilot license and to partake in the SPHAIIR training program. The examinations concluded that the patient was asymptomatic ever since, had a negative family history regarding epilepsy, had no personal history of febrile or other epileptic seizures. Both EEG's, taken six months apart, were perfectly normal at rest as well as during stimulation tests. In July 2017, civil authorities deemed him fit to fly. In April 2018, he had his second grand mal seizure during a take-off heading in direction of the sun. The present SPHAIIR flight instructor managed to land the plane safely. We believe that EEG screening is still a valid procedure.

#### Learning Objectives

1. EEG screening is still a valid selection tool for pilot military pilot selection.
2. Epileptic seizure during a flight is very critical, special education is helpful.
3. Further discussion and exchange of experience is mandatory

Monday, 08/30/2021

4:00 PM

Plaza F

#### [S-19]: SLIDE: BACK AND NECK INJURIES

Chair: Barry Shender

Co-Chair: Deborah White

#### [88] EFFECTS OF ADDITIONAL AXIAL LOAD ON MOTOR CONTROL OF THE HUMAN CERVICAL SPINE

Ursula Heggli<sup>1</sup>, David Rafique<sup>2</sup>

<sup>1</sup>Aeromedical Center Swiss Air Force, Dübendorf, Switzerland; <sup>2</sup>Integrative Spinal Research ISR, Department of Chiropractic Medicine, Balgrist University Hospital, Zurich Switzerland, Switzerland

(Original Research)

**INTRODUCTION:** The cervical motor control (CMC) is the result of different stabilisation mechanisms produced by the passive, active, and neurological subsystems. The joint position error test (JPE) was developed to quantify changes in cervical proprioception in patients with neck pain. Jet pilots need full mobility of their neck during air combat, while they are exposed to axial G- loads. Helicopter pilots on the other hand, have longer flight times while they are wearing a helmet and potentially a night vision goggle. To prevent neck disorder, a better understanding of cervical motor control under axial load is needed. **METHOD:** 51 healthy young men (mean age of 20.3 ± 1.4 years) were recruited for this study. With an accelerometer (IMU) strapped to the forehead, a sensamove cervical trainer device measured cervical JPE and range of motion (ROM). We assessed in random order 0 or 3 kg (6.6 lbs.) of additional axial load in flexion, extension, rotation, and lateral-flexion. For the statistical comparison we used the paired t- test (SPSS program). **RESULTS:** In the JPE- test, extension (p = .028) and flexion (p = .004) showed significant larger deviations (errors) with an additional axial load of 3 kg (6.6 lbs.) compared with zero, whereas the changes in the rotation (p = .997) and lateral-flexion were not significant (p = .267). In the ROM, there were two significant changes with axial load: an increase in the lateral- flexion (p = .004) and a decrease in flexion (p < .001). ROM of extension (p = .655) and rotation (p = .178) did not change. **DISCUSSION:** CMC seems to get worse under axial load, especially in flexion and extension. A reduced CMC could lead to neck injury or neck pain. This could be one reason why jet pilots often have neck problems. The decrease of the ROM in flexion can be explained by a protective mechanism in response to the unstable position. In contrast, the length of the lateral neck muscles could limit the ROM in the lateral- flexion. **CONCLUSION:** To prevent neck pain in military pilots a stabilization and proprioception neck training is essential.



**Learning Objectives**

1. How does axial load affects the motor control and the range of motion of the cervical spine.
2. To understand probable relationships between proprioception, mobility and neck pain.

**[89] DIFFERENCES IN ELECTROMYOGRAM PROFILE OF NECK MUSCLES IN SUBJECTS WITH AND WITHOUT NECK PAIN**

Sven Rochelt<sup>1</sup>, Janine Rochelt<sup>1</sup>, Nadja Saba<sup>1</sup>, Denis Bron<sup>1</sup>, Andres Kunz<sup>1</sup>

