

## MONDAY, MAY 18, 2020

**Monday, 05/18/2020**

**8:00 AM**

**CENTENNIAL BALLROOM II/III/IV  
OPENING CEREMONIES &  
66<sup>TH</sup> ANNUAL LOUIS H. BAUER LECTURE  
Daniel Kraft, M.D.**

**“THE FUTURE OF HEALTH & MEDICINE: WHERE  
CAN TECHNOLOGY TAKE US?”**

**Monday, 05/18/2020**

**10:30 AM**

**Centennial I**

**[S-5]: PANEL: OPTIMIZING PERSONNEL  
SELECTION IN THE AVIATION ENVIRONMENT:  
TECHNIQUES, METHODS, AND CONSIDERATIONS**

**Chair: Tatana Olson**

**PANEL OVERVIEW:** In the high stakes environment of military and civil aviation, an effective personnel selection program is critical to ensuring individuals possess the knowledge, skills, abilities, and other characteristics necessary for successful job performance. However, it is not always clear what factors to consider when designing and implementing a selection program. This panel includes five presentations discussing techniques, methodological considerations, and best practices for the assessment and selection of naval aviators, unmanned aircraft system (UAS) operators, and civilian air traffic controllers. The first presentation from the Naval Aerospace Medical Institute (NAMI) provides an overview of the Aviation Selection Test Battery (ASTB), the primary tool used to select naval aviation candidates for the Navy, Marine Corps, and Coast Guard. The second and third presentations discuss the purpose, design, and advantages of using computer adaptive testing and approaches for mitigating adverse impact within the context of pilot selection. The panel concludes with presentations on the development and validation of a selection test for UAS operators from the Naval Medical Research Unit-Dayton, and a discussion from the Federal Aviation Administration (FAA) of the unique features and challenges associated with the selection of air traffic controllers.

**[11] COMPUTER ADAPTIVE TEST DESIGN IN NAVAL AVIATION  
SELECTION TESTING**

Henry Phillips<sup>1</sup>

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

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Computer-adaptive testing (CAT) formats have existed for over 70 years and are used widely in high-stakes testing applications (Embretson & Reese, 2002). Advantages of CAT over static test design include individualized test construction, improved test security, shorter test duration, and improved score accuracy. **OVERVIEW:** Statistical assumptions underlying CAT ensure that scores on tests comprised of different items are still comparable. CAT design requires large amounts of data, and delivery requires management of a large item library or libraries. **DISCUSSION:** This presentation will describe the purpose, design, and advantages of the use of CAT on multiple-choice assessments included in the Aviation Selection Test Battery (ASTB), the tool used to select candidates for naval aviation training. Discussion will also include a short explanation of fundamental assumptions underlying classical test theory and item response theory, the 3 parameter logistic (3PL) model of response prediction, the expected a priori method of test score (theta) estimation, a short explanation of differential item functioning and differential test functioning estimation, and a brief discussion of model fit calculations.

**Learning Objectives**

1. Understand the general process by which test items are selected for inclusion in a computer-adaptive test.
2. Understand the advantages yielded by computer-adaptive testing over static form testing.

**[12] DEVELOPMENT AND VALIDATION OF THE SELECTION  
FOR UNMANNED AERIAL SYSTEMS (UAS) PERSONNEL  
(SUPER)**

Tatana Olson<sup>1</sup>

<sup>1</sup>Naval Medical Research Unit Dayton, Dayton, OH, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** In 2013, the Office of Naval Research funded a program titled UAS Interface, Selection, and Training Technologies (UASISTT), one of the goals of which was development of a selection battery for UAS Operators of Group 3, 4, and 5 platforms. This battery was developed by Georgia Tech with support from the Naval Medical Research Unit – Dayton (NAMRU-D), Naval Aerospace Medical Institute (NAMI), Naval Air Systems Command (NAVAIR), Air Force Research Laboratory (AFRL), and Air Force Personnel Center (AFPC) over a five year period, delivered in 2018. **OVERVIEW:** The battery was originally comprised of 15 subtests based on a mission-task analysis, and criterion-validated against performance on a UAS simulation designed for this purpose among a sample of Georgia Tech students. Construct and additional criterion-related validation was conducted using additional samples at Ft. Huachuca (Enlisted N = 38), NAS Pensacola (Officers N = 237), Naval Special Warfare Coronado (Enlisted N = 28), Springfield Air National Guard (N = 4), and Randolph Air Force Base (Officers N = 219). Although field training performance and attrition data were limited, preliminary validation data were collected in a laboratory setting using a realistic UAS simulator. **DISCUSSION:** A reduced version of the battery was delivered using a secure web-based test delivery platform called APEX, and consists of seven subtests, including: Paragraph Completion, Spatial Orientation, Following Directions, Memory for Landmarks, Dial Reading, Necessary Facts/Word Problem Solving, and Traffic Navigation. Additional data collection is planned to establish platform-specific criterion-related validity evidence and recommended cut scores for operators of the MQ-25 Stingray, MQ-4 Triton, and MQ-8 Firescout. Validation work to date has not incorporated any Navy UAS training data.

**Learning Objectives**

1. Understand why an Unmanned Aerial System Operator selection battery is needed.
2. Understand which aptitudes are assessed by the Selection for Unmanned Aerial Systems (UAS) Personnel (SUPER) instrument and why they matter.

**[13] PERSONNEL SELECTION FOR AIR TRAFFIC CONTROLLERS:  
A SPECIALIZED APPROACH**

Kelley Krokos<sup>1</sup>, David Hamill<sup>2</sup>

<sup>1</sup>North Carolina State University, Raleigh, NC, USA; <sup>2</sup>University of Baltimore, Baltimore, MD, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Each day, thousands of aviation professionals manage the National Airspace System (NAS) to ensure that aircraft navigate their cargo and passengers to their destinations safely and efficiently. Among these professionals are more than 15,000 air traffic controllers. Given that it can take years of training to achieve certified professional controller (CPC) status, and given the safety critical nature of the controller job, the FAA devotes significant resources to its controller selection program. An FAA panelist will describe the program's history and some of its unique features. **OVERVIEW:** The FAA's controller selection program consists of numerous steps in a multiple hurdle approach. Applicants begin their journey by submitting their application, followed by minimum qualification screening. Next, applicants must pass a pre-employment selection test battery, a structured interview, and—after receiving a conditional offer of employment—must pass a medical examination prior to reporting for basic training. In support of the development and validation of these steps, the FAA routinely conducts job analyses to ensure that selection procedures accurately reflect job

requirements and replaces its selection procedures and instruments as needed. Experienced job analysts, technical subject matter experts, managers, and labor representatives contribute. Legal requirements and professional standards guide every decision. **DISCUSSION:** The FAA's selection program requires specialized approaches. Aviation is a high-risk industry that is closely tied into the nation's security and its economy; it is closely scrutinized. We must respect the public trust that has been placed in us. The controller job is a single occupational series, but it is performed in three different facility types. Differences and similarities by facility type must be considered. The FAA is the only non-military employer; a significant portion of our controller applicant pool has no air traffic control knowledge or skill. Consequently, our selection procedures must be based primarily on abilities and other non-technical worker characteristics. The NAS is constantly evolving; the controller job must be evaluated on an ongoing basis to determine whether it has also changed and modifications made accordingly. The FAA panelist will highlight some of these special features.

#### Learning Objective

1. Identify situational characteristics that influence how a personnel selection system can and should be designed and implemented.

### [14] MITIGATING ADVERSE IMPACT IN SELECTION TESTING BY INCORPORATING NEW CONSTRUCT ASSESSMENTS IN THE PERFORMANCE-BASED MEASURES (PBM)

Brennan Cox<sup>1</sup>

<sup>1</sup>Naval Postgraduate School, Monterey, CA, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** The Uniform Guidelines on Employee Selection define adverse impact as a condition in which the selection ratio for a protected group making up 2% or more of the applicant population is less than 80% of the selection ratio of the majority group. The existence of adverse impact in itself is not evidence of unfairness, but does require demonstration of criterion-related validity evidence for selection tools used in the private sector. **OVERVIEW:** The US Navy carefully monitors the levels of adverse impact present in its selection tools. This presentation will discuss the degree of adverse impact observed in selection ratios yielded for different groups by scores on the Aviation Selection Test Battery (ASTB), the tool used to select candidates for naval aviation training. **DISCUSSION:** Discussion will address how the incorporation of a series of performance-based measures (PBM) in 2013 assessing audio information processing, psychomotor skills, divided attention, spatial ability, and response under stress changed the selection ratio differences between majority and minority applicants in some groups, and reasons for those observed changes. Discussion will conclude with a consideration of alternatives to optimized Ordinary Least Squares (OLS) regression weighting schemes that can yield similar multiple R estimates for the prediction of training outcomes but less adverse impact after cross-validation.

#### Learning Objectives

1. Understand the process by which adverse impact estimates are calculated.
2. Understand the implications of the existence of adverse impact on a selection instrument.

### [15] IDENTIFYING THE MOST QUALIFIED CANDIDATES FOR NAVAL AVIATION TRAINING: THE AVIATION SELECTION TEST BATTERY (ASTB)

Ken King<sup>1</sup>

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

(Education - Program / Process Review Proposal)

**BACKGROUND:** The Aviation Selection Test Battery (ASTB) is the selection instrument used to identify candidates eligible for Naval aviation training as student naval aviators and student naval flight officers in the Navy, Marine Corps, and Coast Guard. **OVERVIEW:** The ASTB is comprised of six sections, including math skills, reading comprehension, mechanical comprehension, aviation and nautical information, a forced-choice adaptive personality assessment, and a performance based measures (PBM) battery assessing audio information processing, psychomotor skills, divided attention, spatial ability,

and response under stress. These sections yield score components designed to predict academic performance, primary phase flight performance, and training attrition. The ASTB score components exhibit uncorrected criterion-related validity coefficients for the prediction of continuous academic and flight training criterion variables between  $r = 0.30$  and  $0.52$ , and components of the ASTB exhibit biserial correlations with training completion as high as  $r_b = .23$ . **DISCUSSION:** Evidence of the incremental contributions of ASTB sections to multiple R will be reviewed. Finally, the presentation will outline the process by which utility estimates of \$52M/FY in training cost avoidance yielded by the ASTB are calculated. Discussion will also include a summary of the secure web-based test delivery APEX system used to administer and manage the battery.

#### Learning Objectives

1. Understand the process by which cost avoidance estimates for use of the Aviation Selection Test Battery are derived.
2. Understand the degree of predictive validity yielded by the Aviation Selection Test Battery for the prediction of naval aviation training outcomes.

Monday, 05/18/2020

Centennial II

10:30 AM

### [S-6]: SLIDE: VISION SPECTRUM

Chair: Harriet Lester

Co-Chair: Douglas Ivan

### [16] THE HISTORY OF USAF VISION STANDARDS: BACK TO THE FUTURE? – PART IV

Douglas Ivan<sup>1</sup>, Adrien Ivan<sup>2</sup>, Thomas Tredici<sup>3</sup>

<sup>1</sup>ADI Consultants, San Antonio, TX, USA; <sup>2</sup>Vernon College, Wichita Falls, TX, USA; <sup>3</sup>University of Texas Health Sciences Center, San Antonio, TX, USA

(Education - Program / Process Review Proposal)

The fourth installment in this series tracing the historical origins of USAF aircrew vision standards will build on the aeromedical lessons learned during World Wars I and II. The USA (US) and its Allies encountered a number of aeromedical and visual challenges during the war as the operational capabilities of military aircraft expanded rapidly and physiological stressors intensified. In addition, the US struggled with the overwhelming number of individuals being processed for war, making the concept of mass medical screenings a significant challenge given what became obvious disconnects between military vision requirements and existing clinical testing capabilities. At the request of the Army and Navy, the US government created the *Army-Navy-National Research Council (NRC) Vision Committee* to address pre-eminent vision problems needing immediate resolution that emerged during the war, as well as for inevitable future military mobilizations, given emergent developments on the Korean Peninsula. Following creation of the *USA Air Force (USAF)* in 1947, the committee was renamed the *Armed Forces-NRC Vision Committee*. The committee became the epicenter for development and testing of military aircrew vision products, selection standards, and vision testing devices from 1944-1973. Among its most enduring accomplishments were: standardized visual acuity letters and testing charts, the *Armed Forces Vision Test Apparatus (AFVTA)* with its multiple vision function test slides, and standardized tri-service color vision (CV) testing, including development of a new pseudo-isochromatic plate (PIP) CV screening test and secondary test lanterns, such as the Navy's *Farnsworth Lantern (FALANT)* and *Color Threshold Test (CTT)*. Additionally, during this period, the USAF developed a new military spectacle frame (HGU-4/p) and sunglass lenses that eventually became the *Department of Defense (DoD)* standard for US aircrew spectacle eyewear. This presentation will highlight the key historical developments from the end of WWII through 1980 that were instrumental in defining aeromedical vision and standards from that period, many of which are still used today.

**Learning Objectives**

1. The audience will learn about the origins of USAF aircrew vision standards and the history of aeromedical vision screening devices still used today.
2. The audience will learn about.

**[17] THE EFFECTS OF THE AEROSPACE ENVIRONMENT ON THE VISION OF THE AVIATOR**Ramon Yambo-Arias<sup>1</sup><sup>1</sup>USA Air Force, USAF ACADEMY, CO, USA*(Education - Tutorial Proposal)*

**TOPIC:** To prevent vision-related problems and mishaps in flight, it is important to understand the effects of the aerospace environment on the vision of aviator. Vision is of utmost importance to aviators. Among other things, vision is required to properly land the aircraft and to avoid impact with other airborne objects. This is why aviators must have good visual acuity, color vision, depth perception, and night vision. However, the aerospace environment presents many factors that can negatively affect vision. These factors include: hypoxia, rapid decompression, low lighting, empty field, acceleration, and vibration. Aircrew vision devices (e.g., night vision goggles) meant to improve vision during flight can degrade certain aspects of vision. **APPLICATIONS:** The above factors will be discussed in this lecture. The goal is to educate the audience to identify potential cases where the aviator's vision may be compromised thus allowing the flight surgeon to implement countermeasures. **RESOURCES:** Tredici JT, Ivan DJ. "Chapter 14: Ophthalmology in Aerospace Medicine," in *Fundamentals of Aerospace Medicine*, 4th edition, ed. Jeffrey R. Davis, Robert Johnson, Jan Stepanek, and Jennifer A. Fogarty (Philadelphia: Lippincott Williams & Wilkins, 2008), 349-379.

**Learning Objectives**

1. The audience will understand the refractive power of the globe and what areas of the globe are susceptible to a change in refraction either because of hypoxia or corneal refractive surgery.
2. The audience will understand what portion of the electromagnetic spectrum the eye is most sensitive to and the acuity of the cones and the rods in varying intensities of illumination.
3. The audience will understand the difference between stereopsis and depth perception, and they will understand how night vision goggles affect depth perception.

**[18] UNDERSTANDING THE FACTORS CONTRIBUTING TO SPATIAL DISORIENTATION IN UK MILITARY AVIATION: ANALYSIS OF INCIDENTS 2014-2018**Tracy Grimshaw<sup>1</sup>, Jonathan Boyd<sup>2</sup><sup>1</sup>QinetiQ Ltd, Farnborough, United Kingdom; <sup>2</sup>QinetiQ Ltd, Farnborough, United Kingdom*(Original Research)*

**INTRODUCTION:** Accident data shows that spatial disorientation (SD) continues to present a risk to flight safety for UK military aircrew. To understand the factors that contribute to SD and develop mitigation strategies, the Disorientation Incident Survey (DIS) has previously collected anonymous military aircrew reports of in-flight disorientation from 2004-2014. The aim of the current work was to extend the data collection to 2018. This paper presents results from this latest survey and also of the analysis of over 550 SD incidents collected since 2004. **METHODS:** The DIS asks aircrew to describe occasions in flight when they either became confused about their aircraft attitude or position or they suddenly realized that the attitude or position of their aircraft had changed. Aircrew also rated the risk to flight safety of each incident. Independently, SD experts analyzed the incident descriptions to establish the factors that contributed to the incident and whether the SD was recognized or unrecognized (i.e. the aircraft had significantly departed from its intended attitude or position). **RESULTS:** Ninety-two SD incidents were reported across 2014-18. Incidents reflected changes in operational focus, new aircraft and new aircraft systems compared to the last survey period. The rate of SD incidents against flying hours

remained at a similar level across the two survey periods; approximately 1.4 incidents per 10,000 flying hours. Logistic regression analysis of the whole data set (over 550 incidents) found several significant results ( $p < 0.01$ ): for fast jet aircraft, combat maneuvers, in-cockpit distraction and lack of pilot experience all increased the probability that the SD incident was unrecognized by the pilot; for rotary wing aircraft poor crew coordination, deck take-off, cloud and brownout all increased the risk to flight safety of the incident. Cluster analysis indicated that distraction was commonly associated with unrecognized disorientation. **DISCUSSION:** Many incidents involved visual misperceptions, and certain maneuvers were more likely to lead to disorientation, for example air-to-air refueling for fast jet, and landing (including deck landing) for rotary wing. Analysis of all disorientation incidents collected since 2004 found that distraction, either in-cockpit or external to the aircraft, increased the likelihood of the aircraft departing significantly from its intended attitude or position during a disorientation incident.

**Learning Objective**

1. The audience will learn about the factors involved in spatial disorientation, based on aircrew incident descriptions.

**[19] DESCRIPTIVE ANALYSIS OF IN-FLIGHT ILLUSIONS IN YOUNG FIGHTER PILOTS**Kwo-Tsao Chiang<sup>1</sup>, Chung-Yu Lai<sup>1</sup>, Chun-Ming Lin<sup>2</sup>, Tzu-Han Yang<sup>3</sup><sup>1</sup>Kaohsiung Armed Force General Hospital Gangshan Branch, Taiwan, ROC, Kaohsiung, Taiwan; <sup>2</sup>The 5th Tactical Fighter Wing of ROCAF, Taiwan, ROC, Hualien, Taiwan; <sup>3</sup>The 2nd Tactical Fighter Wing of ROCAF, Taiwan, ROC, Hsinchu, Taiwan*(Original Research)*

**INTRODUCTION:** Spatial disorientation (SD) remains a major threat to flight safety and the leading cause of Class A mishaps and fatalities in military aviation. SD has contributed to 12–33% of Class A mishaps in U.S. military aviation, with near 100% fatality rate. However, there were few investigations in young fighter pilot group about their experience of in-flight illusions. We try to figure out their prevalence of in-flight illusions and how they cope with the condition. **METHODS:** This is a cross-sectional study conducted between July 2018 to June 2019. Young fighter pilots who had just completed basic jet fighter training voluntarily participated in the study. An open-ended questionnaire was used to investigate their experience of in-flight illusions and how they cope with it. SPSS 22.0 software was applied for entry, storage, and analysis of data. **RESULTS:** All of the 60 distributed questionnaires were valid (completion rate was 100%). Subjects were all male pilots and the mean age was 24 years old. The mean flight time was 180 hours with about 100 hours in jet-trainer. In-flight illusions were experienced by 68.3% (N=41) of participants, with 75.6% and 61.0% of the illusions occurred in cloudy/night circumstances and under degraded visibility conditions, respectively. Most illusions were vestibular in nature, with 65.9% of respondents experienced the leans. Only 9.8% of the illusions were visual illusions. The majority (68.3%) of respondents recovered from SD by trusting their instruments. With regards to the disappearance of false sensation, only 31.7% were by continuously using instruments, majority (63.4%) of them needed regaining visual reference to get correct orientation. **DISCUSSION:** In this study, we found that in young fighter pilots, the most common illusion was the leans and that visual illusions were relatively rare. Although most young fighter pilots can recover from SD by relying on instrument, but regaining visual reference is needed for the false sensations to disappear. We will extend this investigation to senior experienced pilots to explore the incidence of in-flight SD and coping strategies.

**Learning Objectives**

1. In this study, we found that in young fighter pilots, the most common illusion was the leans and that visual illusions were relatively rare.
2. Although most young fighter pilots can recover from SD by relying on instrument, but regaining visual reference is needed for the false sensations to disappear.



## [20] COMPARATIVE OF CLINICAL EFFECT OF ZENGSHINENG SOFTWARE AND PEN NIB TRAINING FOR THE ABILITY TO CORRECT SMALL DEGREE OF CONCOMITANT EXOTROPIA OF PILOTS

Mingyue Zhang<sup>1</sup>

<sup>1</sup>Civil Aviation General Hospital, Beijing, China

(Original Research)

**OBJECTIVE:** To compare and study the clinical effects of Zengshineng training software and pen nib training for the ability to correct the small degree of concomitant exotropia of the pilots. **METHODS:** 40 cases of pilots who has been diagnosed concomitant exotropia checked the range of fusion in the same Synoptophore. The 40 patients with concomitant exotropia were randomly divided into Zengshineng training group (n = 20) and pen nib training group (n = 20), and were underwent the fusion training. In the Zengshineng training group were taken the intelligent training system for the subject of the convergence function training, 3 times a day, every 10 minutes; While in the pen nib training group were taken the pen nib training for 3 times, every 30 times. Then, the range of fusion for 1 month, 3 months and 6 months were checked by the same Synoptophore, and each group were compared. **RESULTS:** In the Zengshineng training group: the range of convergence for 1 month, 3 months and 6 months were significantly improved than that before the correction (P<0.05). In the pen nib training group: The convergence range for 1 month were not significantly improved before correction (P>0.05), and the 3 months and 6 months were significantly improved before correction (P<0.05). Compared with each groups: the range of convergence for 1 month, 3 months and 6 months in the Zengshineng training group were significantly higher than those of the pen nib training group (P<0.05). **CONCLUSION:** The clinical effects of Zengshineng training software and pen nib training for the ability to correct the small degree of concomitant exotropia are exact, and the Zengshineng software of ability to correct collection is more faster and efficient than that the pen nib training.

### Learning Objective

1. The audience will be able to learn a new treatment- Zengshineng training software, whose ability to correct the small degree of concomitant exotropia of the pilots is more faster and efficient than that the pen nib training.

## [21] 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>Armed Forces Aeromedical Centre, Dhahran, Saudi Arabia

(Education - Case Study: Clinical / Human Performance)

**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 ophthalmolo-

gist 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.

Monday, 05/18/2020

Centennial III

10:30 AM

## [S-7]: PANEL: INNOVATIONS IN AEROSPACE MEDICINE EDUCATION

Chair: Quinn Dufurrena

Co-Chair: Dana Levin

**PANEL OVERVIEW: BACKGROUND:** The field of aerospace medicine continues to grow rapidly, and with exciting changes such as the expansion of the commercial space industry, there is an ever-increasing need for effective education. As this growth in aerospace medicine is occurring, the landscape of medical education, and education in general is changing. Advances in technology and media have ushered in an era of high-fidelity simulation accessible to the general population and self-directed learning in the form of podcasts, online videos and social media-based tutorials. Likewise, interdisciplinary collaboration has become increasingly recognized as essential in order to develop solutions to the problems that arise in complex systems and processes like aerospace medicine. Fortunately, Aerospace Medicine has no shortage of innovators in every aspect of the field, including education. This panel aims to highlight some of the creative methods of education and outreach being pioneered by them. **OVERVIEW:** The panel will start with the Exploration Medicine Podcast, an online community taking advantage of the unprecedented reach and customizability of internet-based education. This will be followed by an overview of a new Aerospace and Extreme Medicine opportunity recently launched for medical students. The third presentation will describe the efforts of NASA's Exploration Medicine Capability Element to involve students and residents in the complex interdisciplinary work advancing medical capabilities in space. The following presentation will discuss the development of a unique long-form simulation course at the University of Colorado that teaches the application of engineering approaches to the challenges of space medicine. The final presentation will describe an interdisciplinary research program at Duke University in which engineers and medical professionals utilize an interdisciplinary approach to solve real-world problems in the field of aerospace medicine. **DISCUSSION:** Included presentations in the panel exemplify ways in which educators are developing innovative programs to broaden the experience base of members of the aerospace medicine community in order to address the complex and multi-faceted challenges that the field encounters.

## [22] CREATION OF A DIGITAL COMMUNITY FOR INFORMAL, ON-DEMAND EDUCATION IN AEROSPACE AND EXPLORATION MEDICINE

Jeremy Sieker<sup>1</sup>, Dana Levin<sup>2</sup>, Quinn Duferrena<sup>3</sup>, Sultana Peffley<sup>4</sup>, Emily Stratton<sup>5</sup>

<sup>1</sup>UCSD, San Diego, CA, USA; <sup>2</sup>Columbia University, New York, NY, USA;

<sup>3</sup>SUNY Stonybrook, Stonybrook, NY, USA; <sup>4</sup>University of Tucson,

Tucson, AZ, USA; <sup>5</sup>SUNY Syracuse, Syracuse, NY, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Aerospace and exploration medicine are fascinating topics. However, the complexity of the fields, interdisciplinary nature, and the relatively small number of experts leave few options for either formal or informal education. Additionally, modern students seek flexible, on demand educational products where involvement can be titrated to their level of interest. **OVERVIEW:** To address the broad range of preprofessional, post professional, and amateur interest in aerospace and exploration medicine education, we created Explorationmedicine.com. It is as an online community centered around short podcast episodes, online discussion forums, and downloadable educational products. The community takes advantage of the unprecedented accessibility and customizability of internet based education to supplement formal training, provide an informal information source, and introduce aerospace and exploration medicine for unfamiliar with the field. **DISCUSSION:** The episodes and website explorationmedicine.com are routinely accessed by 100s of people each month from more than a dozen countries, on 6 continents. Since it started in 2017, it has served to stimulate discussion, increase awareness of the aerospace and exploration medicine, and has had more than 15 individuals contribute content, ranging from students to residents to professionals practicing aerospace and exploration medicine around the world.

### Learning Objective

1. The participant will be able to understand the importance of asynchronous, self directed learning in aerospace medicine.

## [23] INTEGRATING MEDICAL TRAINEES WITH INTERDISCIPLINARY RESEARCH AND DESIGN TEAMS FOR EXPLORATION MEDICAL CARE

Dana Levin<sup>1</sup>, Ben Easter<sup>1</sup>, Melinda Hailey<sup>2</sup>, Kris Lehnhardt<sup>1</sup>

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

(Education - Program / Process Review Proposal)

**BACKGROUND:** NASA's Exploration Medical Capability Element (ExMC) has four main goals. These are to determine the medical conditions likely to occur on long duration space missions, define the associated risk, determine the medical system to reduce the risk, and work within the spacecraft design and crew constraints to build the optimum medical system for overall mission risk. These goals require integrating the subject matter and clinical expertise of physicians, pharmacy workers, and nurses with the technical knowledge of engineers, software designers, mission planners, statisticians, and others. This entails substantial translation between technical languages and defines new processes to address the hybrid workflow and unanswered questions of The Element. **OVERVIEW:** Traditional medical education is not sufficient to prepare physicians to work in this environment so The Element has established a trainee rotation. The rotation pairs students with a mentor and assigns them interdisciplinary projects combining medicine with subject areas like engineering, pharmacology, statistics, radiation physics, and human factors design. Student lead projects have included tracing conditions to capabilities within a systems engineering model, performing systematic reviews, designing processes and protocols for identifying medical conditions requiring risk mitigation, performing volumetric assessments of procedures, designing medical workstations, and building a database of spaceflight environmental effects on medications. Trainees receive an orientation email, and a sign-out from previous trainees or from their mentor. This also includes a schedule of meetings to attend, and resources pertinent to the trainees' project. Students work with their mentor and other members of the project team to complete their portion of the project and develop a presentation of their work for relevant stakeholders. Since ExMC

resources and personnel are located all over the USA the schedule and location of the rotation are flexible. **DISCUSSION:** Students are often able to work remotely and take advantage of their home institution resources while learning about space medicine and advancing NASA's goals. This work exposes the students to the unique challenges of cross-discipline research and development, enhances ExMC productivity/preparedness for internal deadlines, and helps ensure adequate training for the next generation of space medicine workers.

### Learning Objectives

1. Understand the cross-disciplinary challenges of developing exploration medical systems.
2. Understand how trainee rotations have been adapted to address the cross-disciplinary challenges of developing exploration medical systems.

## [24] ENGINEER, PHYSICIAN, AND LIFE SCIENTIST INTER-PROFESSIONAL TRAINING AND COLLABORATION

Daniel Buckland<sup>1</sup>

<sup>1</sup>Duke University, Durham, NC, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Physicians, engineers and life scientists analyze problems in different ways. This difference likely starts in training in medical school/residency vs. engineering school/apprenticeship. Furthermore, it is exacerbated and institutionalized in differing cultural practices and approaches to risk and failure. The presentation will explain these differences. **OVERVIEW:** Describes differences the education, training, practice, and approach to failure in physicians, engineers, and scientists. **DISCUSSION:** Differences in the thought processes of Physicians and Engineers underlie many difficulties in the practice of Aerospace Medicine, learning about how the "other side" learns can contribute to improved teamwork in Physician/Engineer teams and supports all aspects of Aerospace Medicine. This will be followed by discussion of a university research group that uses these lessons to utilize the complementary strengths of the training of Physician and Engineer team members.

### Learning Objective

1. The participant will be able to understand the training differences between physicians, engineers, and life scientists.

## [25] ENGINEERING AND MEDICAL COLLABORATION FOR EDUCATION IN HUMAN SPACEFLIGHT: THE UNIVERSITY OF COLORADO MEDICINE IN SPACE AND SURFACE ENVIRONMENTS COURSE

Benjamin Easter<sup>1</sup>, Allison Anderson<sup>2</sup>, Dana Levin<sup>3</sup>, James Kurrle<sup>4</sup>, Arian Anderson<sup>1</sup>, Richard Cole<sup>5</sup>, John Lemery<sup>1</sup>

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Medical Center, New York, NY, USA; <sup>4</sup>University of Notre Dame,

Sydney, Australia; <sup>5</sup>University of Texas Medical Branch, Galveston, TX, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Advancing human spaceflight requires sophisticated, interdisciplinary collaboration among healthcare practitioners, human health and performance experts, and the engineers who design the systems and devices used for medical care delivery. Maintaining astronaut health and safety in extreme, exploration environments necessitates unique training, preparation, technology, and advanced medical care. To address these challenges, the University of Colorado Departments of Aerospace Engineering and Emergency Medicine pioneered a course for undergraduate and graduate students called Medicine in Space and Surface Environments (MiSSE). The course begins with traditional didactics, but concludes with a weeklong immersive field simulation conducted at an analogue Martian Habitat in the remote desert environment. This allows participants to learn the challenges conceptually and then experience them first-hand when providing medical care in simulation. **OVERVIEW:** MiSSE focuses on several primary objectives. First, participants receive didactic education on aerospace and extreme environmental

medicine (e.g. dysbarisms and toxicology), and learn basic hands-on skills, such as primary assessment, Wilderness First Aid, and CPR. Second, students then apply this conceptual knowledge to an operational environment with simulated EVAs. During each EVA, a medical scenario arises that they must address using the didactic training as well as operational skills, such as effective radio communications, task prioritization, group dynamics, and situational awareness. Third, students apply engineering solutions to address the challenges of remote, operational medicine. They identify a conceptual need, assume the role of an engineering design team, and work to design devices under mass, power, and volume constraints. This helps them to better understand the unique requirements that human physiology and medicine pose for their systems. Past projects have included a rocket delivery system with an environmentally-controlled payload for medical supplies and a wireless physiological monitoring interface for EVA field teams. **DISCUSSION:** Tackling the challenges of spaceflight to maximize human health and performance requires significant input and collaboration between engineers and physicians. The MiSSE has successfully brought these fields and associated experts together, and is helping to train the next-generation of experts to think and work in multidisciplinary fashion.

#### Learning Objectives

1. The participant will be able to describe the benefits of medicine-engineering collaboration for medical system and device design.
2. The participant will be able to describe novel educational methods for advancing human spaceflight.

#### [26] INTRODUCING AEROSPACE AND EXTREME MEDICINE INTO MEDICAL STUDENT AND RESIDENT EDUCATION

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

<sup>1</sup>Kinetic, Galveston, TX, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Over the past several decades, adventure travel has increased substantially. With more adventure travelers, there is an increasing need for healthcare providers to understand how to prevent and treat diseases and injuries in atypical and austere environments. While there are some medical schools offering medical student education in wilderness and outdoor medicine, medical student education in Aerospace Medicine is extremely uncommon. We created a novel approach to combine aerospace medicine and extreme medicine into a two-week medical student "mini-mester". In addition, we transformed a resident's Masters in Public Health capstone project into a classroom and webcast platform for a recurring Introduction to Aerospace Medicine lecture series. **OVERVIEW:** The "Introduction to Extreme Medicine" mini-mester combined lectures in marine and diving medicine, polar, mountain and desert medicine, and aviation and space medicine lectures with hands-on laboratory experience diving, climbing and sailing. Lectures and lab experiences were reinforced with practical exercises applying knowledge from the range of topics discussed. The online introductory Aerospace Medicine lecture series has begun and is in the process of being modified and formalized for permanent posting online. **DISCUSSION:** Seventeen medical students participated in the mini-mester. Their feedback was overwhelmingly positive. Students spontaneously reported feeling challenged, energized and attaining higher levels of learning than in traditional classroom-based learning opportunities. Feedback from the introductory Aerospace Medicine lecture series was also positive. Inspiring students and residents to explore careers in Aerospace and Extreme Medicine through nontraditional innovative means is an important part of medical education. Having a cohort of medical professionals aware of operationally-focused careers will help ensure continued medical support for aviation, space and expedition medicine as these fields continue to expand.

#### Learning Objective

1. Participants will learn about innovative methods to introduce Aerospace and Extreme Medicine into medical student and resident education.

Monday, 05/18/2020

10:30 AM

Centennial IV

#### [S-8]: SLIDE: EXTREMES IN CARDIOVASCULAR DECISION MAKING

Chair: Gordon Landsman

Co-Chair: Carol Ramsey

#### [27] UNDERSTANDING CAD IN AIR WARRIORS: A CROSS-SECTIONAL STUDY

Srishti Tripathi<sup>1</sup>, Narinder Taneja<sup>1</sup>

<sup>1</sup>Indian Air Force, Nagpur, India

(Original Research)

**INTRODUCTION:** Cardiovascular diseases are the most significant cause of mortality. Although the risk factors of these diseases are well known, the strength of association of various factors are different. It should be noted that the working and environmental conditions of military personnel are very different from those for ordinary people and these conditions can also affect the risk factors of CAD. The following cross sectional study aims to identify the epidemiology of Coronary artery disease in one of the Commands of the Indian Air Force and identify the major risk factors in these cases and make an attempt to make a preventive strategy in the IAF. This study is restricted to one of the commands of the IAF, thus its extrapolation to the other commands.

**METHODS:** A questionnaire was formulated to be filled by all CAD cases in all the stations under the Command Headquarters. The questionnaire was filled by Medical officers using the information from the Annual Medical Exam documents and medical board proceedings at the time of onset of coronary artery disease. The questionnaires were compiled by the Command headquarters and analyzed subsequently. A total of 65 cases of CAD were a part of this cross sectional study. The following factors: Age at detection, Mode of detection, Family History, Overweight, Smoking, Alcohol Consumption History, Physical Activity, Associated co-morbidities. **RESULTS:** The mean age at time of detection is 43.6 which is 10 years earlier than found in the general population. 26 out of the 65 cases were asymptomatic and all were diagnosed during evaluation of ECG abnormality during the Annual Medical Examination. A positive association re-establishment when in concerned co morbidities like diabetes, hypertension, dyslipidemia etc. as well causative factors including alcohol intake, smoking and loss of physical activity. **DISCUSSION:** The following study gave some preliminary insight into the epidemiology of CAD in one of the commands of the IAF. The differences in the IAF and general population in India could be seen. The need to include some more intensive screening tools to be used in the most vulnerable population group (46-55). Identification of personal History and physical activity of the individual and measures in services to correct the same can be recommended.

#### Learning Objective

1. The participant will be able to understand the epidemiology of CAD in the target population. The military personnel. And how the health standards in the IAF helped in early intervention.

#### [28] GENETIC ASSESSMENT IN THE PREVENTION OF ATHEROSCLEROTIC DISEASES IN PILOTS

Denis Bron<sup>1</sup>, Thomas Syburra<sup>2</sup>, Miriam Reif<sup>1</sup>, Andres Kunz<sup>1</sup>

<sup>1</sup>Aeromedical Center, Dubendorf, Switzerland; <sup>2</sup>Lucerne Cantonal Hospital, Lucerne, Switzerland

(Original Research)

**INTRODUCTION:** Family history is a risk factor for coronary artery disease (CAD). Recent studies have identified several genetic variants associated with coronary artery disease. Some of these genetic variants are and some are not associated with classical cardiovascular risk factors and the mechanism of such associations is unclear in the medical assessment in aviation. Preventive measurements in aviation are very important. The aim of the study was to analyze the feasibility of DNA tests in CAD risk prediction algorithms. **METHODS:** During a time of 4 years,



more than 5000 routine aeromedical examinations have been reviewed retrospectively. Those with elevated total cholesterol level ( $>5.0\text{mmol/l}$ ) and with no symptoms of CAD the AGLA Risk score calculations has been applied. Pilots with an AGLA Risk Score  $\geq 7.5\%$  a genetic testing has been offered. Pilots with an AGLA Risk Score  $< 7.5\%$  but a strong family history the same offer has been made. This genetic test encompasses an analysis of the relevant genes, a determination of your genetic risk, a personalized prevention plan, a printed booklet explaining the results and prevention plan. **RESULTS:** Twenty-six subjects fulfilled the criteria to be offered a genetic testing but only four of them underwent finally this investigation. Most striking was that one pilot was an aspirin non-responder and received due to severe atherosclerosis clopidogrel. Further, each subject received a personalized risk and prevention plan. **CONCLUSION:** Our results do not allow a clear statement about the significance of genetic testing for CAD risk because of the small numbers of persons being tested so. Because the question if there is a correlation between the CAD risk prediction of genetic testing and the one by applying classical risk scores is of big interest, further studies with larger cohorts should be undertaken.

#### Learning Objectives

1. The participant will be able to understand the importance of the genetic assessment as a supportive element in the prevention of atherosclerosis.
2. Genetic testing is a in individual assessment.
3. Genetic testing could have in near future a bigger impact in the prevention of CAD.

### [29] STUDY ON THE HEALTH STATUS AND OUTCOME OF AGING PILOTS OF A JAPANESE MAJOR AIR CARRIER DURING THE 5 YEARS FROM 60 YEARS OF AGE

Kazunori Takazoe<sup>1</sup>, Hideho Gomi<sup>1</sup>

<sup>1</sup>Japan Aeromedical Research Center, Tokyo, Japan

#### (Original Research)

**INTRODUCTION:** It is a critical issue whether or not aging pilots over 60 can continue flying maintaining their health. In Japan, pilots wishing to be engaged in flight operation beyond age 60 must undergo medical examination in addition to regular aviation medical examination (additional aviation medical examination, AAME) and fulfil the criteria. The purpose of the study is to clarify health status and outcome of aging pilots. **METHODS:** Data from aging pilots from a Japanese major air carrier who had an initial AAME at age 59 or 60 at Japan Aeromedical Research Center during the 6 years from 2008 to 2013 were analyzed for 5 years from age 60 regarding occurrence of disqualifying diseases, application for and decision by Aviation Medical Review Board (AMRB), and dropouts due to medical reasons after the initial AAME. **RESULTS:** Two hundred and sixty-two aging pilots were included. There were 17 cases disqualified at the initial AAME (8 in cardiology, 8 in central nervous system (CNS), 1 in ophthalmology, 1 in otorhinolaryngology). All of them applied for AMRB for decision and 16 cases obtained conditional qualification (special issuance) with pass rate of 94.1%. The disqualified case was due to suspected spinocerebellar degeneration. Sixty one cases including 28 in cardiology, 15 in gastroenterology and 14 in ophthalmology had already been conditionally qualified by AMRB before becoming aging pilots, all of whom were again conditionally qualified at the time of initial AAME. Forty-four cases developed disqualifying conditions (including 25 in cardiology, 6 in CNS, and 6 in ophthalmology) during the 5-year period after the initial AAME. Among them, 39 cases obtained conditional qualification by AMRB (pass rate 88.6%). Disqualified cases consisted of 3 heart and 2 lung diseases. Furthermore, 29 cases gave up flying duties halfway for medical reasons including 10 in cardiology and 4 in CNS without application for AMRB. Aging pilots not able to complete the 5 years for medical reasons comprised 34 cases (13.0%). On the other hand, there were no incapacitation episodes. **DISCUSSION:** In this study, nearly 90% of aging pilots above 60 maintained their health or returned to work even if they developed some illness during their career, and they contributed to flight safety.

#### Learning Objective

1. The participant will be able to understand the health status and outcome of aging pilots in a Japanese major airline during the 5 years from age 60.

### [30] TAKOTSUBO CARDIOMYOPATHY IN A PRIVATE PILOT: A CASE REPORT

Ganesh Anbalagan<sup>1</sup>, David Fitzgerald<sup>1</sup>, Rachell Mackellar<sup>1</sup>

<sup>1</sup>Civil Aviation Safety Authority, Australia, Canberra, Australia

#### (Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes a private pilot with Takotsubo cardiomyopathy (TTC), the aeromedical implications and the approach to medical certification. **BACKGROUND:** TTC is a syndrome characterized by transient regional systolic dysfunction of the left ventricle, mimicking acute coronary syndrome, but in the absence of angiographic evidence of obstructive coronary artery disease or acute plaque rupture. **CASE PRESENTATION:** A 69-year-old male private pilot experienced some chest discomfort while he was trying to open the aircraft hangar doors. In the next few days he had two further episodes of chest discomfort that lasted for 1-2 hours. They were not associated with any other symptoms or exertion. His ECG showed an inferolateral ST elevation and left axis deviation. His Troponin was elevated. His ECGs did not evolve. His coronary angiogram showed mild to moderate coronary artery disease with no flow-limiting lesion. The left ventriculogram showed mild segmental systolic dysfunction with apical hypokinesis and ballooning and preservation of basal and lateral function. Echocardiogram findings were similar to what was noted on the ventriculogram. A follow-up resting echocardiogram and stress echocardiogram performed 3 weeks later, showed restoration of normal left ventricular systolic function with no evidence of inducible myocardial ischemia. The findings were consistent with TTC. **DISCUSSION:** Symptoms of TTC can cause subtle or overt incapacitation. Aeromedical concerns revolve around the risk of recurrence of TTC and increased risk of mortality. Current literature reports a recurrence rate of 1% to 6%, with no significant relationship between presenting features and the subsequent recurrence. Long term follow-up of patients with TTC revealed a rate of death from any cause of 5.6% per patient-year and a rate of major adverse cardiac and cerebrovascular events (MACCE) of 9.9% per patient year, with men at higher risk than women. A recent large multicenter study estimated a recurrence rate of 4% at a median follow-up of 830 days. In addition, the study demonstrated that 46% of patients have had a new stress trigger at TTC recurrence and most recurrences were common the first years after a TTC event. The case was discussed in the CASA's Complex Case Management panel and he was issued a restricted medical certificate to fly with safety pilot only and unrestricted medical certificate will be considered 12 months post recovery.

#### Learning Objective

1. The audience will learn about the aeromedical concerns of Takotsubo cardiomyopathy and approach to assessment of fitness for a Civil Aviation Medical Certificate.

### [31] SUBTLE INCAPACITATIONS WITH HEART AND LUNG PROBLEMS AND DECREASE OF MEDICAL FITNESS AMONG INDONESIAN PILOTS IN 2016-2017: A RETROSPECTIVE COHORT STUDY

Inne Yuliani<sup>1</sup>, Ferdi Avian<sup>2</sup>

<sup>1</sup>Aviation Medical Center, Jakarta, Indonesia; <sup>2</sup>Aerospace Medicine Specialty Study Program, Department Of Community Medicine, Faculty Of Medicine Universitas Indonesia (FMUI), Jakarta, Indonesia

#### (Original Research)

**BACKGROUND:** Incapacitation may well present suddenly or slowly. Subtle incapacitation causing difficulties to be identified among pilots in Indonesia. Medical fitness for pilots is pivotal in managing optimal cognitive and skill performance. Although pilots are known as healthy individuals, pilots face challenges during their careers that can result in health problems. In Indonesia, changes in the aviation industry has been rapid since the last 5 years, which could lead pilots to fatigue, lack of managerial support, social strain and job insecurity. Thus, pilots become more prone to decrease of medical conditions that compromised with flight safety. **METHODS:** A comprehensive review from numerous decreases of medical condition reports among pilots in 2016-2017 was collected from the database of medical records at Aviation Medical Center, Jakarta. Subjects were pilots who were

reported experiencing heart and lung disorders that cause them to be grounded and required for further examination or management. Data that consisted of risk factors identified from each pilot were analyzed with logistic regression. **RESULTS:** Subjects were 15 pilots who experienced decrease of medical conditions. The highest prevalence of subjects' risk factors was 86.6 % had Body Mass Index (BMI) more than 30 kg/m<sup>2</sup>, followed by 66.6% had HDL/LDL ratio > 1/4 and age above 50-year-old; 60% had prehypertension and smoking habits; 26 % had diabetes mellitus and hyperuricemia; while 40% had recurrent cardiovascular problems. Analysis study showed that pilots with prehypertensive conditions had 3.3 times higher risk to experience cardiac incapacitation and 3 times higher to experience pulmonary incapacitation compare to pilots with normal blood pressure. **DISCUSSION:** Prehypertension is a strong predictor in cardiac and lung problems. This condition is also applicable in aviation. The result indicated that it is required to elaborate comprehensive analytical studies to further investigate significant risk factors of decrease medical conditions among pilots in Indonesia.

#### Learning Objectives

1. The participant will be able to know the prevalence of risk factors that could cause decrease of medical conditions among pilots in Indonesia.
2. The participant will be able to understand the relationship of risk factors to decrease of medical conditions among pilots with heart and lung problems.

### [32] ASSOCIATION BETWEEN ANTI-G STRAINING MANEUVER EFFECTIVENESS ON THE GROUND AND CARDIAC PERFORMANCE IN THE CENTRIFUGE

Chung-Yu Lai<sup>1</sup>, Min-Yu Tu<sup>1</sup>, Hsin Chu<sup>2</sup>

<sup>1</sup>Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan; <sup>2</sup>National Defense Medical Center, Taipei City, Taiwan

#### (Original Research)

**INTRODUCTION:** Military flight cadets and aeromedical trainees must be qualified by high G endurance training. Anti-G straining maneuver (AGSM), by increase preload and enhance cardiac function, is essential to preventing pilots from G-force induced loss of consciousness (GLOC). Before centrifuge training, aviation physiology officers (APO) demonstrate correct AGSM to all trainees. Then APOs subjectively assess the validity of trainees' AGSM performance. **AIMS:** To evaluate the correlation between trainees' AGSM performance on the ground with their cardiac indices in the centrifuge. **METHODS:** This was a longitudinal study conducted between August 2018 and August 2019; participants were recruited from aeromedical personnel training program. AGSM performance is graded by 1=very poor, 2=poor, 3=average, 4=excellent, and 5=outstanding. Cardiovascular variables, including cardiac output (CO), stroke volume (SV) and heart rate (HR), were measured using noninvasive impedance cardiography (Physio-Flow® Enduro™ Manatec Biomedical, Paris, France) before and after executing AGSM during high G endurance training (gradual onset run: 0.1G/second) in a human centrifuge (Latécoère, France). Data was handled by SPSS 22.0 software. **RESULTS AND CONCLUSIONS:** A total of 22 subjects (mean age, 26.7±3.4 years) participated in this study. The mean relaxed and straining G tolerance were 5.1G and 8.8G, respectively. AGSM effectiveness was 3.8G. The proportion of subjects with AGSM scores ≤2, 3, and 4 were 27.3%, 40.9%, and 31.8%, respectively. In addition, five (22.7%) subjects experienced GLOC. The ratios of SV after and before AGSM at initial (1 to 10 seconds), second (11 to 20 seconds) and final stage (21 to 30 seconds) were 1.04, 1.01 and 0.94, respectively. The ratios of CO during initial, second and final stage were 1.09, 1.06 and 1.00, respectively. Corresponding to the same stage, the ratios of HR were 1.05, 1.05 and 1.07, respectively. When compared with the group with AGSM score under three, the ratios of SV and CO in the group with AGSM score equal to three and four were greater although not statistically significant (AGSM score ≥3 vs. <3 at SV: 1.02 vs. 0.91; CO: 1.07 vs. 0.99). From the results, we found the association between objective cardiac data and subjective AGSM performance assessed by experienced APO. In the future, we will integrate these two methods to evaluate the effectiveness of AGSM according to different training scenarios.