<sup>1</sup>Swiss Airforce Aeromedical Center, Dübendorf, Switzerland

*(Original Research)*

**BACKGROUND:** Neck pain is a growing medical problem among military Air Force pilots. Strong G-forces, vibration, additional helmet weight and a non-ergonomic sitting posture can lead to muscular tension and neck pain. Muscle activity can be measured by surface electromyography (sEMG). EMG signal is used to monitor fatigue of a particular muscle. The purpose of this study is to use sEMG signal to determine differences in neck muscle activity in military pilots with non-specific neck pain and without neck pain. **METHOD:** Twenty military pilots and twenty control subjects participated in this study. Each subject group consisted of ten participants with acute or chronic neck pain and ten without. All subjects performed one reference movement and seven exercises in a standardized way. Simultaneously, a sEMG recorded the specific activity of defined muscles. Visual analogue scale (VAS) reported pain experience. To query the subjective state of health, the Bournemouth questionnaire was used. A wavelet analysis was also applied on the sEMG pattern. For inter-individual analysis, data of the performed exercises was normalized to the reference movement.

**RESULTS:** The firing frequency of left trapezius muscle in group Symptomatic Pilots was significantly higher ( $p < 0.05$ ) than those of the other groups for arm abduction, shoulder lifting, shoulder rotation and teacup left. Furthermore, a shift to the lower frequency spectrum could be reported in the right trapezius muscle for shoulder lifting, shoulder rotation and teacup right respectively. No significant differences could be found in head inclination nor head rotation between all groups, as well as in the other recorded muscles. **DISCUSSION:** The increased intensity could be explained by the fact that the affected muscle in question fires more frequently and therefore, fatigues faster. Moreover, a tired or painful muscle shows a frequency shift to the lower frequencies. This shift may be related to an impairment of fine motor skills, which are the basis of a good functionality of the deep muscles of the cervical spine. This could imply that the support function of the deep neck muscles is no longer guaranteed in neck pain pilots. In summary, inter-individual differences could be shown, especially in pilots and non-pilots. Further investigations are needed to substantiate these results in order to develop a preventive tool to counteract neck pain in Air Force Pilots.

**Learning Objectives**

1. Understand the importance of prevention of neck pain in Military pilots.
2. Wavelet Analysis can be used to evaluate EMG raw data.
3. The Change in Amplitude and frequency spectrum can be an indicator for neck pain.

**[90] AN ASSESSMENT OF CERVICAL SPINE RANGE OF MOTION REQUIREMENTS FOR AH-64 AVIATORS RELATIVE TO TIME OF DAY**

Steven Williams<sup>1</sup>, Adrienne Madison<sup>1</sup>, Valeta Chancey<sup>1</sup>

<sup>1</sup>USAARL, Fort Rucker, AL, USA

*(Original Research)*

**INTRODUCTION:** Neck pain is an established flight safety issue for military rotary-wing aviators. Military flight surgeons tasked with making determinations regarding an aviator's flight fitness based on cervical spine range of motion (CROM) do not have adequate guidance to make an informed decision as there is currently no regulation defining what range of motion is adequate during flight operations. Describing the real-world CROM during flight would inform flight surgeons and provide a more useful and substantial reference than the physiological normal

limits that flight surgeons currently employ. USAARL is conducting a study among AH-64 and UH-60 pilots to characterize CROM requirements in simulated and actual flight using optical head tracking equipment. One area of investigation is CROM differences relative to time of day. **METHODS:** Three-dimensional pilot and co-pilot head position data from the maintenance data recorder (MDR) readings from AH-64 missions were provided by Apache Attack Helicopter Project Management Office. Data were filtered down to three-dimensional pilot and co-pilot head position data reported as unit vectors. Missions were classified as either day or night flights. Each data point was analyzed to determine neck posture. Neck postures were then categorized as neutral, mild, or severe for flexion/extension, lateral bending, and axial twist based on neck postural categories from the work of Punnett et al. (1991). **RESULTS:** Presented here is an analysis of head position data from pilots and co-pilots during a collection of day and night AH-64 flights. Preliminary analysis of a small data sample showed a higher frequency of head movement during night flights. These preliminary results also showed greater cervical activity with co-pilots compared to pilots (during day and night flights). The length of time in each posture category was also greater during night flights for both pilots and copilots. **DISCUSSION:** This investigation provides a preliminary assessment of AH-64 CROM during day and night flight missions. Limitations of the analysis to consider include the type of aircraft being flown, the type of mission being performed, and the conditions of the flight, which could lead to varying CROM requirements. Accordingly, future research will occur in both actual and simulated flight in both an AH-64 and UH-60 where the mission and flight conditions can be controlled and a statistical evaluation can be performed.