#### Learning Objective

1. To find the objective cardiac parameters applied to assess the AGSM efficiency.

Monday, 05/18/2020

10:30 AM

Regency 6

### [S-9]: PANEL: NO KIDDING, THERE I WAS: LESSONS FROM THE FIELD, AEROMEDICAL RESEARCH, AND PILOT-PHYSICIANS

Chair: Joe Zhang

Co-Chair: Chris Bates

**INTRODUCTION:** Panel Abstract: Multidisciplinary aeromedical research continually strives to optimize human and aircraft performance in aerospace endeavors. **BACKGROUND:** By maintaining dual qualification in both their assigned aircraft and as clinicians, civilian and military Pilot-Physicians are subject matter experts in the integration of Human and Weapon Systems performance for their respective aircraft and those with similar capabilities. They also provide a unique perspective from the inside out in regards to aviation selection processes and have intimate knowledge of current selection standards. **CASE PRESENTATION:** This panel will present case studies from both military and civilian organizations that demonstrate how pilot-physicians help identify important aviation selection and research issues. **DISCUSSION:** The presentations will demonstrate how these experiences were used to develop specific aeromedical research projects, and how results from these research efforts were used to improve operational capability, thus contributing to the body of Aerospace Medicine knowledge and Human Performance optimization.

### [33] CONTRIBUTIONS OF PILOT PHYSICIANS TO ATTACK HELICOPTER OPERATIONAL REQUIREMENTS

Ian Curry<sup>1</sup>, Steve Gaydos<sup>2</sup>

<sup>1</sup>British Army, Middle Wallop, United Kingdom; <sup>2</sup>US Army School of Aviation Medicine, Fort Rucker, AL, USA

#### (Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** The presentation will describe the application of aeromedical expertise and unique skills of pilot-physicians with respect to decisive input to enable operational success during real-world operations. **BACKGROUND:** Operation Ellamy was part of an international coalition aimed at enforcing a Libyan no-fly zone in accordance with a United Nations Security Council Resolution stipulating that necessary measures shall be taken to safeguard vulnerable civilian populations. Key to British Army contributions to this effort was a detachment of AH-64D Apache Longbow attack helicopters. **CASE PRESENTATION:** Prior to engagements a potential capability gap was assessed by the operational force regarding vulnerability to ground anti-air fires. As this made up a significant proportion of the threat, it was determined that the spectral addition provided by standard night vision goggles (ANVIS-9) to the extant aircraft imaging systems would be advantageous. The preferred solution was a novel dual-system Integrated Helmet and Display Sight System (IHADSS) over the right eye and a monocular NVG over the left. British Army pilot-physicians provided valuable aeromedical expertise and were able to test-fly the combination proposing a method of employment that was both effective and safe. This process was achieved within an extremely tight operational time window and allowed the first combat sortie to go forward on time. **DISCUSSION:** Without the unique skills of the pilot-physicians addressing operational capability the hybrid solution would not have been cleared for flight, thereby compromising the operational effectiveness of the unit and potentially risking aircraft loss.

#### Learning Objective

1. The audience will be invited to consider the difficulties inherent in the fielding of novel capabilities in a short time frame that may have flight safety implications, and the utility of dual qualified personnel.



### [34] PROCESSING AN RPA AIRCREW WAIVER BASED ON AIRCRAFT REQUIREMENTS

Joe Zhang<sup>1</sup>

<sup>1</sup>U.S. Air Force, Las Vegas, NV, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This is a case review for an initial flying class physical that identified a deficit of concrete data with regards to Remotely Piloted Aircraft (RPA) cockpit setup requirements. **BACKGROUND:** Traditionally, RPA aircrew medical standards have been based on manned aviation platforms. Only recently have separate categories have become better defined for RPA operators. The actual physical dimensions of the combat operator's work space, however, have not been examined in detail by medical standards. Taking a more accurate assessment based on combat (not just simulator) control setups would result in much more accurate medical requirements. **CASE PRESENTATION:** The subject was a 26-year-old active duty US Air Force member applying for a position as an RPA sensor operator. The member had no significant medical history other than short stature. The patient was an excellent candidate and was highly motivated for retraining. On review of the medical standards directory, the RPA sensor operator category required standard seating height and reach requirements for traditional aircrew. The RPA sensor operator controls however do not actually require use of the lower extremities to operate any controls and this was not reflected in any medical reference. A medical waiver was, however, still submitted and approved though this identified a critical lack of understanding of the actual RPA operator's working environment. This presentation will review the physical limitations of different versions of the RPA operator's operating space. **DISCUSSION:** This case highlights the difficulties of maintaining an accurate assessment of the ever-changing combat environment our RPA operators encounter on a regular basis. This process is further hampered by poor medical penetration into the combat operator's actual work spaces and frequent changes to equipment configurations that are opaque to the medical field at large. This lack of knowledge further factors back into decreased accuracy in counseling of proper ergonomics for RPA operators. This case illustrates the need for continuous evaluation of the combat operator's work space.

#### Learning Objectives

1. Understand a need for continuous review of basic anthropomorphic measurements in the aviation environment.
2. Understand that flight medicine must interface with the flying units at the aircraft level and can help identify deficits in the medical knowledge database.

### [35] NO RADIO CALL RESPONSE, NO VISUAL, NO CHUTES, NO BEEPERS, NO SMOKE, NO CRASH SITE

James Webb<sup>1</sup>

<sup>1</sup>Scientific Aerospace Research Consulting (SARC), LLC, Bandera, TX, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** When aircraft disappear with their occupants, questions and searches begun. This search has never ended. I met Dave at Seymour-Johnson AFB, NC in 1967 where we were both new USAF pilots. We served as back seat pilots in F-4D fighters in the 336<sup>th</sup> TFS, later upgrading to Aircraft Commander positions before our Vietnam tours. About a month after I finished my tour at the 389<sup>th</sup> FS at Phu Cat AB, Vietnam, Dave arrived. After his year at Phu Cat, he was later assigned to fly F-4Es at Elmendorf AFB, AK where we got back together in October 1973 for supper at their home. **BACKGROUND:** On December 17, 1973, Dave and his back-seat pilot were flying an F-4E Phantom Jet about 100 miles NNW of Anchorage, Alaska to accomplish an aerial combat maneuvering (ACM) training mission as #2. As a trainee, he was supposed to fly his F-4E to get in a trail position relative to #1, using a hard (high Gz) left turn from which he could acquire #1, as a simulated target and execute a simulated missile launch. Within one minute, the flight lead, #1, no longer able to see #2, initiated radio calls, several times, to no avail. Dave's plane went down with him and his back-seat pilot, leaving no trace. Searchers have subsequently been unable to locate their remains or those of the plane. **CASE PRESENTATION:** The F-4E aircraft was designed to turn faster than the F-4D Dave was used to flying. His ACM training flight was conducted in between

cloud layers about 100 miles NW of Anchorage, AK where it's always dusk in the winter months. **DISCUSSION:** An over-aggressive, high-G<sub>x</sub> left turn could have resulted in G-induced Loss of Consciousness (GLOC) followed by ground impact before recovery. Alternatively, spatial disorientation caused by reduced visibility in all directions including loss of ground and horizon visibility may have caused loss or orientation followed by the crash. The author has attempted to recruit efforts to find the accident site over the past 46 years since learning of the accident in early 1974. Reason: Cause and closure.

#### Learning Objectives

1. Appreciate that changes in aircraft greatly affects pilots during transition training.
2. Appreciate High-Gz turns could result in GLOC and crash. Experienced aviators are also subject to this.

### [36] INCENTIVE RIDE DISQUALIFICATION- QUESTIONS RAISED

Zachary Masters<sup>1</sup>

<sup>1</sup>14th Medical Group-Columbus Air Force Base, Columbus, MS, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** 32 yo female with anxiety, depression, insomnia and frequent unexplained pre-syncope events presents for incentive flight physical. Currently pending follow-up and further testing with both neurology and cardiology. **BACKGROUND:** Incentive, orientation or familiarization flights are provided by all branches and are invaluable for motivation and mission understanding amongst the people who support the mission every day. It's a once in a lifetime experience for the individuals selected, usually as a reward for strong job performance. Flight surgeons are the main obstacle for some of these individuals. The guidance that Air Force flight surgeons work from is fairly vague, with the 48-123 leaving everything except for anthropometrics up to their judgement. **CASE PRESENTATION:** A 32 yo female TSgt aviation resource management NCOIC presents for incentive flight physical. In reviewing her record you find that she has significant mental health concerns as well as open referrals to cardiology and neurology for pre-syncope events. PMH- depression/anxiety. PSH- knee scope. Exam- benign. **DISCUSSION:** Presumptive diagnosis of POTS currently with recommended increased fluid and sodium intake. C-code in place for unexplained or recurrent syncope; disqualifying for retention as well as all flying classes, RPA, GBC, MOD, OSF, SWA. She is also on 3 different medications that are disqualifying for flyers. The pertinent question is what standards do we hold her to? The 1% or less chance of sudden incapacitation per year standard is unnecessarily stringent to apply to incentive flyers and would rob many high performing service-members of this great opportunity. Many flight surgeons seem to take the approach of disregarding FCI, II or III standards and making a judgement call of whether their personal safety or that of others will be jeopardized by their participation. In this case, given multiple recent pre-syncope events, her likelihood of GLOC on an F-16 profile including extensive high G maneuvering is elevated. Because there is the potential for an incapacitated back-seater to actuate flight controls this poses unnecessary risk to mission safety. It is also relatively unknown whether the high G environment could worsen her condition long-term. I believe this opens the opportunity for an in-depth discussion of the ideal approach to incentive flight physicals, what standards they should be held to and whether further guidance should be published.

#### Learning Objectives

1. Understand the importance of the incentive/orientation flight program in the USAF and the role of Flight Surgeons in facilitating it.
2. Understand key differences in determining aeromedical disposition for incentive/orientation flyers as opposed to full-time rated flyers.

### [37] F-35 PILOT-PHYSICIAN: A PERSPECTIVE ON AEROMEDICAL ISSUES IMPACTING THE JOINT STRIKE FIGHTER

Christopher Bates<sup>1</sup>, Matt Stein<sup>2</sup>

<sup>1</sup>U.S. Air Force, Andover, KS, USA; <sup>2</sup>U.S. Air Force, Luke AFB, AZ, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This is a review of 5<sup>th</sup> generation aircraft human performance factors and challenges from a pilot-physician perspective.

**BACKGROUND:** Fifth generation aircraft have human-factor challenges similar to that of the previous generations, while additionally introducing many new significant issues. This presentation will provide a review of human systems integration issues pertaining to the aircraft, as well as multiple stressors that could lead to degraded pilot performance. **CASE PRESENTATION:** The F-35 has significant improvements to the aircraft form and survivability but retains many of the same human factors issues as previous generations of aircraft. Crews still deal constantly with heat stress while on the ground, difficulties with micturition over long flights, and a relatively cramped cockpit. The newly developed helmet mounted display improves situational awareness but often has associated difficulties in alignment with the operator's eyes. The overall ergonomics of the cockpit also seems to raise the challenge of basic fighter maneuvers on the pilot as compared to prior generation aircraft. Overall, the aircraft is liked and trusted by the crews but there are still many areas that could benefit from improvements in the future. **DISCUSSION:** This presentation highlights the current state of the Joint Strike Fighter and the different factors affecting the human inside the machine. The pilot-physician's perspectives are invaluable in helping to assess the future focus of aviation medicine. More research is recommended to help further evaluate and improve systems within the ever-evolving F-35.

#### Learning Objective

1. The audience will learn about the current Joint Strike Fighter human-factor challenges affecting the human inside the machine.

### [38] CHANNELIZED ATTENTION AS DEMONSTRATED BY C-17 APPROACH INTO KABUL, AFGHANISTAN

Christopher Backus<sup>1</sup>

<sup>1</sup>Mike O'Callaghan Military Medical Center, Nellis AFB, NV, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** A U.S. Air Force (USAF) C-17 crew experienced fixation during approach, which nearly led to a mishap and as a case, illustrated this human factor to aerospace medical professionals. **BACKGROUND:** Department of Defense (DoD) uses Human Factors and Analysis System (HFACS) to organize human factors identified in investigation (HFACS 7.0, Air Force Safety Center). Previous papers described fixation or channelized attention as a recurring human factor in F-16 accidents, as discussed by Holland and Freeman in their October 1995 article in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* and further demonstrated by Knapp and Johnson in their August 1996 paper in *Aviation, Space, and Environmental Medicine*. Fixation was a factor in the fatal C-17 crash at Elmendorf AFB, AK, per the public accident investigation board report. **CASE PRESENTATION:** A USAF C-17 cockpit crew, composed of an Instructor Pilot (IP) in the left seat with an Evaluator Pilot (EP) performing copilot or "pilot not flying" (PNF) duties in the right seat, performed a night vision goggle aided, tactical approach to Kabul, Afghanistan (International Civil Aviation Organization or ICAO identifier OAKB). Due to an unexpected external factor of no airport lights, the IP became fixated on finding and identifying the runway. The PNF, rather than performing normal duties of announcing key altitudes, also became fixated on finding the runway. The C-17 is unusual in that it typically lands in "backside" configuration, where power is used to control descent rate and pitch is used to control airspeed. The runway was identified below the normal altitude of 50 feet above ground level (AGL) for power addition to reduce the rate of descent and only an abnormally large power addition prevented a hard landing or crash into the approach end of the runway. **DISCUSSION:** Due to the instructor pilot's survival, he lived to become an experienced flight surgeon and pilot physician. His experience in what could have been a fatal mishap allows a firsthand description of the experience of this common human factor and the perceived risk factors that contributed to his fixation, despite extensive training throughout his USAF pilot career on the dangers of channelized attention. He hopes that this discussion will allow aeromedical professionals to better counsel aviators on this human factor. Further, it may help them to recognize fixation during incident investigation.

#### Learning Objectives

1. The audience will be aware of the human factors analysis and classification system (HFACS).
2. The audience will learn about channelized attention, also known as fixation, and the role of this human factor in potential mishaps.

Monday, 05/18/2020  
Regency 8

10:30 AM

### [S-10]: SLIDE: GOING FOR THE JUGULAR: VENOUS PHYSIOLOGY IN SPACEFLIGHT

Chair: Yael Barr

Co-Chair: Serena Aunon

### [39] INTERNAL JUGULAR VENOUS BLOOD FLOW STASIS AND THROMBOSIS DURING SPACEFLIGHT, BUT NOT BED REST

Karina Marshall-Goebel<sup>1</sup>, Steven S. Laurie<sup>1</sup>, Irina Alferova<sup>2</sup>, Kathrine Bretl<sup>3</sup>, Douglas Ebert<sup>1</sup>, Stuart M.C. Lee<sup>1</sup>, Brandon R. Macias<sup>1</sup>, David Martin<sup>1</sup>, Scott Dulchavsky<sup>4</sup>, Alan Hargens<sup>5</sup>, Michael B. Stenger<sup>6</sup>  
<sup>1</sup>KBR, Houston, TX, USA; <sup>2</sup>Institute of Biomedical Problems of the Russian Academy of Sciences, Moscow, Russian Federation; <sup>3</sup>University of Colorado Boulder, Boulder, CO, USA; <sup>4</sup>Henry Ford Hospital, Detroit, MI, USA; <sup>5</sup>University of California, San Diego, San Diego, CA, USA; <sup>6</sup>NASA Johnson Space Center, Houston, TX, USA

(Original Research)

**INTRODUCTION:** Cerebral venous congestion has been hypothesized to occur in weightlessness; however, cerebral venous outflow through the internal jugular veins (IJV) has not been assessed during spaceflight. We aimed to characterize IJV blood flow during spaceflight and bed rest, a spaceflight analog. **METHODS:** Thirteen International Space Station crewmembers (10M, 3F) consented and participated in the Fluid Shifts study. Doppler ultrasonography was used to characterize the left IJV blood flow preflight in 3 postures (seated, supine, and 15° head-down tilt [HDT]) and approximately 50 and 150 days into a spaceflight mission. In addition, we characterized IJV blood flow before and after 14 days of 6° HDT bed rest in 11 healthy male subjects. IJV blood flow was categorized using a scale of 1-4 as continuous (grade 1), pulsatile (grade 2), stagnant (grade 3), or retrograde flow (grade 4). These studies were approved by the NASA Institutional Review Board. **RESULTS:** Preflight, all crewmembers had nominal left IJV flow (grade 1 or 2) in all postures. However, chronic exposure to weightlessness resulted in stagnant or retrograde left IJV flow in 7 of the 13 crewmembers; 2 of the 7 with stagnant left IJV blood flow developed left IJV thrombi in flight. Interestingly, 6 of the 7 crewmembers with stagnant/reverse flow in the left IJV had anatomically dominant right IJVs. In the bed rest study, all participants had normal flow (grade 1 or 2) in the IJV before and after 14 days of 6° HDT bed rest. **DISCUSSION:** Stagnant left IJV flow represents a new risk during spaceflight that may lead to thrombosis. Stagnant IJV flow did not develop during exposure to the 6° HDT bed rest spaceflight analog and appears to be a response unique to weightlessness. Countermeasures aimed at enhancing flow in stagnant areas warrant further research as well as the role of lateralized IJV flow dominance.

#### Learning Objective

1. The audience will learn about changes in venous hemodynamics during spaceflight and a spaceflight analog.

### [40] WHOLE BLOOD VISCOSITY: A MISSING CONSIDERATION IN SPACE PHYSIOLOGY AND MEDICINE

Ashot Sargsyan<sup>1</sup>, James Pavela<sup>2</sup>, Kadambari Suri<sup>1</sup>, Aaron Everson<sup>1</sup>, Mansur A. Ghani<sup>3</sup>, Chad L. Roberts<sup>4</sup>, Douglas Ebert<sup>1</sup>, Richard Cole<sup>2</sup>  
<sup>1</sup>KBR, Houston, TX, USA; <sup>2</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>3</sup>Yale University, New Haven, CT, USA; <sup>4</sup>Southern Colorado Family Medicine, Pueblo, CO, USA

(Original Research)

**INTRODUCTION:** Relative overcapacity of the supratheracic venous space in microgravity may be a contributor to facial plethora, nasal congestion, neuro-ocular changes, and other phenomena seen in astronauts. We present a physiological construct that factors contributions of non-Newtonian, shear-thinning properties of whole blood to vascular ultrasound findings in an astronaut. **METHODS:** Upper extremity vascular

sonography was performed in an International Space Station (ISS) long-duration crewmember as part of medical surveillance. Standard 2-dimensional and color flow Doppler views were collected bilaterally, with respiratory maneuvers. **RESULTS:** The right internal jugular vein (IJV) showed strong dominance for both cross sectional area (R/L ratio of 5.32) and for peak flow velocity (R/L ratio of 1.8). Valsalva maneuver provoked sustained unilateral loss of flow spontaneity in the non-dominant IJV. The decline in flow velocity was accompanied by a rise in blood echogenicity, achieving a static state of sustained loss of flow despite resumption of normal respiration. Augmentation by impedance breathing (Mueller maneuver) purged the echogenic content of the left IJV and restarted spontaneous flow. **DISCUSSION:** Human blood is a thixotropic fluid, but the topic of spatial and temporal variability of whole blood viscosity (WBV) is rarely mentioned in medical education or practice. Flow patterns in the presented case are consistent with a local rise in WBV provoked by a Valsalva maneuver. This can be explained by further reduction of already low shear rates in the venous system, combined with other pro-viscosity factors, such as relative dehydration with elevated hematocrit, and potentially hyperfibrinogenemia. A non-dominant, distended left IJV, coupled with available anatomic bypass conduits for cerebral venous outflow, represents a vascular site vulnerable to local hyperviscosity in microgravity, with sustained cessation of flow as an extreme manifestation. Further elucidation of WBV-associated phenomena in human space flight appears to be warranted. Circadian patterns of venous overcapacity and whole body hematocrit, effectiveness of impedance breathing in microgravity, and the potential of viscosity-reducing pharmaceuticals in some individuals such as pentoxifylline are appropriate topics of interest. We propose that our evidence and existing literature support a central role of WBV in vascular space physiology and medicine.

#### Learning Objective

1. The audience will learn about the relevance of whole blood viscosity to circulatory physiology in microgravity.

#### [41] EFFECT OF MICROGRAVITY ON THE VENOUS SYSTEM AND BLOOD COAGULATION; A REVIEW OF CURRENT LITERATURE AND STATE OF UNDERSTANDING

David Kim<sup>1</sup>, Lucia Mazzolai<sup>2</sup>, Lara N. Roberts<sup>3</sup>, David Green<sup>4</sup>, Jonathan Scott<sup>5</sup>, Guillaume Weerts<sup>4</sup>, Sergi Vaquer Araujo<sup>4</sup>

<sup>1</sup>The European Space Agency and The University of British Columbia, Vancouver, British Columbia, Canada; <sup>2</sup>Lausanne University Hospital (CHUV), Lausanne, Switzerland; <sup>3</sup>King's College Hospital NHS Foundation Trust, London, United Kingdom; <sup>4</sup>European Space Agency, Cologne, Germany; <sup>5</sup>KBR Wyle GmbH, Cologne, Germany

#### (Original Research)

**INTRODUCTION:** The physiology of the human venous system is affected by intrinsic (cardiac function, musculo-venous pump, abdominal-thoracic pump, venous gradient, tone, and integrity) and extrinsic (external compression, ambient pressure, and gravity) factors. In microgravity ( $\mu$ G), several of these factors are known to be affected due to the loss of the hydrostatic gradient and fluid shifts. The pathogenesis of venous thromboembolism is associated with venous stasis, endothelial damage, and hypercoagulability; known as Virchow's triad. This review assessed the current state of knowledge of the impact of  $\mu$ G upon venous and coagulation physiology as it relates to Virchow's triad. **METHODS:** A systematic review following the Cochrane guidelines were initially performed in 6 electronic databases. Search criteria was set for human studies reporting venous system or coagulation parameters in  $\mu$ G or ground-based  $\mu$ G analogues (Bedrest, head down tilt, immersion, and lower body negative pressure). Due to the heterogeneity of data and identification of significant knowledge gaps, a narrative review of the literature was performed. **RESULTS:** Literature search retrieved 705 publications, of which 25 publications were included in the final review. Of these, 20 investigated the venous system and 5 investigated the coagulation system. 8 studies were conducted in spaceflight and 17 on ground-based analogues. None of the studies assessed the venous or the coagulation system as a whole. Results suggest hypercoagulable states may be induced in  $\mu$ G; as increased fibrinogen levels and shortened thrombin time have been reported. Additionally, venous system changes contributing to venous stasis and endothelial damage were observed in  $\mu$ G and its analogues: loss of musculo-venous pump, venous dilation, and

decreased blood flow. **DISCUSSION:** There is evidently a paucity of knowledge regarding venous function and coagulation in  $\mu$ G. Taken together, the literature suggests that changes in both vascular and endothelial function may result in a prothrombotic state in  $\mu$ G. However, published studies were underpowered, heterogeneous, and frequently equivocal rendering definitive conclusions impossible. Given the low occurrence probability but potentially catastrophic consequences of venous thromboembolisms in space, it is imperative that knowledge gaps are addressed in venous and coagulation pathophysiology to reduce overall medical mission risk during spaceflight.

#### Learning Objectives

1. Participants will be informed about the current state of understanding with regards to venous and coagulation physiology in microgravity.
2. Audience will learn about knowledge gaps in venous and coagulation physiology understanding in microgravity.
3. Audience will be informed about the potential implications in space medicine about the risk of VTEs in space.

#### [42] COMPARISON OF INTERNAL JUGULAR VEIN CROSS-SECTIONAL AREA IN A HUMAN MALE DURING TILT-TABLE TESTING AND MICROGRAVITY

Jason David<sup>1</sup>, Richard Scheuring<sup>2</sup>, Andrew Morgan<sup>2</sup>, Ashot Sargsyan<sup>2</sup>, Cara Olsen<sup>3</sup>, Alexey Grishin<sup>4</sup>

<sup>1</sup>US Air Force, University of Nevada, Las Vegas, Las Vegas, NV, USA; <sup>2</sup>NASA-Johnson Space Center, Houston, TX, USA; <sup>3</sup>Uniformed Services University of the Health Sciences, Bethesda, MD, USA; <sup>4</sup>Gagarin Cosmonaut Training Center, Star City, Russian Federation

#### (Original Research)

**INTRODUCTION:** To date, there does not seem to be any published literature comparing the effects of a dedicated tilt-table training protocol on Internal Jugular Vein Cross Sectional Area (IJV-CSA) in microgravity on the same astronaut subject. Specifically, comparisons between Russian tilt-table training protocol known as the "Braslet protocol" and subsequent vascular studies in microgravity have never been conducted in US medical literature. Therefore, this single-subject case study provides an interesting and unique data point to the study internal jugular vein hemodynamics in microgravity which has potential implications for human brain, eye, and hematologic spaceflight physiology. **METHOD:** A convenience sample of a single healthy male astronaut was chosen at random by a single examiner for this case-study. The Right IJV-CSA (RIJV-CSA) was identified and measured using real time ultrasound at varying times throughout the Roscosmos "Braslet" protocol, a method of physiologic preparation for microgravity using tilt-table training. Preflight Russian impedance data was also collected. In microgravity, the subject's RIJV-CSA measured again for comparison. **RESULTS:** The mean difference from in-flight RIJV-CSA for Pre-Tilt 0° was -0.438 cm<sup>2</sup> ( $p = 0.0003$ ), for -15° was 0.887 cm<sup>2</sup> ( $p = 0.04$ ), for -30° was 0.864 cm<sup>2</sup> ( $p = 0.0008$ ), for +50° was -1.15 cm<sup>2</sup> ( $p < 0.0001$ ), and for Post-Tilt 0° the difference was (-0.305) cm<sup>2</sup> ( $p = 0.114$ )... **DISCUSSION:** The cross-sectional areas of the subject's Right Internal Jugular Vein were significantly different between in-flight values and several angles of the "Braslet" Protocol as mentioned above. The end-state RIJV-CSA of the protocol at 0° (horizontal) was not significantly different from the in-flight measurements, however the sample size of this measurement was small. In summary, this single-subject case-study represents, to our knowledge, the first time a comparison of internal jugular vein cross sectional area has been compared between various angles of a tilt-table training protocol and orbital microgravity in the same astronaut subject, and lends support to similar cohort studies studying the same principles. Significant differences were found between the tilt table angle values and the in-flight values except for the end supine measurements, further rigorous investigation is merited; both to better describe the relationship between the cardiovascular effects of tilt-table simulations of microgravity and their correlating in-flight values, and to evaluate and study the "Braslet Protocol" effects on cardiovascular physiology from a training and preparation perspective.

#### Learning Objectives

1. The Audience will learn about a potential avenue of study for vascular physiology in micro-gravity.
2. The Audience will learn about found differences in vascular physiology between a human subject on Earth and in Space.



#### [43] IMPEDANCE THRESHOLD BREATHING FACILITATES JUGULAR VENOUS DRAINAGE IN A PLACEBO-CONTROLLED STUDY

Doug Ebert<sup>1</sup>, Brandon Macias<sup>1</sup>, Millennia Young<sup>2</sup>, Alan Hargens<sup>3</sup>, Smith Johnston<sup>2</sup>, Michael Stenger<sup>2</sup>, Ashot Sargsyan<sup>1</sup>  
<sup>1</sup>KBR, Houston, TX, USA; <sup>2</sup>NASA JSC, Houston, TX, USA; <sup>3</sup>University of California, San Diego, San Diego, CA, USA

(Original Research)

**INTRODUCTION:** Jugular venous overcapacity has been observed during sustained microgravity and terrestrial microgravity analogs. This phenomenon may be a contributing factor for spaceflight-associated neuro-ocular syndrome (SANS) and has recently been linked with internal jugular vein (IJV) stasis. An impedance threshold device (ITD) was evaluated as an effective, practicable countermeasure to facilitate drainage of IJVs. ITD provides up to 7 cm H<sub>2</sub>O resistance to inspiratory airflow, lowering intrathoracic pressure (ITP) and facilitating venous return to the heart during the inspiratory phase, which comprises at least 25% of the respiratory cycle. We hypothesized that use of the ITD in a spaceflight analog [head down tilt, (HDT)] would counteract IJV congestion. **METHODS:** Fifteen test subjects participated in two trials each, one with an ITD and one with a sham ITD (placebo), in seated, supine, 6° HDT, 15° HDT, and 15° HDT-extended (additional 30 minutes) postures. Measures analyzed from each posture included IJV cross-sectional area (CSA) and flow patterns, estimated IJV pressure (VeinPress), superior ophthalmic vein (SOV) direction of flow, as well as central retinal artery (CRA) and vein (CRV) flow measures. Questionnaires were completed at each posture to document subjective status. **RESULTS:** When integrated over a full respiratory cycle, IJV CSA enlarged with increasing HDT ( $p \leq 0.0006$ ) in both ITD and placebo device trials. IJV CSA was reduced with ITD versus placebo across all posture conditions, reaching significance in the 6° HDT ( $p=0.015$ ), 15° HDT ( $p=0.031$ ), and 15° HDT extended ( $p=0.021$ ) conditions. Over all postures combined, IJV CSA was reduced 19% with ITD breathing, and Doppler demonstrated improved flow patterns as compared to placebo. End-expiration IJV pressure estimates also rose with increasing HDT, but were partially mitigated by ITD as compared to placebo, reaching significance at 15° HDT ( $p=0.005$ ). Significant CRA, CRV, and SOV Doppler flow differences with posture or ITD use were also documented. **DISCUSSION:** In the context of a posture-based spaceflight analog, we conclude that: 1) based on IJV parameters, ITD relieves congestion while improving IJV flow, and 2) based on orbit Doppler data, ITD has positive peripheral vascular effects in HDT, returning values toward seated. ITD may have utility as a countermeasure to both jugular venous stasis and SANS, and therefore should be tested in microgravity.

##### Learning Objective

1. The audience will understand the effects of inspiratory impedance breathing on cervico-cranial venous drainage, and the potential of impedance threshold devices as a countermeasure for venous stasis and spaceflight-associated neuro-ocular syndrome.

#### [44] SIMULATION OF INTRAVENOUS FLUID RESUSCITATION CAPABILITIES IN REDUCED GRAVITY

Ishita Jain<sup>1</sup>, Justin Heidel<sup>1</sup>, Scott Warner<sup>1</sup>, Thomas Barefoot<sup>1</sup>, Rachel Baker<sup>1</sup>, Melinda Hailey<sup>2</sup>, George Pantalos<sup>1</sup>  
<sup>1</sup>University of Louisville, Louisville, KY, USA; <sup>2</sup>KBR Wyle, Houston, TX, USA

(Original Research)

**INTRODUCTION:** Critical care for exploration space missions may require intravenous fluid resuscitation therapy. Resource constraints may limit availability of standard Earth-based, infusion technologies, therefore, the effect of variable acceleration on infusion flow rates using simple fluid resuscitation supplies was investigated. We hypothesize that the reduced hydrostatic pressure experienced in reduced gravity environments will reduce the infusion flow rate for intravenous fluid resuscitation therapy and that this reduced hydrostatic pressure can be sufficiently overcome with the use of pressure bag augmentation. **METHODS:** Infusions of water ( $\mu = 1.0$  cP) or 40% glycerol in water (blood analog,  $\mu = 3.5$  cP) from a 1 L IV bag were performed using pressure bag augmentation at 0, 150 or 300 mmHg. The solution bag rested on an adjustable mount positioned at different heights to simulate relevant gravitational accelerations

(1-G, Martian-G, Lunar-G, and 0-G). The bag emptied through an IV line with a bubble trap, into a 14 or 20 gauge angiocath submerged in a venous pressure reservoir of 3 mm Hg. Flow rates were measured using an in-line flow probe; three determinations were made for each test condition. Statistical analysis was performed in GraphPad Prism 8 using a Shapiro-Wilk test for normality and a 2-way ANOVA for determining statistical significance ( $\alpha = .05$ ). **RESULTS:** Temporal flow rate data for the test conditions displayed one-phase exponential decay. At 300 mmHg pressurization, maximum infusion rates ranged from 92 to 222 mL/min for water and from 21 to 49 mL/min for blood analog. For 500 mL infusion volumes, infusion times were significantly less for 1-G compared to Lunar-G and 0-G for both test solutions ( $p < 0.05$ ). For 1000 mL, all reduced gravity conditions had significantly longer infusion times in comparison to 1-G for both test solutions ( $p < 0.05$ ). **DISCUSSION:** Reduced acceleration significantly altered flow rates and infusion times for fluid resuscitation. Infusion flow rates are highest with less viscous fluid at greater acceleration through larger bore needle at a higher infusion pressure. Fluid resuscitation protocols specify a desired volume to infuse for a target time (e.g. 20-30 mL/min for a 75 kg adult). This data demonstrates that this protocol parameter can be achieved with pressure infuser bag augmentation alone and provides information for the refinement of fluid resuscitation protocols for exploration space missions.

##### Learning Objectives

1. In reduced gravity, the hydrostatic pressure that normally drives intravenous fluid infusion is reduced resulting in lower fluid infusion rates and longer fluid infusion times.
2. Intravenous fluid infusion rates are influenced by the size of the catheter/needle in the vein and the viscosity of the infusion fluid (e.g. lactated ringers vs whole blood).
3. The use of standard pressure bag augmentation on a bag of intravenous fluid for infusion can greatly increase the fluid infusion rate to values recommended for fluid resuscitation therapy without having to use an infusion pump.

Monday, 05/18/2020  
 Regency 5

10:30 AM

#### [S-11]: PANEL: MH-60S NEXTGEN GUNNER SEAT PROGRAM: FROM ORIGINAL JUSTIFICATION TO FINAL FIELDING

Chair: Bethany Shivers

**PANEL OVERVIEW:** This panel will provide a full spectrum look at the complex and collaborative effort that took the MH-60S NextGen Gunner Seat Program from building a justification to becoming a fielded reality in two years time. The prevalence and type of injuries, lack of congruent means to document injuries, or means to mitigate them lead to justification and funding approval for a landmark effort to address a critical issue in today's MH-60S aircrew. Key performance parameters of crashworthiness and aircrew endurance were defined and received equal emphasis in the design process, but raised unique challenges in development and execution of the qualification testing. Design features specifically included to address known acute and chronic injuries will be reviewed as they relate to mishap survivability as well as long-term aircrew health and well-being. Crashworthiness and aircrew qualification test development, execution, and results will be discussed. Finally, lessons learned and best practices will be identified for future seat design and qualification efforts.

#### [45] MH-60S NEXTGEN GUNNER SEAT ENDURANCE QUALIFICATION: MH-60S NEXTGEN GUNNER SEAT ENDURANCE QUALIFICATION: SUBJECTIVE PAIN SCORES AREN'T ENOUGH

Bethany L. Shivers<sup>1</sup>, Matt Pontarelli<sup>1</sup>, Meredith Fielder<sup>1</sup>, Lindley Bark<sup>1</sup>  
<sup>1</sup>NAWCAD, Patuxent River NAS, MD, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** The MH-60S NextGen Gunner Seat program was a two-year rapid acquisition effort to design, qualify, and field a new MH-60S

gunner seat with aircrew endurance as a named key performance parameter alongside crashworthiness. Unlike crashworthiness, aircrew endurance does not have established injury criteria for qualification. Previous efforts to assess aircrew endurance or comfort relied on subjective questionnaires to quantify pain, temperature, or pressure. Subjective questionnaires provide invaluable information, but cannot provide the objective data necessary for qualification testing. **OVERVIEW:** Test techniques and metrics from aircrew seating analogs in industry and medicine guided development of a robust qualification test providing both objective and subjective data. Wheelchair-design pressure map testing was identified as the best fit analog due to the similarities in seat design constraints (thin flat cushion), occupancy conditions (sustained pressure points, long-duration occupancy, restricted movement/mobility), and physiological concerns (neurovascular occlusion and tissue ischemia). Repeated measures pressure map and subjective pain data (six sub-regions: neck, torso, back, buttocks, upper legs, and lower legs) were collected from seven aircrew covering a broad spectrum of anthropometry during two (legacy and NextGen gunner seats) 2.5-hour ground test events. A Wilcoxon Signed-Ranks Test showed that NextGen gunner seat performed significantly better than the legacy seat on multiple pressure map and pain metrics, such as RMS pressure gradient (median 0.71, 1.52, respectively;  $Z = 8.81$ ,  $p < 0.00$ ), and maximum difference from baseline pain score (median 0, 2.5, respectively;  $Z = -2.03$ ,  $p = 0.016$ ). **DISCUSSION:** Pressure mapping provided objective quantification of the high-pressure areas or 'hot spots' under the ischial tuberosities and posterior thigh that cause neurovascular occlusion and tissue ischemia-related issues common to aircrew and wheelchair occupants such as pain, paresthesia, and swelling in the buttocks, legs, and feet. In the absence of clearly defined endurance standards, objective and subjective data from a one-to-one comparison between the legacy seat and NextGen gunner, clearly established superior performance of the NextGen gunner seat and identified best practices for use in future endurance qualification efforts across the Department of Defense and our international partners.

#### Learning Objective

1. The audience will learn about the process to develop an endurance qualification test for the MH-60S NextGen Gunner Seat in the absence of any known or established endurance criteria.

#### [46] MH-60S NEXTGEN GUNNER SEAT ENDURANCE QUALIFICATION: CHALLENGES AND LIMITATIONS OF ADOPTING WHEELED MOBILITY PRESSURE MAPPING METRICS

Matthew Pontarelli<sup>1</sup>, Bethany L. Shivers<sup>2</sup>, Lindley Bark<sup>3</sup>

<sup>1</sup>NAWCAD, Patuxent River, MD, USA; <sup>2</sup>NAWCAD, Patuxent River, MD, USA; <sup>3</sup>NAWCAD, Patuxent River, MD, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Seat bottom Interface Pressure Mapping (IPM) was chosen as the quantitative measure to augment subjective pain/discomfort evaluations for endurance qualification from legacy to NextGen systems. IPM wheeled mobility metrics were successfully used to provide a detailed quantification of performance change between the legacy and NextGen seat. However, effects of flight equipment necessitated adaptation both in application and interpretation of clinical wheeled mobility metrics applied to military aviation conditions. **OVERVIEW:** Definitions of metrics like Peak Pressure Index (PPI) were developed for the evaluation of clinical data where bony anatomy is the most likely cause of the largest pressure concentration. Minor features from everyday clothing like seams, folds and buttons are known to cause smaller pressure concentrations unrelated to the bony anatomy. Similarly, the bulk from aircrew flight equipment can affect interface pressure results, but to a greater degree. The bony anatomy can become obscured, and the flight equipment can be the dominating factor for pressure concentrations. This was most evident in the interface pressure data of the legacy gunner seat. The unsupported fabric seat bottom provided no envelopment of the flight equipment features like the vest webbing and seat restraint webbing. In some user cases, this completely obscured the ischial tuberosity (IT) region, where PPI is applied to quantify the peak pressure concentration in the contact area of the IT. Furthermore, the flight equipment caused severe pressure drop off at its boundaries, causing high pressure gradients in multiple locations. As a result, PPI was not always a clear indicator of improvement, despite a decrease in peak pressure. Pressure gradient

metrics showed clear improvement, but the location of peak pressure gradient did not always correlate with anatomical factors. **DISCUSSION:** Pressure concentration issues caused by flight equipment are important for seat endurance. Wheeled mobility metrics provide a powerful method for quantifying seat interface performance. However, measured flight equipment effects are a more indirect measure of the tissue-seat interface, and application of adopted metrics requires more consideration.

#### Learning Objective

1. Participants will learn important considerations when applying clinical wheeled mobility metrics to a military seating environment.

#### [47] ESTABLISHING REQUIREMENTS FOR BACK AND NECK PAIN INITIATIVES

Hadley Sulpizio<sup>1</sup>

<sup>1</sup>USN, Pensacola, FL, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** No formal surveillance program for back/neck pain among USN Aircrew populations exists. As such, gathering data to identify a readiness impact or safety concern has been historically challenging. Informal and localized initiatives to collect data among Squadrons and Air Wings have filled this gap. From this data, it has been reported that 91% of Naval Rotary Aircrew were experiencing pain following flights. The average pain reported was 5 out of 10 and 82% would report the pain increasing during flight. Data collected in one USN Rotary Wing reported that in a 90 day period 5% of Aircrew were medically downed with over 2,257 lost work days. In 2016, the primary intervention strategy requested was a systems and engineering approach: a redesign of the MH-60S Gunner Seat. Despite being a well-documented contributing factor to injury and pain, funds had yet to be aligned to replace or design a new seat. **OVERVIEW:** The Enabler Naval Air Requirements Group (eNARG) aligns funding and requirements in accordance with Fleet priorities. Due to the lack of formalized data, unique approaches to reporting were used at the 2016 eNARG. The data used included post-flight surveys, X-Ray images of aircrew, and images of surgical scarring prevalent across Squadrons. Data collected from the 940 Aircrew flying in the MH-60S showed a chronic injury burden and readiness concern. Data presented at the 2016 eNARG was impactful enough to establish a Rapid Acquisition Program. **DISCUSSION:** The innovative approach and the alarming trend it demonstrated highlighted a capability gap in the Naval Aviation Enterprise (NAE) in regards to surveillance, prevention, and mitigation of back and neck injury throughout Naval Aviation. The Rapid Acquisition and Development of the NextGen MH-60S Gunner Seat serve as the first step in the prevention of chronic injury among this population. Significant collaborative efforts emerged from the information provided at the 2016 eNARG addressing back and neck injury in NAE including: a Fleet Forces Request to BUMED to establish a prevention, surveillance, and mitigation program, a new Aeromedical Division at NAVAIR to address chronic injury alongside the catastrophic event, and Pre-and-Post Flight Stretching and Strength studies.

#### Learning Objective

1. Identify the formal method to align funding for USN requirements, such as the MH-60S NextGen Gunner Seat, with funding cycles.

#### [48] CRASH-PROTECTIVE PERFORMANCE OF THE NEXTGEN MH-60S GUNNER SEAT

Eric Anderson<sup>1</sup>

<sup>1</sup>Virginia Tech, Patuxent River, MD, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** The MH-60S NextGen Gunner Seat blends crash protection with enhanced chronic injury mitigation for crew chief (gunner) positions. For qualification, dynamic crash-testing of the seat demonstrates compliance with specifications and illuminates the efficacy of design features to prevent or mitigate acute injury. It also highlights important crash-protective attributes of this seating system intended to aggressively reduce the incidence and severity of crash injury. **OVERVIEW:** Rotary wing seating must be capable of limiting vertical loading to prevent whole-body accelerative injury during survivable mishaps. For this test program, 21 dynamic tests covering four anthropometric test dummy (ATD) sizes and five seat orientations

demonstrated compliance with structural and injury criteria requirements. The tests were heavily instrumented to obtain additional data for assessment beyond the qualification decision. Additional testing with approximately twice the vertical energy was conducted, assessing the energy-absorbing capability of the seat to absorb energy and limit compressive lumbar loading to tolerable levels. **DISCUSSION:** When rotary wing aircraft are involved in a crash mishap, a vertical velocity component is nearly universal; therefore, spinal injuries are a primary concern. Because lumbar compressive injuries are one of the most common for vertical crash conditions, the most direct assessment of spinal injury mitigation are pure-vertical tests where the crash pulse vector is parallel to the aircraft vertical axis. In a 37 ft/s simulated pure-vertical crash event, lumbar forces on the 95<sup>th</sup> male ATD reached 52 percent of the injury threshold, and the 50<sup>th</sup> male ATD were 84 percent. The 50<sup>th</sup> and 95<sup>th</sup> males were tested with an approximately doubled energy pulse of 47 ft/s resulting in lumbar forces 30 and 82 percent of injury limits respectively. These values fluctuate in other orientations; however, in all tests compressive lumbar forces satisfy established injury thresholds. Using measured data and injury criteria analyses, this seat has been demonstrated to greatly improve crash protection and reduce risk of injury during a mishap. Demonstrating that it is possible for cabin seats to provide similar levels of protection as pilot seats may influence requirement changes for future seating systems across all services.

#### Learning Objective

1. The audience will learn about the results of dynamic crash testing of the NextGen MH-60S Gunner Seat.

#### [49] FEATURES OF THE NEXTGEN MH-60S GUNNER SEAT

Lindley Bark<sup>1</sup>

<sup>1</sup>Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** The MH-60S NextGen Gunner Seat (crew chief seat) replaces a legacy seat that was associated with discomfort, aircrew endurance issues, and in some cases, chronic injury severe enough to require surgical intervention. The new seat, developed in-house by the Naval Air Warfare Center Aircraft Division, is intended to mitigate these problems and also function to mitigate acute injury potential in crash impacts. The in-house development was initiated because the new seat was needed within two years and clear, quantifiable, and objective test criteria for comfort and aircrew endurance could not be developed with the then-present knowledge. There has long been a rule of thumb that rotorcraft seating can't be crashworthy and comfortable. Success also was dependent on successfully challenging this guidance. **DISCUSSION:** The overall design philosophy of the NextGen Gunner Seat was quite different than for a typical rotorcraft seating system because this design sought to resolve chronic injury as well as acute injury. Several key features of the seat were developed to meet the acute and chronic injury mitigation targets. The human injury problem(s) to be solved was identified, a mechanical solution was developed and employed, and the qualification program demonstrated general results and documented the benefits achieved. Following this overview presentation, other panelists will describe in specific detail the genesis of the NextGen seating system and the novel approaches that were used to qualify it against abstract requirements such as comfort, pain, and chronic injury mitigation. As an example, occupants suffered from numbness in legs and feet which was worse when the gunner was sitting on the front edge of the outboard-facing seat. This was tracked to a poor seat pan design, poor accommodation between the seat and aircraft structure, seat pan height, and excessive vibration. A novel seat pan was designed with a hybrid suspension system that provided vibration-mitigating characteristics when seated normally, spread the loads from the front seat edge when on the gun, reacted the potential crash loads, and allow occupant motion to face forward, side or aft. The features developed and the related success achieved will be discussed here and a later presentation will discuss the approaches used to make objective measures that could be correlated with abstract issues such as comfort and pain for use in future programs.