**Learning Objectives**

1. The audience will learn about cervical spine range of motion requirements for AH-64 aviators during routine flight respective to time of day.
2. The audience will learn about the postural categories used to analyze head position data.

**[91] NECK PAIN IN RCAF FAST JET PILOTS: PREVALENCE, CHARACTERIZATION AND OPERATIONAL IMPACT**

Erin Smith<sup>1</sup>

<sup>1</sup>Canadian Forces Environmental Medicine Establishment, Toronto, Ontario, Canada

*(Original Research)*

**INTRODUCTION:** Neck pain is increasingly prevalent in the aviation community. Previous studies conducted in the Royal Canadian Air Force (RCAF) have established that operationally significant neck pain is prevalent in RCAF rotary wing aircrew. While it is well established that fast jet pilots are also at risk of neck pain and injury, the RCAF fast jet pilot population has not yet been studied. This survey will provide insight into the proportion of the RCAF fast jet population affected by neck pain and to what extent this affects operations and quality of life.

**METHODS:** All RCAF fast jet pilots received a presentation on neck pain and were provided an opportunity to complete an on-line anonymous survey. This survey was the first to include the 'Core Questions' recommended by the NATO HFM RTG 252. All RCAF fast jet pilots were eligible to participate, including International Instructor Pilots and Student Pilots and those in non-flying positions at the time of data collection. There were no specific exclusion criteria. Ethics approval was obtained from DRDC's Human Research Ethics Committee. **RESULTS:** 229 RCAF fast jet pilots completed the on-line survey resulting in an 85% completion rate. Significant flight-related neck pain was prevalent in all (currently) non-flying pilots, 97% of operational pilots, 86% of instructor pilots and 79% of student pilots. Notably, flight-related neck pain was reported in 98% of CF-188 pilots. Those with pain reported an average of 1-4 episodes in the last 12 months, typically lasting 7 days or less. Age, night flying hours, use of NVGs and other survival equipment were positively correlated with significant flight-related neck pain. 63% of RCAF fast jet pilots report modifying their flying activities due to neck pain and 57% report modifying their activities of daily life due to significant flight-related neck pain. Worsening symptoms, fear of additional injury and fear of impact to quality of life were reported as the primary reasons for modification of activities. **DISCUSSION:** These results confirm that

neck pain is a significant issue for RCAF fast jet pilots as well as rotary wing aircrew. It is also clear that neck pain has a significant impact on the health and operational capability of the RCAF Fighter Force. This information can be utilized to direct future efforts towards further characterization of the contributing factors, minimizing impact to operations and mitigating the risk of further injury.

#### Learning Objectives

1. To understand the prevalence of neck pain in RCAF fast jet aircrew.
2. To understand the operational impact of neck pain in RCAF fast jet aircrew.

### [92] PRE-FLIGHT AND POST-FLIGHT STRETCHING (PPS): AN APPROACH TO MITIGATING BACK AND NECK PAIN IN THE HELICOPTER COMMUNITY

James Walsh<sup>1</sup>, George Armas<sup>2</sup>, Adam Church<sup>3</sup>, Curtis Hardy<sup>4</sup>, Peter Le<sup>5</sup>, Andrea McGlynn<sup>6</sup>, Almer Mendoza<sup>1</sup>, Grey Pickerill<sup>7</sup>, Hadley Sulpizio<sup>9</sup>, Martin Wright<sup>9</sup>

<sup>1</sup>Naval Hospital Jacksonville, Jacksonville, FL, USA;

<sup>2</sup>COMHELMARSTRKWINGLANT, Mayport, FL, USA; <sup>3</sup>COMHSCWINGPAC, Coronado, California, USA; <sup>4</sup>NMC San Diego, San Diego, CA, USA; <sup>5</sup>NMRU Dayton, Dayton, OH, USA; <sup>6</sup>NMC Portsmouth, Portsmouth, VA, USA;

<sup>7</sup>HELSEACOMBATWINGLANT, Norfolk, VA, USA; <sup>8</sup>TRAWING 5, Milton, FL, USA;