#### Learning Objective

1. Learn about chronic injury mitigation in Helicopter seating.

Monday, 05/18/2020

Centennial I

2:00 PM

#### [S-12]: PANEL: COMPLEX PROBLEMS AND NOVEL SOLUTIONS FROM JUNIOR AND FUTURE FLIGHT SURGEONS LEADING INNOVATION: PART 1

Sponsored by USAF School of Aerospace Medicine (USAFSAM); Society of U.S. Air Force Flight Surgeons (SoUSAFFS)

Chair: Brian Hanshaw

Co-Chair: Quinton Keigley

**PANEL OVERVIEW:** The constant and evolving mission of aviators, special duty operators, and aircrew trainees across the USA Air Force is diverse and presents complex operational medicine problems. This panel features junior and future Flight Surgeons across the Department of Defense, who will discuss how their flight medicine program delivers innovative solutions to combat the medical issues seen in their diverse population of war fighters. The following presentations carry one theme: bringing medical services directly to their supported populations to increase the value of clinical services to both the patient and the mission they support across the globe at any time and in any condition. This panel has become tradition over recent years and is critical as we strive to build the future of our Flight Surgeons. These individuals are showcasing their vision on the fight against complex and unique medical problems and the impact on keeping our flyers in the fight.

#### [50] SMOKE AND FUMES IN THE COCKPIT

Jeremy Berger<sup>1</sup>

<sup>1</sup>US Air Force, Little Rock Air Force Base, Jacksonville, AR, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** In June 2019, a C-130J aircraft with six crew members developed thick, acrid smoke on the active runway during a touch-and-go training profile. This case presentation describes the action and responses of the crew members and flight medicine response team during an in-flight emergency (IFE). The presentation will also review the most up-to-date treatment options available and make recommendations to further the proficiency of new flight surgeons. **BACKGROUND:** A cockpit with smoke and fumes is a common IFE, yet is challenging for junior flight surgeons to treat due to lack of experience and hands-on training. Smoke and fire can quickly incapacitate a crew unless immediate protective action is taken. **CASE PRESENTATION:** This presentation includes a case vignette where pungent smoke filled the cockpit while an aircrew was performing touch-and-go procedures in a C-130J. A follow-up mishap investigation revealed that the smoke originated from a fluid leak in the number two engine which, in turn, caused noxious fumes to fill the cabin. The flight surgeon onboard immediately urged the crew to don oxygen masks. The crew promptly obliged, opened the fuselage hatch, and performed the prescribed emergency procedures. Treatment options for smoke and fume exposure will be discussed along with a review of in-flight aircrew safety protocols and training. **DISCUSSION:** This case highlights the need of aircrew and flight medicine teams to effectively train together for IFE's. Post-hoc analysis revealed that an aircraft commander did not have time to don his oxygen mask due to task saturation. The flight surgeon lacked experience and relied on clinical intuition to triage the situation. Fortunately, an emergency medical kit was available, and the on-board medic closely monitored the at-risk pilot for incapacitation until the aircraft safely landed. The entire crew emergently egressed without assistance. In hindsight, the other crew members could have aided the pilot with donning his oxygen mask to ensure his safety while he was performing emergency procedures. Three possible solutions can easily be implemented to prevent similar occurrences in the future. (1) Annual safety presentations by flight medicine teams to the flying squadrons can address these specific issues. (2) Shortly before takeoff, flight surgeons can provide the aircrew with succinct reminders of relevant safety procedures. (3) During AMP, junior flight surgeons can formally train for this IFE.



**Learning Objectives**

1. The participant will learn about treatment options for smoke and fumes in the cockpit.
2. The participant will learn about common causes of smoke and fumes in the cockpit.

**[51] DECOMPRESSION SICKNESS IN A C-17 PILOT**Samuel Philbrick<sup>1</sup><sup>1</sup>USUHS, Eagle River, AK, USA*(Original Research)*

**CASE PRESENTATION:** A 28 y/o female pilot presented to flight medicine with 2 days of joint pain that started several hours after a HALO jump sortie in which the pilot's C-17 underwent a planned rapid decompression from cabin-pressurized effective altitude of 10,000 ft to its actual altitude, 17,000 ft. The patient had pre-breathed 100% O<sub>2</sub> for 30 minutes before the decompression, and questioned whether her joint pain was merely due to lack of sleep and spending too much time in the gym. She complained of 2/10 pain that started in the right hip, then partially improved in the hip but manifested in the right knee, and later the right S.I. joint. Her pain felt the same as aches experienced after working out. She had also had a headache the day after the flight that lasted for a few minutes, was not associated with any neurologic deficit, and resolved with over-the-counter NSAIDs. On presentation to the medical group, she was relocated to a treatment room, started on 100% O<sub>2</sub> NRB, laid in the supine position, and oral hydration was started. A head-to-toe neurological exam was normal. Musculoskeletal, pulmonary, and skin exams were also unremarkable. Her unilateral joint pain that started in a large joint and migrated to adjacent joints was concerning for decompression sickness, and the prior presence of a headache was concerning for neuro DCS. However, no hyperbaric chambers were available in the local area. The hyperbaric service in San Antonio was consulted, and the case was discussed with the SGP at Eielson. To avoid an air-evac that could worsen symptoms, the team decided to treat the patient using Eielson's Hyperlite chamber. The pilot was driven straight to Eielson. She was taken off 100% O<sub>2</sub> in transit to avoid oxygen toxicity on the 8-hour drive. Immediately upon arrival she underwent the HAART table. While in the Hyperlite chamber she noticed her joint pain vanishing. On completion of the treatment her symptoms had resolved, and she was returned to duty without restrictions. **DISCUSSION:** This case illustrates the sometimes-unassuming presentation of DCS. The patient had a normal exam and expressed that she thought she was only sore from working out. Yet the immediately resolution of her symptoms in the hyperbaric chamber clearly established the diagnosis of DCS. The case also calls attention to the need to take all potential neuro DCS seriously. Additionally, it highlights the importance of having a plan in a clinical setting with limited resources.

**Learning Objectives**

1. Audience will recognize symptoms of the various manifestations of decompression sickness and will understand how manifestations in different organ systems portend varying disease severity.
2. Audience will review immediate and definitive treatment for DCS and understand the particular importance of definitive treatment for aviators.

**[52] A SURVEY OF AEROMEDICAL EVACUATIONS AND MEDICAL CHALLENGES FROM THULE AB GREENLAND**Thomas Powell<sup>1</sup><sup>1</sup>The Ohio State University, Columbus, OH, USA*(Original Research)*

**INTRODUCTION:** Located only 1000km from the North Pole, Thule AB, Greenland is one of the most northern permanently inhabited communities in the world. Operated by both the US Air Force and the Kingdom of Denmark, the joint base was constructed as an early warning radar installation and northern base of operations; a task it still performs to this day. Although the base used to be home to some 10,000 personnel, only 700-900 live there on a daily basis. Logistical support of such a remote area is challenging, particularly the medical needs of the military personnel stationed there. Although serviced by Danish contractor physicians, the Air Force members there do not have access to sub-specialty care and must be sent back state-side for these needs in a costly "special medical

trip". Additionally, the general austere location of this base can make aeromedical evacuation from the site difficult. **METHODS:** Here we describe two main logistical difficulties of medical operations for the base. First, the rates of medical TDY for both the contractor population and the military personnel were gathered and examined over a 5 year span. Second, the number of days of inclement weather which could preclude aeromedical evacuation to the base were averaged over a 20 year span from 1996 to 2016. **RESULTS:** Rates of medical travel for base military personnel were around 10% per year, with an annual rate of off-site medical use that approached 20% per year when these trips were combined with total MEDEVAC numbers. Weather averages of days with storm conditions, defined as winds above 35kts and visibility less than 800m, were found to average 48 days per year, preventing travel to and from the base at least 13% of the year. **CONCLUSIONS:** When compared to contractor personnel, a off-site medical usage rate of 20% is much higher than the average Contractor rate which was found to be 2%. Further, a MEDEVAC utilization of almost 10% is much higher than Air Force average. Complicating this picture is the severe nature of the weather of the weather at this location, which prevents aviation operations at least 15% of the time, complicating any potential aeromedical evacuation. These issues highlight the challenge of providing medical support to this austere locale.

**Learning Objectives**

1. The audience will understand the medical challenges of operating in the High Arctic.
2. Attendees will learn why USAF personnel have higher utilization rates of off-island medicine.
3. Listeners will understand the challenge of providing aeromedical evacuation to a high latitude locale with its complex weather and logistical challenges.

**[53] OVERBOOK SITUATION ON A KC-135 AEROMEDICAL EVACUATION MISSION**Jeremy Garlick<sup>1</sup><sup>1</sup>USAF, Hickam, HI, USA*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case describes a strategic aeromedical evacuation (AE) mission that was limited in capability by the aircraft type. This required patient triage and tailoring of the medical/non-medical attendants for flight safety, as well as mission execution. **BACKGROUND:** TRANSCOM and its 3 geographic Patient Movement Requirements Centers validate 7,008 patients annually for movement around the globe. Both in INDOPACOM and EUCOM areas of responsibility (AOR), a strategic AE msn is flown weekly which loops through the AOR and collects patients for redistribution to higher levels of care in CONUS or civilian medical facilities. In the Pacific, the route originates at Travis AFB (CA), flies to Hickam Air Field (HI), Andersen AFB (Guam), Kadena AB (Japan), Hickam, on occasion NAS North Island (CA), and terminates at Travis AFB. This mission is typically accomplished using the C-17. Onward distribution of patients to other CONUS locations is typically conducted via civilian air ambulance. **CASE PRESENTATION:** In September 2019, a Tanker Airlift Control Center (TACC) tasked KC-135 embarked on the Pacific mission. One notable limitation of the KC-135 for AE is that space is limited to 40 souls on board. The 6 day mission had an augmented front end crew of 5 and a plussed up AE crew of 9, leaving a total of 26 available. The validated manifest included the following: (1) globally weak Guillain Barre patient with a tracheostomy and percutaneous endoscopic gastrostomy tube; (2) a newborn with a renal vein thrombosis; (3) a 21 month old with an umbilical hernia; (4) an 11 year old (y/o) VATER syndrome patient with intestinal obstruction; (5) Active Duty (AD) 27 y/o with a hand avulsion injury; (6) AD 21 y/o attempted suicide; (7) an 11 y/o with delusions; (8) AD 29 y/o with suicidal ideation; (9) AD 18 y/o with psychosis and possible ingestion; (10) AD 35 y/o prisoner/patient with a multi-year mental health history in pre-trial confinement requiring an armed escort; (11) AD 45 y/o with suspected leukemia; (12) a 65 y/o non-interference patient status post angioplasty with worsening symptoms. Before triage, 50 people were manifested to the flight. **DISCUSSION:** This case highlights the need for a flexible validation system requiring triage and tailored approaches to each mission. This involves coordination between sending Military Treatment Facilities, receiving facilities, crew, specialty teams, and both medical and non-medical attendants.

**Learning Objectives**

1. Audience will gain an appreciation for the TRANSCOM patient movement process, review principles of triage and discuss benefits and limitations of specialized teams, medical/non-medical attendants and trainees. Additionally they will learn the capabilities of AE care in the air and the impact of a complex patient load on the mission.
2. The audience will learn about aeromedical considerations in regards to clearing and validating patients for movement, including appropriate stops, remain overnight stops, cabin altitude restrictions and prescription considerations for flight.

**Monday, 05/18/2020**  
**Centennial II**

**2:00 PM**

### **[S-13]: PANEL: "MAKING SENSE OF SPECIAL SENSES"**

*Sponsored by AsMA Aerospace Human Factors Association*

**Chair: Harriet Lester**

**Co-Chair: David Schall**

**PANEL OVERVIEW:** Intact vision and neuro-vestibulo-auditory functionality are critically important to human performance in the aerospace environment. Techniques and equipment used to assessing these sensory functions can be mystifying to non-specialists. This panel will attempt to demystify some of the current advanced testing tools that may be used to evaluate aviators and share case examples. Seeing, vestibular function, and hearing have unique nuanced qualities and their functions are intertwined in the aeromedical world. Spatial orientation depends upon intact vestibular and visual function. Communication requires visual and auditory input. Danger cues are heard and seen. The brain must integrate all this information to enable human performance in the aerospace environment. We cannot well understand our own anatomy and function without technology, which continues to advance. The impact of some pathology on aeromedical performance can often be mitigated, sometimes not. The aeromedical decision maker needs to be reasonably conversant with current tools and techniques used to assess remaining functionality. They need to understand the information provided in order to apply it to clinical risk based decision making. Clinical testing is usually not functional testing, and aeromedical risk determinations often require extrapolating clinical data to functional performance. Utilizing case presentations, this panel will explain some current technologies used to assess vision and neuro-vestibulo-auditory function, and how technology can help make operational aeromedical determinations about human performance.

### **[54] "DIZZYING TESTS" OR NEUROVESTIBULAR TESTING MADE EASY**

David Schall<sup>1</sup>

<sup>1</sup>FAA, Oklahoma City, OK, USA

*(Education - Tutorial Proposal)*

**TOPIC:** An overview of Neurovestibular testing available to evaluate Aviators. **APPLICATION:** Accurate diagnosis is critical when assessing whether an aviator with dizziness can safely return to the sky. Often the diagnosis is elusive creating a conundrum. Understanding tests available to evaluate the Neurovestibular system may help get the answer. There is a plethora of vestibular tests out there, with a variety of acronyms, which create a bewildering array for the clinician. Tests such as oVEMP, cVEMP, VNG, CDP and EOG are just a few of them. The author will present an overview of these vestibular tests, who does them, what they measure, when it should be used, what it can tell you, and some of the pitfalls associated with their use. Case studies will highlight their clinical application. **RESOURCES:** 1) "Practical Management of the Dizzy Patient," Edited by Joel Goebel; Lippincott Williams & Wilkins Philadelphia, 2001 ISBN 0-7817-1820-1. 2) "Vestibular Function; Clinical and Practice Management" 2<sup>nd</sup> Edition, by Alan Desmond; Thieme, New York; 2011 ISBN 978-160406-361-5.

**Learning Objective**

1. The clinician will have a better understanding of Neurovestibular tests that are currently available, what they measure, when to use them, pitfalls associated with using them and what they can diagnose.

### **[55] TO THE COCHLEA AND BEYOND; PURE TONES ARE NOT THE WHOLE STORY**

John Allen<sup>1</sup>

<sup>1</sup>NASA, Washington, DC, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** Conductive and sensorineural hearing losses impact aviators differently, often require differing test procedures, and require different management procedures. **BACKGROUND:** Referrals for hearing evaluations of aviators are generated for issues ranging from middle ear pathology to neurotologic conditions. Assessments required encompass a variety of measures beyond pure tone audiometry. Two cases are presented to help better understand the measures conducted and the information they can provide, both diagnostic and operational. **CASE PRESENTATION:** The first case describes a pilot suffering a tympanic membrane rupture secondary to inability to ventilate the middle ear during rapid altitude change. The second case involves a pilot who has a bilateral, asymmetric sensorineural hearing loss. In each case the evaluation procedures are described and results are interpreted. Test batteries that include pure tone and speech audiometry; middle ear analysis; otoacoustic emissions; central auditory processing measures; and auditory fitness for duty evaluations will be discussed. **DISCUSSION:** Audiological assessments can do much more than identify peripheral sensitivity. Proper assessment can help with differential diagnosis of conductive, sensorineural, and central pathology; identify need for and type of treatment; guide preventive measures; and determine the potential impact of a loss on quality of life and aviation abilities. Understanding what tests are needed, as well as how they are interpreted and reported is very helpful to the referring aerospace medicine professional.

**Learning Objective**

1. The clinician will understand the variety of audiological tests conducted, for what they are used, how they can guide career/life decisions, and what best to request when making a referral.

### **[56] VISION PERFORMANCE ISSUES: QUALITY OF VISION (QOV) AND COLOR VISION (CV) TESTING**

Douglas Ivan<sup>1</sup>

<sup>1</sup>ADI Consultants, San Antonio, TX, USA

*(Education - Tutorial Proposal)*

Advanced ophthalmic diagnostic testing has revolutionized the ability to visualize histopathological and functional changes in common vision disorders to degrees previously not possible. These diagnostic tools not only provide clinicians and patients with easy diagnostic assessment of the status of their condition, but also provide enhanced understanding of the optical consequences of such disorders, the latter of which contribute to our overall quality of vision (QoV). These technologies go well beyond assessing disease impact by using only traditional high contrast *Snellen letter visual acuity* (SLVA) testing under ideal conditions, a functional limitation that underestimates the occupational impact of such diseases under all operational conditions. Using a progressive clinical corneal thinning and steepening disorder, *keratoconus*, as an occupational case example, this presentation will introduce current and emergent QoV technologies as tools to better understand potential vision performance shortfalls related to clinical disease and limited by SLVA testing alone. Similarly, the degree of color vision (CV) performance necessary for safe and successful occupational task completion has often complicated selection requirements and created policy dilemmas. The debate has been complicated by using clinical tests vulnerable to misclassification or misidentification of a given subject's CV performance. Several transport accidents have already occurred because of some of these CV testing disconnects. International gold standard anomaloscopes for accurately determining the type and degree of an existing CV deficiency are usually only available in specialized testing centers. However, new computer-based CV testing technologies that benefit from more effective color displays and testing logarithms are now available as reasonable replacements in lieu of traditional anomaloscope testing. This presentation will discuss some of these CV testing issues and present these new CV testing technologies.

**Learning Objectives**

1. The audience will understand new ophthalmic technologies used to evaluate overall quality of vision.
2. The audience will understand the limitations of some traditional color vision tests and learn about new tests that can be used in lieu of anomaloscopes.

**[57] ASSESSING RETINAL PATHOLOGY, CAN THE EYE FLY?**Harriet Lester<sup>1</sup>, Benisse Lester<sup>2</sup><sup>1</sup>FAA, Jamaica, NY, USA; <sup>2</sup>NA, Washington, DC, USA*(Education - Case Study: Clinical / Human Performance)*

**PROBLEM STATEMENT:** The unhealthy retina or optic nerve may hamper aerospace visual performance. Two retina case discussions will highlight modalities relevant to aerospace ophthalmology determinations—Optical Coherence Tomography (OCT) and Visual Fields (VF). **BACKGROUND:** OCT has revolutionized the assessment of retinal and optic nerve anatomy and pathology over the last 2 decades. Visual fields usually, but not always, align with anatomical findings. Aeromedical decision making can be stymied by the nonspecialist's confusion with these current test modalities. Knowing what to ask for, and understanding how to interpret the information is very important to make sound operational aeromedical determinations. Controversies and confusion exists. Which machine, which costly technology to use, when to treat and when to wait, and how to apply some technologies such as optic nerve OCT angiography. Real time, real world functioning is not assessed by these clinical tests. Aeromedical risk determinations typically require extrapolating clinical data to functional performance. **CASE PRESENTATION:** 1. A 60 year old former Marine pilot, currently a Certified Flight Instructor, with OSA and longstanding unilateral Coats disease, has undergone repeat treatment with photocoagulation and anti-vegf injections. OCT and fluorescein angiography were utilized during treatment. OCT and VF were then used in making the aeromedical determination of whether the airman could return to working as a CFI. 2. A 52 year old commercial pilot, formerly a military cargo pilot with an 8 month history of ischemic branch vein occlusion on disability. He is heterozygous for Leiden gene. He had a series of monthly anti-vegf injections for persistent macular edema with fluctuating vision. He assumed that his commercial career is over and is considering returning to the military in a nonflight capacity. OCT and the results of other clinical testing to help determine whether this airman can fly again will be discussed. **CLINICAL RELEVANCE:** Anti-vegf and OCT have revolutionized care of some formerly recalcitrant disabling retinal conditions involving vascular leakage. With timely diagnosis and intervention, vision can be saved. OCT and Visual Fields, and other modalities, provide valuable information for aeromedical determinations. Visual fields are psychophysical, with some subjectivity, and other limitations. Familiarity with these current techniques helps aeromedical decision-making.

**Learning Objectives**

1. Understand the importance of OCT to the assessment of macular retinal pathology.
2. Understand some applications and limitations of visual field testing for aeromedical decision making.

**Monday, 05/18/2020****2:00 PM****Centennial III****[S-14]: SLIDE: ASTRONAUT SCREENING AND SURVEILLANCE****Chair: Volker Damann****[58] PRE-FLIGHT MEDICAL SCREENING IN THE COMMERCIAL SPACEFLIGHT PARTICIPANT**Maia Gummer<sup>1</sup>, Lauren Church<sup>1</sup>, Eleonor Frost<sup>2</sup>, Nina Purvis<sup>4</sup><sup>1</sup>King's College London, London, United Kingdom; <sup>2</sup>University College London, London, United Kingdom; <sup>4</sup>Queen Mary University of London, King's College London, London, United Kingdom*(Original Research)*

**INTRODUCTION:** With the advent of commercial spaceflight, the safety of commercial spaceflight participants (CSP) is paramount. There is

currently no commercial spaceflight-specific medical standard, yet companies are recruiting passengers. Each CSP will need to be fit-to-fly to ensure their own and others' safety. This research considers anticipated and studied medical conditions that may be aggravated by the suborbital spaceflight environment (SSE), and describes a standard of pre-flight medical screening for medical professionals. **METHODS:** A suborbital vehicle profile is defined, detailing the environment a participant would experience including G-force acceleration, microgravity, radiation, noise and confinement. A three-phased approach was used to hypothesize medical checks. A literature review was conducted to understand the physiological changes in the SSE, and to identify conditions with which a CSP may present and how these would respond in the SSE. Medical conditions were categorized according to the limitation they might impose on a CSP with parameters for fit-to-fly where appropriate. Certain conditions were subject to extra scrutiny if they were believed to disproportionately affect the predicted demographic. Concurrently, a survey was distributed to aerospace medicine professionals (responders n=19) to assess current knowledge and identify any other considerations. **RESULTS:** Literature review and questionnaire results are collated and presented. There are conditions which would be prohibited, such as recent surgery (14 days), ventricular arrhythmia, or severe inflammatory bowel disease. There are conditions, where appropriately managed, which would be permissible, such as controlled hypertension (150/90mmHg), diabetes mellitus types 1 and 2 (ideally below 48mmol/mol), and asthma (no recent hospital admissions). An extensive table of conditions is presented with parameters for fitness-to-fly, along with guidance for pre-flight medical history taking, examination and investigation – to be personalized according to the CSP. **DISCUSSION:** It is hoped that the proposed pre-flight medical screening will serve as an aid to aerospace physicians and the wider medical community to screen for prohibitive and permitted conditions in order to ensure the safety of CSPs, ensuring full informed consent of the risks of participation. Further research studies into the tolerance of the SSE in participants with pre-existing medical conditions is advocated.

**Learning Objectives**

1. The delegate will be familiarized with the environment experienced by participants during suborbital spaceflight and how this may impact on disease states.
2. The delegate will read guidance collated from existing literature and professional opinion on pre-flight medical checks for commercial spaceflight participants.

**[59] MEDICAL WAIVER FOR SPACEFLIGHT FOR ASTRONAUTS WITH LOWER LIMB AMPUTATIONS: RELEVANT ISSUES**Mark Sheehan<sup>1</sup>, John Charles<sup>2</sup><sup>1</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>2</sup>ACT4space, LLC, Houston, TX, USA**WITHDRAWN****[60] MORTALITY OF COSMONAUTS WHO TRAVELLED INTO SPACE AND THOSE WHO DIDN'T**Igor V. Bukhtiyarov<sup>1</sup>, Igor B. Ushakov<sup>2</sup>, Yuri I. Voronkov<sup>3</sup>,Galina I. Tikhonova<sup>1</sup>, Kristina V. Betts<sup>1</sup>, Tatyana Yu. Gorchakova<sup>1</sup><sup>1</sup>Federal State Budgetary Scientific Institution "Izmerov Research Institute of Occupational Health", Moscow, Russian Federation; <sup>2</sup>Russian State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency, Moscow, Russian Federation; <sup>3</sup>State Research Center, Institute of Biomedical Problems, Russian Academy of Sciences, Moscow, Russian Federation



*(Original Research)*

**INTRODUCTION:** Human spaceflight programs are becoming increasingly ambitious and more extended in time and space, which explains why researches are highly interested in health status problems of cosmonauts, especially in the distant period. **METHODS:** Epidemiological studies of Soviet and Russian cosmonauts' mortality showed a significantly lower risk of dying compared with Russian male population (SMR=40 for all causes, Ushakov I. et al., 2017). American studies also indicated a significantly lower risk of death for astronauts compared with the US population (SMR=72 for all causes, Reynolds R., 2018). **RESULTS:** However, assessing the real effects of the adverse spaceflight factors on cosmonauts' health status and mortality remains a problem due to the absence of an adequate comparison group. Before joining the group, cosmonauts undergo a thorough medical selection process, which continues during training in preparation for spaceflight. That ensures their better initial health status in comparison with the general population and other professional groups ("healthy worker" effect). Reynolds R. et al. (2019) tried to solve this problem by comparing the astronauts' mortality with the mortality of professional athletes, who also undergo professional selection. No statistically significant differences in death rates from all causes between astronauts and athletes were shown, but the risk of death from cardiovascular diseases was significantly lower for astronauts (SMR=39). **DISCUSSION:** In our opinion, cosmonauts who underwent the selection process and special training but did not fly into space for various reasons must be considered as a group for comparative analysis. A historical cohort epidemiological study of USSR and Russian cosmonauts' mortality has started in 2019, including 2 cohorts of cosmonauts: those with experience of spaceflight and those without it. As of January 01, 2019, out of 263 selected cosmonauts 118 had spaceflight experience (44,9%) and 145 cosmonauts had none (55,1%). The cause structure of mortality and mortality rates will be evaluated in both cohorts, the average age of death from specific causes, SMR and other indicators will be estimated. An understanding of the effect adverse spaceflight factors have on the cosmonauts' health will help to preserve their health and improve preventive measures. The reported study is funded by RFBR, project #19-315-90023.

**Learning Objective**

1. To assess the real effects of the adverse spaceflight factors on the cause structure of mortality and mortality rates of cosmonauts.

**[61] EVALUATION OF MEDICAL IMAGING MODALITIES FOR EXPLORATION SPACEFLIGHT**

Michael Boyle<sup>1</sup>, Benjamin Easter<sup>2</sup>, Kris Lehnhardt<sup>3</sup>

<sup>1</sup>University of California, San Francisco, San Francisco, CA, USA;

<sup>2</sup>NASA Johnson Space Center; Baylor College of Medicine, Houston, TX, USA; <sup>3</sup>NASA Johnson Space Center, Houston, TX, USA

*(Original Research)*

**INTRODUCTION:** Exploration-class spaceflight will impose an array of challenges, including severe resource constraints. To design an exploration medical system (EMS) within these constraints, it is important to identify the relative contributions to crew health and performance of every capability in the system. Ultrasound (US) and plain radiography (XR) are ubiquitous imaging modalities with applicability to spaceflight due to their versatility and portability; however, to our knowledge, a comprehensive quantification and comparison of their utility for the diagnosis and management of spaceflight medical conditions does not exist. This work seeks to perform that assessment, an essential step in determining if they should be included in an EMS. **METHODS:** The Exploration Medical Condition List (EMCL), an evidence-informed and subject matter expert-endorsed group of 100 medical conditions of sufficient likelihood or consequence to consider their implications for spaceflight, formed the basis of the analysis. Professional medical society guidelines and the medical literature were reviewed to evaluate the utility of XR and US for the diagnosis and management of each condition. While not systematic, the review was performed with a repeatable search strategy across multiple databases of academic journals and textbooks. Utility was scored on a 0-1-2 scale ("not useful"-"unlikely to change diagnosis/management"-"very useful"). **RESULTS:** US scored > 0 in 44 of 100 conditions, 27 of which had a score of 2. Four commonly-used US probes had scores of 2 for at least one condition, and only 4 of 9 common US modes had a score of 2 for any condition. XR scored > 0 in 27 of 100 conditions, 19 of which

had a score of 2. Importantly, neither XR nor US had any utility for 50 of the 100 conditions. **DISCUSSION:** These results demonstrate that both US and XR can aid in the diagnosis and management of numerous EMCL conditions, but that US provides a wider range of capabilities. XR provided superior utility to US in only 8 conditions. In addition, this work describes a pilot process to appraise the literature to determine the contributions of various capabilities to the EMS. While the ultimate determination of which capabilities to include in such a system requires assessment of their mass, volume, power, and training costs, the development of a traceable process to quantify benefits, such as is described here, is a critical step to a more evidence-based, risk-informed approach.

**Learning Objective**

1. The audience will learn about the relevance of ultrasound and plain radiography for the medical management of conditions that could occur on an exploration class space mission.

**[62] 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>Uniformed Services University, Bethesda, MD, USA;

<sup>4</sup>NASA Johnson Space Center, Houston, TX, USA

*(Original Research)*

**INTRODUCTION:** As NASA plans missions outside low Earth orbit, in-flight medical care must adapt to new mission constraints. We evaluated the operational fitness and imaging performance of Butterfly iQ (iQ, Butterfly Network, USA), an FDA-approved single-probe ultrasound imager with capacitive micromachined ultrasonic transducer (CMUT) technology. **METHODS:** Operational fitness measures included mass, volume, power, availability, interfaces, and data management features. Imaging performance was assessed on an ultrasound phantom (Model 054GS, CIRS Inc., USA) 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). Three simulated emergency procedures were conducted by two physicians (N=5 volunteers). Remote guidance in an ISS scenario (N=5 operators), and autonomous use by untrained operators were also conducted (N=11 operators). Usability ratings and comments were collected by the operators. **RESULTS:** iQ is a single-probe imager weighing <400g using a mobile platform for display, control, and connectivity. In all tests iQ was ready for use in < 30 s. Usability was excellent for constrained mission profiles and acute medical scenarios. Imaging performance of the iQ was comparable to that of the reference device when assessed for superficial, middle-depth, and deep targets. Axial and grayscale resolution in most preset modes 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 achieved excellent results with 10 of the 11 operators successfully obtaining ejection fraction values on a reference patient. **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 with high technology readiness levels are ideal for risk-based care augmentation. Ultimately, these devices will re-define the boundaries of program-agnostic medical capability in human spaceflight. This study is supported by Translational Research Institute for Space Health (TRISH) Grant #FIP0007.

**Learning Objectives**

1. The audience will understand how emerging technologies can enable mission objectives through reduced mass, volume, and power consumption, as well as increased usability and connectivity.
2. The participants will learn about the current trends in the use of "smart" medical devices for remote practice of medical care.

**[63] ASYMPTOMATIC MRI SPINE SURVEILLANCE IMAGING FOR U.S. ASTRONAUTS**

Amy Kreykes<sup>1</sup>, Richard A. Scheuring<sup>2</sup>

<sup>1</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>2</sup>NASA Johnson Space Center, Houston, TX, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Back pain during spaceflight has an incidence of approximately 60%. Four multidisciplinary spine summits held by the National Aeronautics and Space Administration (NASA) since 2005 have investigated space-flight related back pain and back injury in U.S. Astronauts, yet the etiology of in-flight back pain remains unknown. The purpose of this project was to review available information from the summits and develop a spine surveillance protocol for U.S. Astronauts.

**OVERVIEW:** Available summaries and minutes from the following meetings were reviewed: The Operational and Research Musculoskeletal Summit of 2005, The NASA Intervertebral Disc (IVD) Damage Summit of 2009, The 2015 NASA Low Back Pain Meeting, and the 2018 NASA Spine Workshop. The 2005, 2009, and 2015 summits determined that micro-gravity is associated with lumbar spine pain, and IVD damage following spaceflight is evident in U.S. astronauts. These summits recommended pre- and post-flight surveillance spine imaging with MRI as clinically indicated, but an imaging requirement was not adopted in asymptomatic astronauts for surveillance. In recent years, two mission assigned crewmembers have developed symptomatic back pain pre-flight. MRI confirmed IVD, facet hypertrophy, and a single level herniated nucleus pulposus (HNP). Treatment was rendered according to the current standard of practice and the pre-flight strength and aerobic conditioning program was modified. On-orbit conditioning was also modified. Both crewmembers completed their long-duration missions without symptoms. Post-flight MRI was remarkable for near complete resorption of the HNP. The 2018 NASA Spine Workshop reviewed individual astronaut clinical case reports and provided a review of relevant literature and current knowledge of spinal adaption to microgravity. It focused on conditioning programs, back pain in space, and post-flight spine disorders. The multidisciplinary subject matter expert panel recommended the adoption of pre- and post-flight spine MRI. **DISCUSSION:** Asymptomatic spine MRI for surveillance has been considered independently at four summits since 2005. Crewmembers with symptomatic spinal pathology have successfully completed their missions with modification of their conditioning pre-, during, and post-flight. Pre- and post-flight non-contrast spine MRI surveillance imaging has now been recommended and a surveillance protocol is being taken to the appropriate governing bodies at NASA for consideration.

**Learning Objective**

1. Understand the scope and evidence behind spine surveillance imaging for U.S. Astronauts.

**Monday, 05/18/2020****2:00 PM****Centennial IV****[S-15]: PANEL: NEUROLOGIC SELECTION ISSUES****Chair: Roger Hesselbrock**

**PANEL OVERVIEW:** Neurologic conditions are commonly encountered in aviators. Particularly worrisome aeromedical risks include potential for sudden incapacitation, operational distraction, and unrecognized subtle functional impairments. Some neurologic disorders have well-established evidence-based risk data that are directly applicable to aviators, but many neurologic conditions do not have relevant evidence-based future risk information, producing difficulties in determining suitability for initial aviation service. Military aviation service medical certification for selection is particularly challenging, with the need to not only forecast risk during initial training but also to assess risk over a full career. Advances in technology and medical care have allowed safe medical certification of neurologic conditions that formerly were considered permanently unfitting. Genetic analysis tools allow for earlier identification of neurologic conditions in their presymptomatic stage, some of which may be compatible with aviation service training and continuity. This panel will present information on aeromedical selection and retention risk for several neurologic conditions encountered in aviators. Topics to be covered include childhood seizures/persistent abnormal EEG findings, traumatic brain injury, headache/migraine, hereditary/genetic conditions, and implanted neurologic devices. Audience participation and discussion are encouraged.

**[64] EEG IN AIRCREW SELECTION**Frank Weber<sup>1</sup>, Denis Bron<sup>2</sup><sup>1</sup>German Air Force Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>2</sup>Aeromedical Center Swiss Air Force, Dubendorf, Switzerland*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** The use of EEG in aircrew selection is controversial. Eg the EASA regulations do not stipulate a routine EEG examination in first examinations for class I medicals. Less than 1% of all aviation accidents are thought to be caused by sudden incapacitation. In military flying, the most common cause of sudden incapacitation is a physiological one (hypoxia, improper G-protection), but the most common disease related onset cause for a sudden loss of consciousness is new-onset epilepsy. **METHODS:** The frequency of epilepsy in the total population 0,4% to 1%, in the comparable age group 0,3% bis 0,8%. Paroxysmal EEG abnormalities are found in 2 to 3% of all healthy individuals. Own data show a prevalence of paroxysmal EEG abnormalities in healthy applicants of 1,5%. Given a prevalence of epilepsy of P(E)=0.005, a sensitivity of the EEG of P(EEG+|E+)=0.52 and a specificity P(EEG-|E-)=0.97, Bayes theorem calculates a positive predictive value of 0.08 and a negative predictive value of 0.9975. This selection procedure is exemplified by a case of the SWISS Air Force, who has been selected out for military flying due to so far incidental EEG abnormalities. Further on, the applicant moved to civilian flying and experienced subsequently an epileptic seizure during take off. **CONCLUSION:** Because of the high negative predictive value, we believe that EEG screening is still a valid procedure.

**Learning Objectives**

1. The participant will be able to understand the predictive value of EEG in aircrew selection.
2. The participant will be able to understand the problems of incidental findings in EEGs of previously healthy individuals.
3. The participant will be able to understand the various interictal epileptiform discharges in EEG.

**[65] AN APPROACH TO THE DETECTION AND AEROMEDICAL DECISION MAKING IN AVIATORS WITH GENETIC DISORDERS**Christopher Skinner<sup>1</sup><sup>1</sup>University of Ottawa, Ottawa, Ontario, Canada*(Education - Case Study: Clinical / Human Performance)*

This presentation illustrates several cases of genetic disorders discovered in experienced aircrew including tuberous sclerosis, Charcot-Marie-Tooth Disease and Huntington's Disease. The approach to investigation and rationale for decisions made for aircrew fitness disposition in these disorders will be discussed. The detection of potentially significant genetic disorders in experienced aircrew presents significant challenges to regulators in that these disorders are usually rare with atypical presentations and life histories. There is also little scientific literature for guidance with respect to aeromedical disposition these cases. These disorders are usually adult variants of genetic syndromes which were not detected clinically during the recruitment and training process. The use of an enhanced aeromedical risk assessment matrix for both sudden incapacitation and chronic disability will be demonstrated to provide a framework for discussion of the disposition in the cases presented.

**Learning Objectives**

1. To describe several cases of genetic disorders discovered in experienced aircrew.
2. To describe the challenges faced by regulators in assessing the fitness of aircrew affected by these disorders.
3. To illustrate how the aeromedical risk matrix can be adapted to assist in decision making with respect to these disorders.

**[66] IMPLANTED NEUROLOGICAL DEVICES**Peter Letarte<sup>1</sup><sup>1</sup>Premier Health, Dayton, OH, USA*(Education - Case Study: Clinical / Human Performance)*

Management of Neurological Conditions often can involve the placement of devices. Examples include ventriculo-peritoneal Shunts, Morphine and Baclofen pumps, epidural stimulators and deep brain stimulators. The presence of these devices in candidates for flight training

is not disqualifying for all devices. Screening criteria focus more on the condition being treated than on the device itself. Little is known about the air worthiness of some newer devices. A brief description of these devices will be provided. What is known and unknown about the impact of barometric pressure change and electromagnetic interference will be discussed. Concerns about device reliability will be examined. There is little experience in evaluating patients with Deep Brain Stimulators for flight duties and some possible concerns will be reviewed.

#### Learning Objectives

1. The participant will be able to describe the purpose and function of commonly implanted Neurological Devices.
2. The participant will be able to discuss the potential air worthiness issues surrounding these devices.
3. The participant will be able to discuss the issues to be considered in evaluating individuals with implanted Neurological devices for fitness for flight duties.

### [67] AVIATION SELECTION CHALLENGES IN THE INDIVIDUAL WITH A HISTORY OF TRAUMATIC BRAIN INJURY

David Van Wyck<sup>1</sup>

<sup>1</sup>U.S. Army, Fayetteville, NC, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Aviation medical selection has historically relied on explicit criteria, as often as possible, designed to aid in determining an applicant's medical fitness for flight duty. Traumatic brain injury (TBI) presents a challenge to this approach considering the significant heterogeneity across all degrees of TBI severity; two applicants with the same severity of TBI often experience the condition in vastly different ways. With an increasing worldwide incidence and prevalence, TBI can be expected to be encountered more frequently in the aviation selection processes. It is therefore critical that aviation medicine practitioners maintain a familiarity with the evolving TBI science to include pathophysiology of different mechanisms, diagnosis and treatment, and how evolution in these areas can affect aeromedical fitness determinations. **OVERVIEW:** Aeromedical concerns in the aviation selection process of a patient with TBI focus on three key elements: 1) fixed neurological deficits, 2) neurocognitive impairment, and 3) seizure risk with sudden incapacitation. Higher injury severity typically results in more significant dysfunction in each of these categories, and extends the period required for the brain to form or reorganize synaptic connections that result in functional recovery. Nevertheless, TBI and its sequelae are varied and diverse, and recent evidence is increasingly demonstrating that even with mild TBI (mTBI), a significant percentage of patients may suffer from complications for much longer than traditionally believed. This is further complicated by a tendency amongst aviation applicants to downplay their symptoms if they believe doing so will increase the likelihood of application approval. These considerations highlight the inadequacy of existing TBI aeromedical selection criteria and the need to individualize the approach to TBI in aviation selection. **DISCUSSION:** Determining aeromedical fitness in applicants with a TBI history is critical to ensuring the safety of other aircrew, passengers, and the aircraft. An individualized approach to each case will ensure fairness to the applicant and allow the clinician to identify and address elements of aeromedical concern. Traditional diagnostics such as neuroimaging and cognitive screenings should be used with up-and-coming prognostic biomarkers and automated neuropsychological assessment tools to optimize the selection process.

#### Learning Objectives

1. Understand the complex challenges TBI poses to aviation selection and the need for individualized evaluation and assessments.
2. Become familiar with future diagnostic and screening options that will be available and may aid in making medical determinations in the aviation selection process.

### [68] AEROMEDICAL DISPOSITION OF PRIMARY HEADACHE DISORDERS IN US NAVAL AVIATION

Edwin Park<sup>1</sup>

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

(Education - Program / Process Review Proposal)

**BACKGROUND:** Primary Headache disorders are common neurological conditions that have implications for safety of flight and

mission effectiveness in military aviation. A diagnosis of Migraine, with or without Aura, or one of the Trigeminal Autonomic Cephalalgias, is considered disqualifying (CD) for flight duty in US Naval Aviation. Other Primary Headache disorders may be CD if they cause service members to alter their behavior due to interference by the headache or related symptoms. **OVERVIEW:** Aeromedical waiver for disqualifying primary headache disorders may be granted when assessment indicates that the likelihood of adverse impact to flight safety or mission effectiveness is low. Applicants to Naval Aviation flight programs who carry disqualifying primary headache diagnoses or otherwise have headaches that are CD may be denied a waiver under conditions that would be accepted for designated personnel. Headaches disorders with the potential to cause impairment of vision, such as Migraine with visual Aura, represent their own unique hazard to safety and mission. Waivers are considered on a case-by-case basis but rarely supported by the Naval Aerospace Medical Institute's (NAMI's) Clinical Advisory Committee for applicants and generally invoke restrictions for designated personnel. **DISCUSSION:** This presentation will discuss waiver criteria and considerations for and against aeromedical waiver as applied by the NAMI Clinical Advisory Committee to disqualifying headache disorders. For designated personnel with migraine factors taken into account include frequency and severity of attacks, predictability, success at trigger avoidance, recognition of prodromal symptoms, ease of and response to treatment (abortive and/or preventive), accompanying symptoms, presence or absence of aura, type of aura, aircraft type, experience, exacerbating or ameliorating factors. For applicants with a history of migraine factors additionally include remoteness of regular attacks, duration of remission, as those with active, frequent attacks and/or visual aura are not eligible for waiver. **RESOURCES:** US Navy Aeromedical Reference and Waiver Guide <https://www.med.navy.mil/sites/nmotc/nami/arwg/Pages/AeromedicalReferenceandWaiverGuide.aspx>

#### Learning Objectives

1. Understand the process for determining whether the diagnosis of a primary headache disorder is disqualifying for US Naval Aviation personnel.
2. Understand the NAMI process for determining whether a waiver for a disqualifying primary headache disorder is appropriate.

Monday, 05/18/2020

2:00 PM

Regency 6

### [S-16]: PANEL: "ALL I NEED IS THE AIR THAT I BREATHE" - DIFFERENT PERSPECTIVES ON AIRCRAFT CABIN AIR QUALITY

Sponsored by Air Transport Medicine Committee

Chair: Quay Snyder

**BACKGROUND:** Air transportation of passengers, cargo and potentially hazardous materials is growing rapidly worldwide. Aircraft Cabin Air Quality (CAQ) affects the health and safety of both crew and passengers. Questions raised by some organizations coupled with the general paucity of readily quantifiable measures of potential harmful substances both in vivo and in vitro create uncertainties regarding the potential health effects of air travel. This panel addresses crew/passenger concerns, available current and potential future measurement and mitigation technologies and strategies to minimize health risks. **OVERVIEW:** Passengers and aircraft crew are exposed to a variety of potentially hazardous compounds in aircraft cabin air. Additionally, noxious odors/fumes may increase anxiety about CAQ even if not harmful to health. Real-time measurement of cabin air components during specific events is particularly challenging. In vivo measurements of suspected cabin air contaminants and assigning a health risk is currently not clinically available. Individual variations in sensitivity to particular compounds from single events or sensitization to multiple exposures complicate risk assessment and mitigation strategies. Media sources have increased awareness of CAQ issues in the public, while the scientific community looks for evidence-based detection, mitigation and prevention techniques. **DISCUSSION:** This panel will discuss CAQ issues from various perspectives. Pilots and cabin crew are occupationally exposed to various CAQ environments and have particular concerns



about potential effects on health. They may be exposed to noxious or hazardous airborne substances from passengers, food, cargo, the aircraft or air contaminants introduced in to aircraft cabin air. Industrial hygienists seek to measure potential hazardous components of CAQ and assess risk, if any, to single and repeated exposures. Aircraft manufacturers seek to design systems to insure safe air quality for all who fly. Measurement and filtration of potentially hazardous CAQ environments presents challenges. Finally, airlines have a strong interest in protecting the health and comfort of their employees and passengers while maintaining a reasonable economic return on their services. Standardized universal CAQ event reporting and data collection is essential for progress. Education of the public and aircrews is essential to understanding relative risk and mitigation strategies for the flying population.

#### [69] "ALL I NEED IS THE AIR THAT I BREATHE" - DIFFERENT PERSPECTIVES ON AIRCRAFT CABIN AIR QUALITY. A PILOT PERSPECTIVE

Helen Hoar<sup>1</sup>

<sup>1</sup>AME, Bristol, United Kingdom

(Education - Program / Process Review Proposal)

**BACKGROUND:** Aircraft environmental control systems are critical in maintaining safety and comfort in air transport operations. The cabin environment has been under scrutiny for decades, but whilst research has furthered our understanding of the issues, uncertainties still remain. This presentation will review cabin air quality events (CAQE) from a pilot perspective, focusing on education, training, health and reporting.

**OVERVIEW:** Contamination of cabin air by smoke, fumes or odors can arise from a vast multitude of sources both internal and external to the aircraft. In most commercial aircraft, air is extracted (bled) from the engine compressors, cooled and introduced into the cabin to maintain the desired pressure and temperature. Infrequently, this air may become contaminated by engine oil or hydraulic fluid, leading to odors, fumes or smoke in the cabin. Significant CAQEs may cause symptoms in passengers and crew; pilot education and training is vital to ensure crew can recognize and respond appropriately to a CAQE in order to maintain flight safety. Short-term health effects are typically irritant in nature; medical advice should be sought should symptoms be significant or persistent in nature. Pilots should be aware of when and how to seek medical advice post-event; an assessment pathway has been developed in order to facilitate proportionate and appropriate medical evaluation. Longer-term health effects remain more controversial. The symptoms reported are wide-ranging and no incontrovertible causal link has yet been established despite extensive research, whilst the impact of individual variability or any cumulative effects have yet to be fully determined. Reporting procedures should be standardized to improve our understanding of the scale and nature of CAQEs. Detailed crew reports will assist with engineering investigations; a standardized reporting form has been published to facilitate this process. It is also recommended that CAQE reports are incorporated into an operator's Safety Management System to facilitate a wider understanding amongst flight operations personnel. **DISCUSSION:** CAQ events remain an area for pilot concern in terms of both flight safety and health effects. Evidence-based education and training of pilots and crew remains an essential component in ensuring a proportionate and appropriate response, whilst comprehensive reporting and further research will allow a greater understanding of this - at times - controversial topic.