<sup>9</sup>US Naval Academy, Annapolis, MD, USA

#### (Original Research)

**INTRODUCTION:** The Naval Aviation Enterprise (NAE) plays a vital role in our nation's warfighting strategy. In order to complete the mission, the community relies on exceptionally well-trained men and women to fly their aircraft and employ its unique weapons systems. However, flight-related poor posture, cockpit ergonomics, heavy man-mounted gear, and whole-body vibrations have been cited as causal factors to the debilitating effect of non-specific back and neck pain. Safety surveys within the Navy's rotary wing communities have shown back pain as the top physiological factor affecting in-flight performance. A standardized stretching protocol does not exist within the NAE. Therefore, Pre-Flight and Post-Flight Stretches (PPS) was designed to provide structure and standardization to stretches most relevant to flight. The purpose of this study is to determine whether PPS can mitigate flight-related back and neck pain. This project is now complete and was conducted in two phases. **METHODS:** PPS was performed following the pre-flight brief and once again upon completion of the post-flight debrief in the variable squadron. The control squadron did not perform PPS. Utilizing the Universal Pain Assessment Tool, pain questionnaires were completed before and after each flight. Phase I incorporated pilots and aircrewmembers from two squadrons from NAS Jacksonville and was conducted over four weeks. Phase II added three squadrons at NAS North Island (one variable and two control groups) and three squadrons at NS Norfolk (one control and two variable groups) and was conducted over 12 weeks. Comparisons were analyzed with the Mann-Whitney U test. Squadrons consisted of both female and male subjects. PPS received Institutional Review Board approval from Naval Medical Center Portsmouth.

**RESULTS:** Combined, Phase I and II matched 189 surveys. Six questionnaires were excluded as they were completed incorrectly. The difference between groups was statistically significant for Mid-Back ( $p < 0.001$ ), Lower Back ( $p < 0.001$ ), and Overall Pain ( $p < 0.001$ ). The Neck ( $p = 0.161$ ) and Buttocks ( $p = 0.145$ ) regions were not statistically significant. **DISCUSSION:** There is a statistically significant improvement in flight-related back pain when PPS is performed in the rotary wing community. The prehabilitation aspect reduces conventional medical intervention and costly pharmacological management of back pain and could potentially be applied to other aviation communities.

#### Learning Objectives

1. The audience will learn how flight related posture, cockpit ergonomics and whole-body vibration are causal factors to neck and back pain, which is the top physiological factor affecting in-flight performance in rotary wing aircraft.
2. The audience will learn about a series of pre-flight and post-flight stretches that reduce flight related back and neck pain.

Monday, 08/30/2021  
Governor's Square 12

4:00 PM

### [S-20]: SLIDE: "YOU WANT ME TO WEAR WHAT IN SPACE, DOC?"

Chair: Jeff Myers

Co-Chair: Benjamin Easter

### [93] MEDICAL CONSIDERATIONS FOR A PERMANENT MARTIAN HABITAT

Anthony Yuen<sup>1</sup>, Nissem Abdeljelil<sup>2</sup>, Bruno Pavletic<sup>3</sup>, Kristi Ray<sup>4</sup>, Ahmed Baraka<sup>5</sup>, Lauren Church<sup>6</sup>, Rochelle Velho<sup>7</sup>

<sup>1</sup>Weill Cornell Medicine, Ithaca, NY, USA; <sup>2</sup>University of Carthage, Tunis, Tunisia; <sup>3</sup>University of Zagreb, Zagreb, Croatia; <sup>4</sup>Louisiana State University, New Orleans, LA, USA; <sup>5</sup>Alexandria University, Alexandria, Egypt; <sup>6</sup>King's College, London, United Kingdom; <sup>7</sup>University Hospitals Birmingham NHS Trust, Birmingham, United Kingdom