#### Learning Objective

1. The audience will learn about various reporting systems available to commercial pilots for cabin air quality events.

#### [70] FLIGHT SAFETY AND OCCUPANT HEALTH IMPLICATIONS OF BREATHING OIL AND HYDRAULIC FLUID FUMES ONBOARD

Judith Anderson<sup>1</sup>

<sup>1</sup>AFA-CWA, Washington, District of Columbia, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** With the exception of the B787 "Dreamliner", commercial and military aircraft are designed to supply unfiltered engine bleed air to ventilate the cabin and flight deck. The problem with this

design is that engine oil and hydraulic fluid fumes, which are either produced in or ingested into the engine(s), can contaminate the ventilation air that is supplied directly to the occupied spaces, whether on the ground or in flight. The associated flight safety and crew health hazards of breathing these types of fumes onboard have been recognized since at least the 1930s, but are not yet remedied, either by regulation or common practice. **OVERVIEW:** An overview of the chemical constituents of these types of fumes, the exposure conditions (i.e., enclosed space, reduced pressure), and the flight safety and occupant health implications, will all be described. **DISCUSSION:** The documented complexity of the chemical mixtures in these types of fumes, combined with the typical onboard exposure conditions, preclude any simple assessment of hazard based on comparison of the predicted concentration of one or more individual chemicals to published exposure limits. Sources of documentation that may be available to confirm the type of fumes, as well as lab/clinical tests that have been recommended post-exposure, will be summarized. Additional resources for treating doctors will also be provided.

#### Learning Objectives

1. The participant will be able to describe the different types of fumes that can contaminate the ventilation air in the aircraft cabin and flight deck, the complexity of the mixture of chemicals in these fumes, and the toxicity of the key constituents.
2. The participant will understand what sources of exposure documentation are available (and unavailable) to supplement the crew/passenger's report of onboard exposure to oil or hydraulic fluid fumes.

#### [71] WHAT WE KNOW ABOUT THE TOXICOLOGY OF THE CHEMICALS IN CABIN AIR

Richard Pleus<sup>1</sup>

<sup>1</sup>Intertox, Inc., Seattle, WA, USA

(Education - Program / Process Review Proposal)

This presentation is an overview of the chemicals in aircraft, with a focus on commercial aircraft. The substances of interest include those that affect the nervous system. Both the central and peripheral nervous systems are targets of concern. I focus on the chemicals that have either the most significant toxicological interest and compounds related to reported health effects. These chemicals are found in aviation products, such as jet engine oil, or are the result of some modification, such as by-products of pyrolysis. Integrated into this presentation are the route and time of exposures, the characteristic odors and how they can affect the nervous system, and health effects reported by aircrew. Relevant research in both laboratory animals and humans is key to supporting the information in this presentation.

#### Learning Objectives

1. Understand the approach to conducting a toxicological risk assessment for environmental chemicals.
2. Understand the how health risk is related to the hazard (the chemical) and exposure.
3. Understand the current knowledge regarding the toxicology of fume or odor events.

#### [72] CABIN AIR QUALITY EVENTS: AN AIRLINE MEDICAL PERSPECTIVE

Ian Hosegood<sup>1</sup>

<sup>1</sup>University of Queensland, Sydney, Australia

(Education - Program / Process Review Proposal)

**BACKGROUND:** The term Cabin Air Quality Event (CAQE) is a collective designation for events where there is an reported reduction in the quality of air onboard an aircraft. Such events can range from an odor through to events where there are visible smoke, fumes or mist. Potential origins of the events include contamination of aircraft cabin conditioning systems, entrainment of extraneous air sources and other internal sources separate from the conditioning system. There has been an increasing focus and research on the possible health implications of such events and it is clear that some contamination events lead to short and sometimes medium term health effects. Whilst several large international reviews have found no evidence of a causative relationship to long term health effects, controversy and uncertainty remains. Whilst further research is underway in relation to the significance of these events, airlines are

working on ways to reduce the incidence of such events and on how to manage events including the provision of appropriate health care to affected crews and passengers. **OVERVIEW:** This paper describes one airline medical departments approach to the medical management of these events including the experience in applying a real time teleconference approach when events occur to assist in the triage, treatment and risk communication aspects of these events. The paper also discusses the data collection used to track CAQEs and efforts underway to prevent events and to troubleshoot aircraft that have been involved in CAQEs. The paper discusses how some well intentioned efforts to highlight the potential risks to health from CAQEs may potentially create anxiety issues amongst aircrew. **DISCUSSION:** CAQEs remain a challenge in terms of prevention and management. Ongoing research is required in order to better understand the potential health implications but action on improvements in management and prevention activity should not be linked to research timelines. Sharing of best practice between airlines, manufacturers and unions provides the best opportunity to preserve aircrew health. Healthcare and risk communication needs to be evidence based to avoid the creation of additional health burden from anxiety.

#### Learning Objectives

1. The participant will be able to understand how an airline medical department approaches the medical management of Cabin Air Quality Events (CAQEs).
2. The participant will understand why risk communication is an important aspect of managing CAQEs.
3. The participant will understand the IATA medical management protocol for CAQEs.

### [73] CABIN AIR FILTRATION ARCHITECTURE AND IN-SITU PERFORMANCE

Paul Roux<sup>1</sup>, Marilena Dinca<sup>1</sup>

<sup>1</sup>Portsmouth University, Portsmouth, United Kingdom

#### (Original Research)

**INTRODUCTION:** Air quality in commercial aircraft cabins is a subject of much scrutiny. Contaminants such as VOCs, ultrafine particles and occurrences of odor events give rise to discussion regarding subjects such as health & safety of crew and passengers & disruption of air transport services. Although advances in filtration technology and materials have enabled effective treatment of such contamination, the application of these technologies in the restricted environment of the aircraft is more problematic. Analysis of returned cabin air filters helps establish the effectiveness of cabin air filtration & to generate a profile of cabin contamination over many thousands of operating hours. This information can be used to help identify improvements for cabin air treatment in the future. **METHODS:** Routine analysis is carried out regarding the performance of HEPA & activated carbon cabin air filters returned from service with known operating hours, or after a reported odor event. Analysis includes visual inspection, pressure drop testing, adsorbed species analysis and residual VOC removal efficiency. To date, a total of more than 250,000 flight hours of data related to HEPA/activated carbon filter performance has been accumulated, with returned filters having service intervals up to 6000 operating hours. Dedicated flight deck odor filters from cargo aircraft are also analyzed. These filters are free from the VOCs generated in the passenger cabin & provide closer representation of VOCs generated by the aircraft and within the airport environment.

**RESULTS:** GCMS analysis of returned cabin air filters shows that:

- VOCs with boiling points above 150°C are adsorbed effectively.
- VOCs with boiling points between 50°C & 150°C are adsorbed effectively whilst the filter is new, but efficiency reduces during the first 1000 flight hours
- A significant proportion of the VOCs adsorbed are generated in the cabin, however aircraft fluid related compounds and compounds from the airport environment are also prevalent particularly on cockpit filters from cargo aircraft.

**DISCUSSION:** ECS architecture on current aircraft allows certain contamination into the fresh air supply, whether from the environment or aircraft systems, which will pass through the cabin once before being filtered by the recirculation air filters. The quality of the air in the cabin could be significantly improved by using filtration in the fresh air flow, removing those contaminants.

#### Learning Objectives

1. Understand the capabilities of combined HEPA/VOC recirculation filters and how they affect the quality of the air in the aircraft cabin.
2. Understand the limitations of recirculation air filtration and the steps necessary to make significant improvements to cabin air quality.

### [74] CABIN AIR QUALITY - THE MANUFACTURER PERSPECTIVE

Andreas Bezold<sup>1</sup>

<sup>1</sup>Airbus Operations GmbH, Hamburg, Germany

#### (Education - Tutorial Proposal)

At cruise altitudes for commercial aircraft, conditions of very low temperature and pressure, elevated ozone concentrations as well as the lack of humidity constitute a hostile environment to human beings. In order to create a life-supporting atmosphere inside the aircraft, environmental control systems regulate pressure, temperature and air exchange in the cabin and hence are crucial for passenger flight. As passenger air travel is increasing and aircraft cabins are therefore increasingly becoming a part of the usual habitat for humans, passenger & crew expectations for the cabin environment are growing. Hence, both aircraft manufacturers and operators place considerable focus on the provision of odorless clean air supply. The ban of smoking in aircraft cabins was one important step towards this objective. However, in certain circumstances, cabin air may become contaminated inadvertently during operation, which could lead to temporary odor occurrences in the aircraft cabin. On occasion, the mere perception of odor in cabin air may also contribute to conscious or subconscious physiological responses. There is a growing interest in the investigation of odor events in order to ensure these do not pose a risk to human health. During last decades, concerns have been raised in particular about the potential contamination of hot bleed air with jet engine lubricating oil. Although many studies have been conducted including in-flight measurements partially with reported odors and laboratory studies on thermal decomposition of jet engine lubricating oil, little was known about the specific contaminant pattern in the bleed or cabin air and its chronological sequence during an odor occurrence related to jet engine oil contamination compared to other flight conditions. In order to identify and trace airborne contaminants, Airbus performed flight tests with artificially provoked engine oil contamination. Additional measurements in a test cell on ground were accomplished to further narrow down the main specific pollutants introduced by such contamination. In order to investigate the contamination patterns monitoring of inorganic gases and traditional sampling was combined with online mass spectrometry with proton transfer reaction ionization. The results identified a very low concentration (parts per billion) of a number of specific organic pollutants, which may be used as marker substances for identification of the root cause of specific cabin odors.

#### Learning Objectives

1. Understand partially conflicting design requirements and design restrictions of environmental control systems.
2. Understand the basic principle of odor perception and the difficulty to determine odors based on objective analytical means.
3. Understand, which substance species are assumed to mainly contribute to the odor perception during an oil related contamination.

Monday, 05/18/2020

2:00 PM

Regency 8

### [S-17]: SLIDE: TOPICS IN SPACE MEDICINE PRACTICE

Chair: Keith Brandt

Co-Chair: Moriah Thompson

### [75] MEDICINA AD ASTRA: A REVIEW OF OPERATIONAL FLIGHT SURGEONS FROM 1958 - 2019 AND BEYOND

Richard Scheuring<sup>1</sup>, Jason David<sup>2</sup>, James Polk<sup>3</sup>, Michael Barratt<sup>1</sup>, Josef Schmid<sup>1</sup>, Thomas Marshburn<sup>1</sup>, Charles Doarn<sup>4</sup>

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*(Original Research)*

**INTRODUCTION:** Space operations in the USA have required the skills of trained aerospace medical specialists since before the inception of the national space agenda in 1957. The scientific literature is extensive in its coverage of physiology, clinical science, and conjectures on the nature and future of Space Medicine. Yet there is a paucity of subject matter on the operational aspects of the Space Medicine. More than a half-century of experience and lessons remain to be explored, and more importantly, documented in a comprehensive manner. The goals of this project are to examine the evolution of the space Flight Surgeon, define the space flight surgeon today, and explore the future of operational space medicine. **METHODS:** The data gathered for this project was taken from several sources including: a literature review; 3 panels of flight surgeons on Apollo, Skylab, and Shuttle eras; and personal interviews with several active space flight surgeons. **RESULTS:** The Literature Review along with the oral histories yielded 87 titles, with 30 citations used. The Apollo study had approximately 81%, (18/22) participation; generating 107 human factors and flight medicine-related recommendations. The Skylab study had 100% participation with 13 unique recommendations. The 1981 – 2011 study had approximately 75% (35/47) participation. 13 personal interviews with past and current NASA flight surgeons, astronauts and other personnel (1964 - 2019) were examined ( 25-30 hours of interview time). **DISCUSSION:** To our knowledge, this paper is the first project to comprehensively review the evolution and current meaning of operational space flight medicine, as well as to explore its future development as a specialty. In recent history, the role of the operational flight surgeon in Space Medicine has become obfuscated. Their virtue as the source of expertise in the operational and clinical aspects of space medicine has been overlooked and somewhat unrecognized by the general public. Therefore, this paper has documented the evolution of operational flight medicine 1958, the extensive and critical role that operational flight surgeons played in American spaceflight and has illustrated this information with individual accounts that give personal depth to six decades of activity. This paper is not an exhaustive account of these subjects, but rather the seminal first-step of what should be a vigorous further interest and investigation into the story of Operational Space Medicine.

**Learning Objective**

1. The Audience will Learn about the evolution of the Space Flight Surgeon as well as predictions about the development of the medical specialty from an operations standpoint based on the opinions of several current thought-leaders.

**[76] FILLING THE VOID: THE ROLE OF THE MEDICAL PROVIDER IN ANALOG SPACE**

Bonnie Posselt<sup>1</sup>, Sheyna Gifford<sup>2</sup>, Rochelle Velho<sup>3</sup>, Marc Shepanek<sup>4</sup>, Marc O'Griffo<sup>5</sup>, Adrianos Golemis<sup>6</sup>

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*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Simulated space missions were introduced by government space agencies to support initial human spaceflight attempts during the Apollo era. Analog space, is a unique environment utilized for invaluable training, testing, and as a performance-optimization platform prior to and during every subsequent phase of actual space exploration including Skylab, shuttle, and the International Space Station. It is vitally important appropriate medical risk assessments have been performed and the best medical care possible is aspired to. **OVERVIEW:** Simulated space missions have expanded into a spectrum of citizen science projects of varying scales and fidelities. These extra-governmental efforts provide further opportunities to examine human-spaceflight-relevant clinical and technological issues. Where agency-run analogs have been essential to the past success of human spaceflight, citizen-scientist analogs may be able to confer similar benefits to future space habitation: if standards in data collection and human safety can be formulated and applied. Currently, rigorousness in terms of data collection and human safety in non-agency analogs varies widely, this

may be due to lack of awareness, limited funding or inadequate situation specific medical preparation. The diversity of these simulated space environments creates a range of medical and data-relevant risks making any solutions even more challenging.

**DISCUSSION:** We will discuss the opportunities provided by these potential analogs, and challenges for how they might support space mission research. Additional recommendations will be offered for optimizing medical conduct to these analog missions to enhance safety while maintaining fidelity, which will have the added effect of improving any data gathered. In addition, we will present opportunities for medical community involvement in ongoing in-sim health surveillance and performance improvement.

**Learning Objectives**

1. The audience will learn about the critical role of human analogs in exploration space missions.
2. The audience will learn about the diversity and variety of human analog missions and the issues that arise from that.
3. The audience will learn about the evolving role of healthcare practitioners and how the aerospace medical community could assist in guiding this development.

**[77] QUANTIFYING MEDICAL PROVIDER KNOWLEDGE, SKILLS, AND ABILITIES FOR USE IN EXPLORATION SPACEFLIGHT MEDICAL SYSTEM DESIGN**

Dana Levin<sup>1</sup>, Kerry Mcguire<sup>1</sup>, Kris Lehnhardt<sup>1</sup>

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*(Original Research)*

**INTRODUCTION:** Knowledge, skills, and abilities (KSA) are a key part of spaceflight medical systems. The latest medications and the best digital and mechanical tools are meaningless without the KSA to use the equipment, interpret the data, and execute a treatment plan. KSA is traditionally dependent on a provider's training and referenced by a title that represents a baseline skillset and scope of practice each provider is expected to possess, such as paramedic, doctor, nurse, etc. Different training confers various levels of proficiency in each KSA area. This affects how the provider interacts with the available medical tools and the medical system's capability to impact health and performance. While some KSAs will be critical in spaceflight, others may not be needed at all. For this reason, appropriately scoping the medical system to lower overall mission risk requires trades between KSAs similar to how equipment and device trades are made to optimize mass/power/volume requirements. **METHODS:** The Exploration Medical Capability Element (ExMC) of the NASA Human Research Program recently initiated a pilot study to determine the feasibility of this concept. This pilot includes identifying key skillset differences between medical provider types, literature reviews for evidence to support quantifying these skillset differences, and creating metrics to model how the degree of proficiency in each attribute affects the ability to manage illness and injury in space.

**RESULTS:** The most impactful skillset attributes identified include; preventive measures, which modify the incidence of a disease process; diagnostic capabilities, which modify the probability of correctly identifying a specific illness/injury; stabilization techniques, which modify disease progression; equipment stewardship, which modifies the amount of supplies needed to accomplish a diagnostic or treatment procedure; and procedure skill, which modifies the overall chance of success for a given proficiency level with each individual or group of procedures. **DISCUSSION:** Adjusting each skillset attribute can be used to modify the incidence and progression of each illness/injury, the type of equipment and amount needed for diagnosis and treatment, and the likelihood of treatment success or failure. ExMC intends to incorporate these KSAs into an integrated medical system trade space analysis tool suite and the requirements for the medical system.

**Learning Objectives**

1. Understand how medical provider knowledge skills and abilities affect medical system performance.
2. Define one method by which medical provider knowledge skills and abilities (KSA) can be modeled to facilitate KSA trades during medical system development as part of a method to optimize the system for the lowest possible overall mission risk.



# **[78] REMOTELY GUIDED ULTRASOUND DRAIN PLACEMENT WITH "JUST IN TIME" TRAINING: AN ANALOGUE FOR TREATMENT OF SURGICAL EMERGENCIES ON LONG DURATION MISSIONS**

David Lerner<sup>1</sup><sup>1</sup>University of Washington, Seattle, WA, USA

(Original Research)

**INTRODUCTION:** Surgical emergencies on Exploration Missions could have devastating effects. Using image guided procedures for treatment has been described. Previous research focused on subspecialists, however, a physician-astronaut with general training is likely to be selected. We show a novel technique for treating such emergencies with remote guidance and "just in time" (JIT) training by volunteers without image guided experience as an analogue for long duration missions. **METHODS:** A phantom with an internal fluid collection was made to simulate surgical emergencies in microgravity such as abscess. A "JIT" training video was made with instructions for performing ultrasound guided drain placement. Medical students and residents were recruited with zero exposure to dedicated ultrasound training. Individually, they were put in a room alone with an ultrasound, prepared phantom, equipment, and a tablet with video camera. Participants viewed the "JIT" video, and asked questions via remote interaction by video conference link on the tablet. They were talked through the procedure with remote guidance using the tablet in a stepwise function by a radiologist. The access needle was guided into the fluid under ultrasound, a wire advanced through the needle, and drain placed using Seldinger technique. Each volunteer was allowed one attempt. Technical success was demonstrated by imaging location of the drain in the collection and return of fluid. **RESULTS:** After watching the "JIT" video and using remote video guidance, each participant localized and advanced the needle into the collection under ultrasound, and placed the wire and drain into the collection. Technical success was achieved in all attempts. Time requirement for the entire process was under 20 minutes per participant. **DISCUSSION:** While surgical emergencies could have grave consequences on long duration missions, supplies might be limited. Using interventional radiologic guided procedures to treat these emergencies has been described by experienced radiologists. However, the question of whether an astronaut-physician with zero/minimal previous image guided experience could be educated with "just in time" training and guided remotely by specialists on Earth using a video link to perform the procedure has been discussed by flight surgeons at NASA. We describe a novel technique as proof of concept that such a remotely guided procedure could potentially be utilized for long duration missions.

## **Learning Objectives**

1. The participant will be able to understand the feasibility of remotely guided surgical procedures for long duration missions in microgravity.
2. The participant will learn the technique for remotely guiding minimally invasive surgical treatments in microgravity using ultrasound.

# **[79] 3D PRINTED, MEAT-FREE, LOW-COST, HIGH-FIDELITY, REUSABLE, AND WEARABLE THORACOSTOMY TRAINER USED BY MARS ANALOGUE CREW MEMBERS**

Jaewoo Park<sup>1</sup>, David Kim<sup>2</sup>, William Fraser<sup>3</sup><sup>1</sup>University of Toronto, Toronto, Ontario, Canada; <sup>2</sup>University of British Columbia, Vancouver, British Columbia, Canada; <sup>3</sup>Sialyuk Research, Toronto, Ontario, Canada

(Original Research)

**INTRODUCTION:** Pneumothoraxes are a potential medical emergency during spaceflight. Crew medical officers receive ground-based training to decompress a tension pneumothorax, however, the absence of in-flight trainers presents a significant challenge to maintaining this life-saving skill during space missions. We assessed the feasibility of using a 3D printed, meat-free, low-cost, high-fidelity, reusable, and wearable thoracostomy simulator for training Mars analogue crew members to perform an ISS protocol of an emergency needle decompression of a simulated tension pneumothorax. **METHODS:** 9 Mars Desert Research Station Crews 207 and 208 members participated in this study. 5 Crew 207 subjects received training with a porcine and 3D printed trainer, and were evaluated on task completion times for 7 sessions. 4 Crew 208 subjects received training solely on the 3D printed trainer and progress was evaluated based on task completion times for twelve

sessions. The regression modeling R based "rms" statistical package was used to determine which factors and regressors were significant predictors of task completion time. ANOVA followed by a Wald test was applied to the fitted model. **RESULTS:** For Crew 207 subjects, both session ( $c^2 = 16.60$ ,  $df = 6$ ,  $p = 0.0109$ ) and subject age ( $c^2 = 6.20$ ,  $df = 1$ ,  $p = 0.012$ ) were significant predictors of task completion times with a clear learning effect across sessions. Porcine and 3D printed simulator task completion times were similar. For Crew 208 subjects, both session ( $c^2 = 28.03$ ,  $df = 11$ ,  $p = 0.0032$ ) and medical background ( $c^2 = 35.4$ ,  $df = 1$ ,  $p < 0.0001$ ) were significant predictors of faster task completion times, again with a clear indication of learning across the sessions. Subjects with medical backgrounds performed better than subjects without medical backgrounds across all sessions. **DISCUSSION:** These results indicate that Mars analogue crew members can use a 3D printed thoracostomy trainer to perform a safe and effective emergency needle decompression of a simulated tension pneumothorax. Advantages of this 3D printed trainer include; simple manual assembly, washable, biodegradable plastic parts, ability to palpate anatomic landmarks, reusability and significantly cheaper cost than commercial mannequin simulators, cadavers or animal models. Future work includes evaluating the 3D printed thoracostomy trainer in remote and underserved regions to teach life-saving surgical skills to healthcare trainees and professionals.

## **Learning Objectives**

1. The audience will learn about the role of 3D printing for medical simulation training for space missions.
2. The audience will learn about the anatomic landmarks for needle decompression in adult patients according to the ATLS 10th edition guidelines.

# **[80] AVATARMEDIC SYSTEM: CONVERGENCE OF MR/AR, AI, 5G FOR EMERGENCY MEDICAL TRIAGE, DISASTER RELIEF, SEARCH & RESCUE IN REMOTE ENVIRONMENTS**

John Hanacek<sup>1</sup>, Susan Jewell<sup>2</sup><sup>1</sup>AvatarMEDIC, Van Nuys, CA, USA; <sup>2</sup>Mars Academy USA, Van Nuys, CA, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** Space is hard and solutions are needed to support astronauts and crews living in austere, remote isolated and confined environments. Integrating exponential technologies, e.g., Mixed Reality (MR), Augmented Reality (AR), Artificial Intelligence (AI), on a 5G communication network could be novel solutions to increase safety and survivability to address challenges in the fields of disaster and emergency medicine and offer solutions to support medical triage, search and rescue in austere I.C.E. **BACKGROUND:** Merging AR/MR using spatial computing technologies, such as, Magic Leap, with AI, i.e., chatbot, can provide ability for immediate diagnosis of trauma, assessment of severity, prompt decision for medical triage. AR/MR provides ability for remote medical rescue team, mission support team, flight surgeon to oversee medical situations in real-time. 5G offers low latency and broad bandwidth and needed in medical emergencies for communications. **CASE PRESENTATION:** We focus on Mars Academy USA (MAU) Mars Medics analog astronauts who tested proof of concept of AvatarMEDIC system at various altitudes and fidelities. Aim to test feasibility in integration of exponential technologies for use during simulation emergency medical triage and remote rescue protocols at various altitudes. The objectives to conduct viability of "avatar tele-presence" using spatial computing, e.g., Magic Leap with pre-programmed AI chatbots on mobile devices where crews could interact via telemedicine using commercially available telecommunication platforms (WhatsApp and Zoom). The telepresence "medical avatars" were used to telementor crews in teletriage, and teleanesthesia-telesurgery simulation training with support of the remote medical teams. The goal was to test real-time training in a full "immersion" simulation. Deploying at various fidelities from low-fidelity at California desert 3,000ft, to high fidelity at 15,000-17,000ft increased level of technical difficulties and challenges for all teams. **DISCUSSION:** We highlight technical issues in providing emergency medical triage and conducting remote medical rescue whilst testing the AvatarMEDIC™ system in austere environments during analog missions. We propose potential novel solutions, to provide risk reductions for medical emergencies. Many technical challenges were encountered, i.e., limited energy supply, lack of access to Wi-Fi, extreme weather conditions extreme cold, heavy rains and reduce pressure.