#### (Education - Program / Process Review)

**BACKGROUND:** A Martian settlement is on the forefront of space exploration. Alongside the operational requirements of travelling to Mars, remote medical capabilities need to be considered to ensure the viability of a permanent habitation. Telemedical technologies were reviewed by the Space Generation Advisory Council Space Medicine and Life Sciences (SGAC SMLS) subgroup as part of the 2020 Mars Society competition. A questionnaire was used to triage the key priorities for the long-term habitation to drive the focus of the review. Telemedicine was a top priority that needed viable solutions pre deployment and establishment of a long-term habitat on Mars. **OVERVIEW:** Telehealth has been instrumental on the international space station (ISS) and most recently during the COVID-19 pandemic. For Mars exploration, telemedicine as well as robotic telesurgery will likely be a mainstay of treatment, especially as we look to permanent surface habitation. **DISCUSSION:** Settlement on Mars is an ambitious challenge. Many technologies needed for future Martian medical requirements are currently available or in development. It is therefore essential to start thinking about the possible use of technology on future Martian missions - not only to make such missions easier, but also minimize casualties during that process. For example, for Mars colonization, it is proposed that extravehicular activity (EVA) suits for exploration and resource gathering have direct radio communication with other suits and city emergency center(s) (EC) on separate channels. They have various sensors monitoring blood and outside pressure, heartbeat, oxygen level, body and environmental temperature, airflow, humidity inside a helmet and force acting on a suit. The healthcare system will be capable of diagnosing and treating anticipated illness and injury through telemedicine and telesurgery including the use of remote robotics. This will include ambulatory care from preventive medicine to trauma response and support tasks such as imaging and laboratory testing. The electronic medical record could be used in an asynchronous mode that will transit data from the Martian surface to Earth in a store and forward mode. This medical informatics and smart medical systems can be considered for the fabric of healthcare in space.

#### Learning Objectives

1. The audience will learn about the telemedicine systems proposed for permanent Martian settlement
2. The participant will be able to understand the importance of a specialized healthcare system for Martian settlement

### [94] EVALUATION OF A SINGLE-PROBE, COMPACT ULTRASOUND IMAGER FOR USABILITY IN THE PRACTICE OF SPACE MEDICINE

Kadambari Suri<sup>1</sup>, Ashot Sargsyan<sup>1</sup>, Douglas Ebert<sup>1</sup>, Aaron Everson<sup>1</sup>, Richard Cole<sup>2</sup>, Taylor O'Neil<sup>3</sup>, Vicky Byrne<sup>1</sup>, James Pattarini<sup>4</sup>, Ronak Shah<sup>4</sup>

<sup>1</sup>KBR, Houston, TX, USA; <sup>2</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>3</sup>USAF MC, O'Fallon, IL, USA; <sup>4</sup>NASA, Houston, TX, USA

#### (Original Research)

**INTRODUCTION:** Innovative commercial-off-the-shelf medical devices continue to expand the scope of medical care in limited resource

environments. As NASA plans missions outside low Earth orbit, the philosophy and design of mission medical capability must harness the benefits of emerging technologies in order to comply with mission constraints while maintaining low medical risk. Sonography is a mainstay of research and medical support on the International Space Station (ISS). We evaluated the operational fitness and imaging performance of Butterfly iQ (iQ, Butterfly Network, USA), an FDA-approved ultrasound imager with capacitive micromachined ultrasonic transducer technology. **METHODS:** Operational fitness measures included mass, volume, power, availability, interfaces, and data management features in three tests: 1) Imaging performance was assessed on an ultrasound phantom and in human "patient" volunteers (N=10; best-achievable images were obtained by two sonographers using iQ and a reference device (Vivid q, GE, USA). 2) Three simulated emergency procedures were conducted by two physicians (N=5 volunteers), and 3) Remote guidance in an ISS scenario (N=5 operators), and autonomous use by untrained operators (N=11 operators). Usability ratings and comments were collected from the operators. **RESULTS:** iQ is a single-probe imager weighing <400g using a mobile platform for display, control, and connectivity. iQ was ready for use in < 30 s and usability was excellent for constrained mission profiles and acute scenarios. Imaging performance of the iQ was comparable to that of the reference device; on average, the iQ was rated 3.8 and the reference device 3.9 on a 5-point scale. Axial and grayscale resolution was similar to the reference device; lateral resolution was inferior to the reference device but adequate for diagnostic and emergency uses. Autonomous use by untrained operators was excellent with 10 of 11 operators successfully obtaining ejection fraction values. **DISCUSSION:** Operational fitness and clinical imaging utility of the Butterfly iQ device for spaceflight were deemed excellent. The intuitive user interface, preset-based operation, and real-time machine learning-based algorithms make iQ amenable to basic point-of-care use by minimally-trained operators. These "smart" digital devices are ideal for risk-based care augmentation. Ultimately, these devices will re-define the boundaries of program-agnostic medical capability in human spaceflight.

#### Learning Objectives

1. Understand how emerging technologies can enable mission objectives through reduced mass, volume, and power consumption.
2. Understand how emerging technologies can enable mission objectives through increased usability and instant connectivity.

#### [95] WEARABLE 3-LEAD ELECTROCARDIOGRAM PLACEMENT MODEL FOR FLEET SIZING OF MEDICAL DEVICES

Katya Arquilla<sup>1</sup>, Sarah Leary<sup>1</sup>, Andrea Webb<sup>2</sup>, Allison P. Anderson<sup>1</sup>  
<sup>1</sup>University of Colorado Boulder, Boulder, CO, USA; <sup>2</sup>Draper, Cambridge, MA, USA

#### (Original Research)

**INTRODUCTION:** Electrocardiography (ECG) provides valuable information on astronaut physiological health. ECG monitoring has been conducted during crewed missions since the beginning of human spaceflight and will continue during astronauts' upcoming long-duration exploration missions (LDEMs) in support of automated health monitoring systems. ECG monitoring is traditionally performed in clinical environments with single-use, adhesive electrodes in a 3, 6, or 12-lead configuration placed by a trained clinician. In the space exploration environment, astronauts self-place electrodes without professional assistance, which can cause discrepancies between monitoring sessions. Wearable ECG systems are an attractive option for automated health monitoring, but standardized electrode placement is key in the development of reliable, wearable ECG monitoring systems that limit noise due to changes in electrode positioning. **METHODS:** We present a method of quantifying electrode placement for 3-lead, chest-mounted ECG using easy-to-measure, two-dimensional chest measurements called the "box method". We trained and tested the box method on body shape models and used them to demonstrate the fleet sizing process. **RESULTS:** We find that male and female dimensions require different electrode positioning computations, but there is overlap in positioning between men and women. The distribution of electrodes' vertical positions is wider than their horizontal positions. **DISCUSSION:** These results can be translated directly to ECG wearable design for the individual and for the size range and adjustability required for the astronaut fleet. Implementation of this method will improve the reliability

in placement and fit of future wearables, increasing comfort and usability of these systems and subsequently augmenting autonomous health monitoring capabilities for exploration medicine.

#### Learning Objectives

1. The audience will be able to understand the importance of repeatable electrode placement for chest-mounted electrocardiogram (ECG) monitoring, especially for astronauts on long-duration exploration missions without access to abundant medical infrastructure.
2. The audience will learn about the development and testing of the "box method" we have developed to standardize the placement of 3-lead ECG electrodes across the chest.
3. The audience will be able to brainstorm potential applications for this type of standardized electrode placement algorithm to enhance future wearable exploration medical capabilities.

#### [96] NON-INVASIVE INTRACRANIAL PRESSURE MONITORING AND ITS APPLICABILITY IN SPACEFLIGHT

Hugo Félix<sup>1</sup>, Edson Oliveira<sup>2</sup>

<sup>1</sup>Faculty of Medicine of Lisbon Medical School, Lisbon, Portugal; <sup>2</sup>Lisbon Medical School, Lisbon, Portugal

#### (Education - Tutorial / Review)

**INTRODUCTION:** Neuro-ophthalmic findings collectively defined as Spaceflight-Associated Neuro-ocular Syndrome (SANS) are one of the leading health priorities in astronauts engaging in long duration spaceflight or prolonged microgravity exposure. Though multifactorial in etiology, similarities to terrestrial idiopathic intracranial hypertension (IIH) suggest these changes may result from an increase or impairing in intracranial pressure (ICP). Finding a portable, accessible and reliable method of monitoring ICP is, therefore, crucial in long duration spaceflight. **METHODS:** A review of recent literature was conducted on the MEDLINE/PubMed database using the search terms "non-invasive intracranial pressure". Studies investigating accuracy of non-invasive and portable methods in human subjects on the past 5 years were included. The search retrieved different methods, that were subsequently grouped by approach and technique. **RESULTS:** Majority of publications included the use of ultrasound-based methods, with variable accuracies. One of which, non-invasive ICP estimation by optical nerve sheath diameter measurement (nICP\_ONSD) presented highest statistical correlation and prediction values to invasive ICP, with area under the curve (AUC) ranging from 0,75 to 0,964. One study even considers a combination of ONSD with transcranial doppler (TCD) for an even higher performance. Other methods, such as near-infrared spectroscopy (NIRS) show positive and promising results (good statistical correlation with invasive techniques when measuring cerebral perfusion pressure (CPP):  $r = 0,83$ ). **DISCUSSION:** Combination of methods, as well as recently introduced and innovative methods in the spectroscopy modality show promise in the field of non-invasive intracranial pressure monitoring. However, for its accessibility, portability and accuracy, ONSD presents itself as the up to date most reliable non-invasive ICP surrogate and a valuable space-flight asset.

#### Learning Objectives

1. The participant will be briefed on what are the main techniques of non-invasive intracranial pressure monitoring being researched at the moment.
2. The participant will be able to understand, from the methods currently available, which ones appear to be most adequate to monitor intracranial pressure in spaceflight.

#### [97] HYPERGOLIC PROPELLANT OFF-GASSING – IMPLICATIONS FOR DECONTAMINATION AND EVACUATION

Hansjorg Schwertz<sup>1</sup>, Lisa Roth<sup>2</sup>, Daniel Woodard<sup>3</sup>

<sup>1</sup>The University of Utah, Salt Lake City, UT, USA; <sup>2</sup>Wiltech, Kennedy Space Center, FL, USA; <sup>3</sup>Integrated Mission Support Services, Kennedy Space Center, FL, USA

#### (Original Research)

**INTRODUCTION:** Hypergolic propellants, dinitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>) and monomethylhydrazine (MMH), can be released in large amounts



during a launch contingency. Egressing spaceflight crew members wearing the NASA Orion Crew Survival System (OCSS) exposed to hypergolic propellants will be decontaminated with a water spray to reduce the toxic hazards of off-gassing. Nevertheless, off-gassing effects from propellant impregnated fabric could pose a risk to rescue crews.

**METHODS:** The NASA Advanced Crew Escape System II (ACES II) used during Space Shuttle Program is similar to the OCSS and was utilized in this test. A 20 cm<sup>2</sup> section of ACES II bilayer fabric (Nomex/Gore-Tex) was placed and sealed inside 5 cm permeation cells equipped with exposure and detection ports. The fabric's exterior surface was exposed to concentrated N<sub>2</sub>O<sub>4</sub> (1000 ppm) or MMH (100 ppm and 500 ppm) vapor for 1 h to saturate the suit material at a constant airflow of 28.3 L/h inside the permeation cell. A 30 s water rinse to simulate decontamination with a water deluge spray was followed by 120 min off-gassing detection in the test cell. The fabric dimensions and air flow parameters were extrapolated to simulate a 2 m<sup>2</sup> suit surface area, and transportation inside an enclosed helicopter cabin (12,472.6 L) without ventilation.

**RESULTS:** During the 120 min detection period, NO<sub>2</sub> off-gassing peaked at 0.5 ppm for a duration of 6 min, a value which does not exceed EPA acute exposure guideline level (AEG-1) 8 h level limits. For the first hour, MMH off-gassing levels did not exceed 0.09 ppm, which is below AEG-2 limits of 0.11 ppm. As the fabric dried out, an MMH off-gassing burst of 2.7 ppm was observed, a value that exceeds AEG-2 30 min level limits of 1.8 ppm.

#### Learning Objectives

1. The audience will learn about the off-gassing of hypergolic propellants from space suits.
2. The audience will learn about the health risks and mitigation in regards of off-gassing of hypergolic propellants from space suits.

#### [98] DEVELOPMENT OF COMMERCIAL SPACE OCCUPATIONAL MEDICINE HEALTH STANDARDS

Edward Powers<sup>1</sup>

<sup>1</sup>The University of Texas Medical Branch at Galveston, Galveston, TX, USA

(Original Research)

**INTRODUCTION:** Medical standards for spaceflight have been established by government space agencies. Commercial space companies will soon fly personnel who are not selected by these agencies. Selectees may have known disease for which no monitoring standards currently exist. The study reviews occupational standards for various populations working in environments analogous to spaceflight, develops occupational medicine standards for space workers and develops or determines the appropriate medical tests and medical monitoring required. Wearable medical monitoring technology is analyzed and tested in extreme conditions analogous to spaceflight. **METHODS:** Current literature regarding medical standards for populations analogous to spaceflight is reviewed. Human factors that would jeopardize participant health or mission completion / are identified and a review of appropriate monitoring and testing hardware is done. Based on the review, appropriate tests and monitoring technologies such as wearable monitors established. Monitoring procedures are established and tested under extreme conditions such as high G and hypobaric atmospheres. Collaboration with industry for portions of assessing human factors and electronic device usability includes use of the ETC/NASTAR centrifuge, sensor hardware and software assistance from Danish Aerospace Company, and a testing environment platform from Axiom Space, Inc. **RESULTS:** Data from current commercial space companies along with environments analogous to spaceflight suggests that eight to ten medical conditions are suitable for monitoring in the spaceflight environment. Monitoring technology for those specific conditions is tested under extreme conditions analogous to spaceflight including hyper G, hypobaric and microgravity conditions. **DISCUSSION:** Occupational medical standards for the population of future space workers does not exist. The results of this study will provide the commercial space industry with guidelines for the evaluation of space workers and reduce the risk of flying those individuals who would have previously been disqualified for flight. Analysis of wearable medical monitoring technology will establish a new standard for commercial spaceflight. Future work includes applying wearable technologies to astronauts or commercial space travelers when they embark on a space journey in order to further evaluate medical monitoring capability in the space environment.

#### Learning Objectives

1. The participant will be able to understand the importance of establishing new health standards for the spaceflight environment based on acceptance of known disease.
2. The participant will know which known diseases can be monitored in the spaceflight environment and how monitoring technology is utilized.

**TUESDAY, AUGUST 31, 2021**

**Tuesday, 08/31/2021**

**8:30 AM**

**Grand Ballroom**

**7<sup>TH</sup> ANNUAL REINARTZ LECTURE**

**Dr. Anthony Wagstaff**

**"The Feedback Loop of Aerospace Medicine and Human Performance"**

**Tuesday, 08/31/2021**

**10:30 AM**

**Governor's Square 14**

#### [S-21]: PANEL: LESSONS LEARNED AND INNOVATIONS FOR ENHANCING HUMAN SYSTEMS INTEGRATION

*Sponsored by Life Sciences and Biomedical Engineering Branch of AsMA*

**Chair: Dwight Holland**

**Co-Chair: Carlos Salicrup**

**Co-Chair: Estrella Forster**

**PANEL OVERVIEW:** This educational panel explores different approaches, lessons learned or not learned (?), and innovative approaches for enhancing human performance through better Human Systems Integration (HSI) while exploring the earth, skies, and space. The emphasis will be on some classic major areas in Human Performance and Human Systems Integration such as example the challenges, strengths and weaknesses of subjective Flying Quality and Mental Workload Assessment, etc. scales used widely in Aerospace Systems evaluation. And, a presentation on the recent 737Max mishap talk given by a 737Max pilot-physician and team. In this diverse session, we also have presentations of newer technologies and opportunities in wearable computers, Virtual/Augmented Reality for better HSI integration and Situation Awareness, and a look at new cutting-edge technologies in Life Sciences to see how changes in metabolomics might occur with longer space flights. Of course, the problem of fatigue seems to always to appear sooner or later in sustained operations, and we examine so aspects of that as well in the context of optimal overall systems design. This panel is dedicated to the memory of Virginia Tech Norton Professor Emeritus and Transportation Institute Associate Director Walter W. Wierwille, Ph.D. who passed away in late October 2020 as this panel was being developed and relating to areas he made direct major contributions to with regard to Human Factors in Aerospace Systems as a researcher, professor, and mentor.

#### [99] COOPER-HARPER HANDLING QUALITIES AND OTHER KEY SUBJECTIVE RATING SCALES

David Mitchell<sup>1</sup>, Christopher Cotting<sup>1</sup>, Dwight Holland<sup>2</sup>

<sup>1</sup>US Air Force Test Pilot School, Edwards, CA, USA; <sup>2</sup>Human Systems Integration Associates, Roanoke, VA, USA

(Education - Program / Process Review)

**BACKGROUND:** Handling qualities are "those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role" (Ref. Cooper & Harper, 1969). They encompass aspects of every element of the aircraft design and response, from pilot-vehicle interface to dynamic response, and can be influenced by complicating factors such as outside