**Learning Objectives**

1. The audience will learn about the integration of innovative exponential technologies that can be incorporated into supporting current medical paradigms for emergency and disaster medicine.
2. The participant will be able to understand the challenges of offering medical care in austere and isolated environments and learn novel solutions to address these challenges.
3. The audience will learn how exponential technologies will transform the medical and healthcare paradigms and how it will improve current state-of-the-art in healthcare delivery services and access and how these technologies will enable astronauts to perform emergency medicine in austere I.C.E.

**Monday, 05/18/2020****2:00 PM****Regency 5****[S-18]: SLIDE: ACCELERATION, IMPACT, AND ORTHOSTATIC STRESS****Chair: Leonid Hrebien****Co-Chair: Bryant Martin****[81] EJECTION OUTCOMES: A RETROSPECTIVE STUDY OF MODERN ESCAPE SYSTEMS**Kathryn Hughes<sup>1</sup>, Camille Bilger<sup>2</sup>, Matt Lewis<sup>3</sup><sup>1</sup>Martin-Baker Aircraft Company, Ltd, Dayton, OH, USA; <sup>2</sup>Martin-Baker Aircraft Company, Ltd, Denham, United Kingdom; <sup>3</sup>Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom*(Original Research)*

**INTRODUCTION:** Ejection Seats have been used for over 70 years, resulting in thousands of Airmen being saved. Previous research addressed survival and injury outcomes in legacy escape systems (Lewis 2006, Newman 2013). Martin-Baker Aircraft Company (MBA) employs continuous design safety enhancement efforts to equip escape systems with advanced engineering, providing Airmen world-wide with the safest escape systems possible. The DoD Airworthiness Certification contains requirements for Escape System Safety to include the dynamic response index Z-axis (DRIz). This presentation summarizes research evaluating the MBA ejection database to determine if new technologies and design enhancements have improved ejection survival rates and spinal injury rates. **METHODS:** MBA's ejection database includes over 8,000 ejections. An analysis was conducted on the historical database to quantify ejection numbers and fatality rates along with the contributing causes of these fatalities. Further analysis was conducted on 226 ejections using modern escape systems (Mk14 and Mk16 series). These ejections were analyzed for rates of fatality and spinal injury, as well as contributing causes for fatality and classification of reported injuries. **RESULTS:** Ejections resulted in a high survival rate (>90%). The majority of fatalities were due to either out-of-envelope ejections or post-ejection causes. The DRIz was lowered from 21g in Mk10A seats to 18g in the older Mk16 seats, and 16g in the US16E (F35) seat. This equates to a reduction of predicted spinal injury risk from 26% to 3% (Mk16) and less than 1% (US16E). This low DRIz is evident while still ensuring fin clearance, terrain clearance and an accommodated anthropometric. The present analysis indicated that actual spinal injury rates have decreased from 29.4% (Lewis, 2006) to 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. 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 helps 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 Mil-Handbook 516C-CN5 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.

**[82] DESIGNING RESTRAINT FOR SIMULATING LATERAL ACCELERATION**Parul Goel<sup>1</sup>, Anupam Agarwal<sup>2</sup><sup>1</sup>Indian Air Force, Delhi, India; <sup>2</sup>Indian Air Force, Bangalore, 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 audience will be able to appreciate issues involving simulation of lateral acceleration in centrifuge using existing five-point harness system.
2. The audience will learn about the newly designed restraint system which can be used effectively while simulating lateral acceleration profiles in centrifuge.

**[83] WHAT IS +9Gz? – CENTRIFUGE VS AIRCRAFT: IMPLICATIONS FOR RESEARCH AND TRAINING**Joseph Britton<sup>1</sup>, Nicholas Green<sup>1</sup><sup>1</sup>Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom*(Education - Tutorial Proposal)*

**INTRODUCTION:** NATO STANAG AAMedP-1.13 requires aircrew to undertake high-G training to withstand up to +9Gz for 15 seconds. The method in which acceleration is generated and recorded is not specified, however, and can lead to variations in the 'true' +Gz experienced. This may impact both training and the interpretation of physiological research. **TOPIC:** Acceleration is proportional to velocity squared and inversely proportional to radius ( $a=v^2/r$ ). The large turn radius of fast jet aircraft (hundreds of meters) results in a functionally consistent level of acceleration across the occupant's body. The short radii of centrifuges (4-18m) result in a gradient of +Gz from head to toe, dependent on centrifuge arm length and target +Gz acceleration. Mathematical modelling identified that, on the UK centrifuge, a +9Gz training target exposes aircrew to +10.6Gz at foot level. Position of the accelerometer in the vertical axis of the gondola therefore affects measured acceleration - for the shortest operational centrifuge by as much as 35% from head level to gondola floor. Furthermore, the orientation of the accelerometer compared to the occupant's axis can lead to under or overestimating accelerative forces at +9Gz by 13.4-15.4% with a seatback angle of 30°. Artefactual physiological influences such as the G-gradient or exposure to acceleration in other axes (predominately +Gx) affect our understanding of the practical application of centrifuge research and the operation or design of protective equipment. In training, how target +Gz is measured can affect the effort required by aircrew and may contribute to increased arm pain. A review of human centrifuge research published over the last 10 years (n=47) was performed and noted that key specifications are not always quoted (centrifuge arm length quoted by 51.1% of studies, seatback angle by

36.2%, accelerometer location by 17% and accelerometer axis by 0%) leading to a potential lack of comparability between research and training on different centrifuges. **APPLICATION:** A process for reporting parameters which affect the centrifuge force environment will be proposed in order to optimize data exchange when considering human research utilizing these devices. Standardized methodology for selecting reference point locations for +Gz acceleration measurement in training and research is required to maximize interoperability and should be reflected in international standards.

#### Learning Objectives

1. The audience will learn about the limitations of human centrifuge research and issues that arise when comparing results between research centers or applying them to the flight environment.
2. The audience will learn about the centrifuge specifications required to populate a mathematical model of the centrifuge force environment. This will be used to illustrate and inform a proposed process to standardize the reporting of high-G research and training.

#### [84] +Gz-INDUCED BRADYARRHYTHMIA IN A HIGH-G RESEARCH SUBJECT: A CASE REPORT

William McLean<sup>1</sup>

<sup>1</sup>University of Nebraska, New Braunfels, TX, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes a High-G research subject in training who experienced +Gz-induced bradyarrhythmia. **BACKGROUND:** Symptomatic bradyarrhythmia in a pilot of a high-performance aircraft could result in significant negative consequences. Sinus tachycardia is a typical cardiovascular response seen in High-G research subjects training in the human-rated centrifuge. Occasionally singlet premature ventricular complexes (PVCs) are observed intermixed with sinus tachycardia. It is rare to note any type of bradyarrhythmia in humans undergoing high-G forces. **CASE DESCRIPTION:** A healthy 31-year-old acceleration research subject in training experienced an episode of bigeminy with a heart rate ranging from 39-50 beats per minute during a +7Gz centrifuge exposure. The run was terminated, and the subject returned to +1Gz. (Base-G). The subject reported feelings of dizziness that he attributed to vestibular stimulation. Auscultation during the initial physical exam, conducted while the subject was still seated in the gondola, confirmed bigeminy. The bradyarrhythmia spontaneously resolved in approximately three minutes. The subject was then transferred via EMS to the emergency department for a complete cardiac workup. **DISCUSSION:** EKG monitoring is a requirement for all High-G research exposures, but not for pilots in High-G training. The bradyarrhythmia observed, in this case, is extremely rare. The subject's reporting of dizziness during the arrhythmia indicated possible symptomatic bradycardia. The short duration and the spontaneous resolution of the arrhythmia after returning to Base-G appeared to demonstrate the event was purely the result of the High-G exposure; however, the subject's medications may have played a role.

#### Learning Objective

1. The audience will learn about the training of High +Gz research subjects and review a case study that indicates the potential for bradyarrhythmias associated with High +Gz exposures.

#### [85] SIMULTANEOUS ASSESSMENT OF BLOOD FLOW IN THE CAROTID AND DORSALIS PEDIS ARTERIES UNDER ORTHOSTATIC STRESS

Munna Khan<sup>1</sup>, Abu Rehan<sup>2</sup>

<sup>1</sup>Jamia Millia Islamia (Central University), New Delhi, India; <sup>2</sup>Al-Falah University, Faridabad, India

(Original Research)

**INTRODUCTION:** Blood flow detection of carotid artery (CA) has many applications in the field of aerospace medicine. Dorsalis pedis artery (DPA) is a good alternative because of lower extremities of pilot are quite accessible. Detection and analysis of DPA blood flow (DPABF) may be useful in the aerospace medicine. An effort has been made for simultaneous assessment of CA blood flow (CABF) and DPABF during orthostatic stress from supine to 90 degree head-up tilt (HUT). **METHODS:** A simple system has been designed and developed to record CABF and DPABF changes in

the human volunteers using piezoelectric sensors. Experiments were performed on 6 healthy human subjects with age from 20 to 25 years of both sexes. The subjects rested for 15 minutes before commencing the test on manually operated tilt table. The CA running by lateral side of throat was palpated and piezoelectric (PZT) sensor placed using medical adhesive tape. Similarly, DPA on the dorsal aspect of foot was palpated and other PZT sensor placed with same steps. Output of the PZT sensors was sent to the laptop connecting Arduino board (microcontroller system). Data were taken in three states: supine (resting), vertical (90 degree HUT) and supine again (recovering). Data of CABF and DPABF analyzed using AcqKnowledge software. **RESULTS:** Average CA values along with the standard deviation ( $\pm$ SD) for peak-to-peak voltage ( $V_{pp}$ ) for supine, vertical and recovery states were found as  $1.900 \pm 0.794$ ,  $1.133 \pm 0.615$  and  $2.402 \pm 0.788$  volts respectively. Corresponding DPA values of  $V_{pp}$  for supine, vertical and recovery states are  $0.651 \pm 0.482$ ,  $1.086 \pm 0.978$  and  $0.532 \pm 0.347$  volts respectively. Other parameter of CA, average area under curve (AUC) of PZT sensor waveform in the Supine, Vertical and Recovery positions was found as  $8.087 \pm 3.457$ ,  $3.329 \pm 2.207$  and  $9.017 \pm 3.798$  respectively. Corresponding AUC values of DPA for supine, vertical and recovery states are  $4.842 \pm 2.720$ ,  $6.321 \pm 3.144$  and  $3.912 \pm 2.339$  respectively. **DISCUSSION:** The CABF and DPABF changes were found to be significant comparing Supine vs Vertical ( $p < 0.05$ ), Vertical vs Recovery ( $p < 0.05$ ) and Recovery vs Supine ( $p < 0.05$ ) positions. Data from supine to vertical position shows a significant decrease in CABF and signifying the gravity based blood flow towards lower limbs. Fact is corroborated by a corresponding increase in the blood flow of DPA. The recorded CABF/ DPABF data and their analysis may be useful to study various simulated parameters of the pilot.

#### Learning Objectives

1. Investigation of blood flow pattern in the carotid artery during 90 degree head-up tilt (HUT).
2. Investigation of blood flow pattern in the Dorsalis pedis artery during 90 degree head-up tilt (HUT).
3. Correlation between blood flow in carotid and Dorsalis pedis arteries during part of simulated PUSH-PULL effect of an aircraft pilot.

Monday, 05/18/2020

4:00 PM

Centennial I

#### [S-19]: PANEL: COMPLEX PROBLEMS AND NOVEL SOLUTIONS FROM JUNIOR AND FUTURE FLIGHT SURGEONS LEADING INNOVATION: PART 2

Sponsored by USAF School of Aerospace Medicine (USAFSAM; Society of USA Air Force Flight Surgeons (SoUSAFFS))

Chair: Brian Hanshaw

Co-Chair: Quinton Keigley

**PANEL OVERVIEW:** The constant and evolving mission of aviators, special duty operators, and aircrew trainees across the USA Air Force is diverse and presents complex operational medicine problems. This panel features junior and future Flight Surgeons across the Department of Defense, who will discuss how their flight medicine program delivers innovative solutions to combat the medical issues seen in their diverse population of war fighters. The following presentations carry one theme: bringing medical services directly to their supported populations to increase the value of clinical services to both the patient and the mission they support across the globe at any time and in any condition. This panel has become tradition over recent years and is critical as we strive to build the future of our Flight Surgeons. These individuals are showcasing their vision on the fight against complex and unique medical problems and the impact on keeping our flyers in the fight.

#### [86] BIOHACKING FLIGHT MEDICINE'S BEST: OPTIMIZING READINESS AND HEALTH WITH LIFESTYLE MEDICINE & PERFORMANCE MEDICINE

Regan Stiegmann<sup>1</sup>

<sup>1</sup>USAF Academy, Castle Rock, CO, USA



*(Education - Program / Process Review Proposal)*

**BACKGROUND:** We recruit the healthiest men and women in America to serve in the USA Military. As the healthiest men and women in the country serve their tours of duty, something drastic happens to them during their time in uniform. Once our active service members separate or retire, transitioning into Veterans, they also transition into the unhealthiest American demographic in this country. What are we doing to the health of our Soldiers, Sailors, Airmen, and Marines? **OVERVIEW:** The Veterans Health Administration (VHA) is the largest integrated healthcare system in the USA. It includes 1,243 facilities spread across the nation along with 170 medical centers and 1,063 outpatient centers that provide state of the art medical care to over five million Veterans. Similarly, the Department of Defense (DOD) is the largest employer in the country with over 1.3 million men and women on Active Duty, and 742,000 civilian personnel. Another 826,000 serve in the National Guard and Reserve force and more than 2 million military retirees and their family members receive benefits. **DISCUSSION:** Estimates suggest that the DOD annually spends \$10-\$17 billion treating chronic degenerative (and largely preventable) diseases every year in this country. Consistent increases in health care spending have become a key concern in within the DOD, and DOD Military Health System (MHS) leadership have started to recognize the need to lower health care costs as part of the MHS strategic framework. Every year, more Americans die from cardiovascular diseases than the number of American lives lost in World War I and World War II combined. This is due lack of emphasis and financial incentives centered around preventive and lifestyle strategies. A new military framework is being integrated within medical treatment facilities, managed under the Defense Health Agency (DHA). We as health experts are primely poised to execute out the DHA mission by means of subsequent Lifestyle/Performance medicine integration. Lifestyle/Performance medicine and the DHA quadruple aim are means to the same endpoint, as Lifestyle/Performance medicine has the potential to increase readiness, improve health, improve care delivery, and decrease cost.

**Learning Objectives**

1. At the conclusion of the session, the participant will be able to describe how Lifestyle/Performance Medicine is being integrated into the military and medical treatment facilities of the Department of Defense.
2. At the conclusion of the session, the participant will be able to discuss various Department of Defense strategies that focus on implementing Lifestyle Medicine measures for our Soldiers, Sailors, Airmen, and Marines.
3. At the conclusion of the session, the participant will be able to discuss how military readiness is directly impacted by the tenets of Lifestyle Medicine, and how the MHS/Defense Health Agency's quadruple aims align within the field of Lifestyle Medicine.

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

Edmond Fenton<sup>1</sup>

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

*(Education - Program / Process Review Proposal)*

**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

everyday, 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.

### **[88] BUILDING THE AEROMEDICAL NURSE PRACTITIONER INTERSHIP**

Jessica Knizel<sup>1</sup>, Christopher Kelly<sup>2</sup>

<sup>1</sup>USAF, Eglin AFB, FL, USA; <sup>2</sup>USAF, Columbus AFB, MS, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** In October 2019, the AF created its newest AFSC the Aeromedical (AM) NP (ANP). This role has come at a critical time during the AFMS reform and will help fill the operational void. FNP's now have the opportunity to expand their scope beyond the traditional primary care roles and integrate their experience into the AM enterprise. After successful completion of these didactic courses, the ANP will complete the ANP ramp-up guide and IQT to be assigned the AFSC. To enhance the educational foundation of AMP, ANPs would benefit from concentrated and standardized experiences.

**OVERVIEW:** A brief structured internship will solidify the foundational didactic instruction and knowledge gained at AMP. The aims of this discussion are to explore the new roles, hands-on training opportunities and improve the retention. We intend to discuss a proposed initial qualification training pipeline that will cement the foundational guidance provided in AFI 48-149. **DISCUSSION:** We will outline several unique facets of the internship focused on the establishment of a mentoring program, peer training and apply AMP academics to real world operational mission requirements resulting in the production of better qualified and retainable ANP. This internship program will be focused on the specific clinical experiences required in the IQT and the ANP credentialing requirements. The integration of this proposed program would occur prior to starting at their new assignment. This four-week program would partner the AMP graduate with an assigned peer for training at a predesignated training site. We recognize that many family medicine providers possess a varying degree of understanding of the unique operational and aerospace medicine fundamentals. The primary goal of this ANP internship program is to close those knowledge gaps prior to beginning this new role as an AM providers. ANP-internship training site should consist an ideal environment to gain experience with multiple airframes, high frequency of sorties, IFE response, air sickness treatments, flight line operations, waivers and flight medicine sick-call workflows. The AF has several bases that can provide a high density "hands-on" experience to achieve the targeted goals of a short duration operational medicine internship. The opportunity to cultivate the clinical skillset of the AF's newest AFSC is now and posture the AFMS to advance the evolving AM mission of tomorrow's AF.

**Learning Objectives**

1. The learner will be able to discuss the training requirements for an ANP.
2. The learner will be able to list three of the potential benefits of an ANP internship program.
3. The learner will be able to describe two of the selection criteria for ANPs.

**[89] MISSED MEDICAL APPOINTMENT SURVEY, 480th ISR Wing JBLE, JANUARY 2013 TO MARCH 2013**Brandon Sellers<sup>1</sup>, Bryant Martin<sup>2</sup><sup>1</sup>Medical College of Georgia, Augusta, GA, USA; <sup>2</sup>US AF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Original Research)

**INTRODUCTION:** In the first quarter of 2013, January 2013 to March 2013, the 633th Medical Group identified an issue that urged them to contact the leadership of the 480th ISR Wing at Langley AFB. A trend of missed medical appointments was becoming prevalent and was leading to underutilization of medical resources. Upon notification of the problem at hand, the 480th ISR Wing leadership requested that the 433th Medical Group conduct a survey directed toward the airmen that missed a medical appointment. This report describes the survey that was conducted to assess the underlying cause of the missed medical appointments. The information extracted from the report can be utilized in the future to better utilize USAF medical resources. **METHODS:** From a broad perspective, questions were asked in such a way that categorized the missed appointment under the responsibility of the patient, hospital, or unit. The research was not conducted under anonymous circumstances, but the airmen were promised that no punitive action would be taken. The responses of the survey may have been impacted by the lack of anonymity; future studies could address this potential source of altered responses if the need arises for a subsequent survey. **RESULTS:** It was identified that nearly half, 44%, of the missed appointments were at the fault of the airmen. The additional half of missed appointments can be subdivided nearly equally into the fault of the hospital (29%) and unit (27%). **DISCUSSION:** From the data extrapolated by the survey, it was determined that the overarching responsibility of missed appointments fell upon the airmen. From this finding, future actions can be taken to reduce the number of missed appointments for better utilization of medical resources. Examples of such actions could include quarterly surveys until the number of missed appointments drop below the desired threshold, or appointment reminders could be sent out at pre-determined intervals prior to the scheduled appointment.

**Learning Objectives**

1. Learning Objective 1: The audience will learn the major causes of missed medical appointments according to the survey assessed in this report.
2. Learning Objective 2: The audience will be able to take into account information from the report in an effort to maximize USAF medical resources in the future.

**Monday, 05/18/2020**  
**Centennial II****4:00 PM****[S-20]: SLIDE: NOISE AND HEARING****Chair: Russell Turner****Co-Chair: Bob Cheung****[90] WIRELESS ASSESSMENT OF ACOUSTIC SOURCE PERCEPTION BY HUMAN SUBJECTS IN THE MEDIAN PLANE**Bharat Bhushan Sharma<sup>1</sup>, Munna Khan<sup>2</sup><sup>1</sup>Banasthali Vidyapith, Newai, India; <sup>2</sup>Jamia Millia Islamia (Central University), New Delhi, India

(Original Research)

**INTRODUCTION:** Acoustic perception (AP) has vital role in the performance of human subjects under numerous environmental settings. Accurate AP of source has benefits on the task performed while addition of noise treated as trouble to the human subjects. An attempt has been made to study wireless assessment of AP of human subjects in the median plane. **METHODS:** A total of 20 human subjects (10 Males and 10 Females) participated in the study as first group of 15 subjects having age from 18 to 35 years and second group of 5 subjects with age above 50 years. The 5 wireless speakers (WS) used and placed in front of human subject in range from +30° to -30° in the median plane. A response

measurement sheet (RMS) provided to each subject indicating detail of all WS. The 5 WS were controlled with the help of computer using standard software and two experiments were performed. In the first experiment, buzz sound was used as acoustic source with Low Fixed Frequency (LFF) of 2000 Hz and High Fixed Frequency (HFF) of 17 kHz. Initially, a set of LFF experiments were performed on all 5 WS working in the random order. The each of WS was sounded with stimulus for 4 seconds one after another. After each stimulus of 4 seconds, the subject was asked to point at one of WS from where the sound was perceived and asked to write corresponding number of wireless Speaker on the RMS. Similar set of HFF experiments were performed and recorded on the RMS. In the second experiment, white noise was added at same fixed frequency and similar task was repeated by the subjects and recorded on the RMS. Data recorded from the two set of experiments was compared and analyzed using statistic technique. A comparative analysis has done for both set of experiments using ANNOVA statistic technique. **RESULTS:** The ANNOVA statistic technique yielded average value of AP for LFF without noise and with white noise as 6.778 and 6.418 respectively. In the HFF experiment, the average value of AP found as 4.978 without noise. Addition of white noise in the HFF resulted in average perception value as 4.418. **DISCUSSION:** Addition of white noise in the LFF experiments does not show significant change in the average perception value of acoustic source in median plane (8.03 %). In the HFF experiments, a significant change of 28.57 % recorded for average perception value with addition of white noise. The AP may be used in various applications related to target detection and localization in the noisy environment.

**Learning Objectives**

1. To study effect of Low Fixed Frequency (LFF) of 2000 Hz and High Fixed Frequency (HFF) of 17 kilo Hz on human perception in Median Plane.
2. To study effect of addition of white noise to LFF and HFF on the human perception in the Median Plane.

**[91] THE STUDY ON HEARING STATUS OF AIRCRAFT MAINTENANCE PERSONNEL**YanGe Zhang<sup>1</sup>, Lin Liu<sup>1</sup>, Qin Yao<sup>1</sup>, Shan Chen<sup>1</sup>, Hua Guo<sup>1</sup><sup>1</sup>Air Force Medical Center China, Beijing, China

(Original Research)

**INTRODUCTION:** Aircraft maintenance personnel often expose to high level noise, and are high risk group of noise induced hearing loss. The study analyzed hearing loss characteristics of aircraft maintenance personnel and may provide suggestions for prevention and protection of noise induced hearing loss for aircraft maintenance personnel. **METHODS:** subjects were 124 male aircraft maintenance personnel, Mean age: 27.48±6.70y, work years: 8.38±6.68y. The subjects were divided into 3 groups according age. Group A (n=81), age < 30y. Group B (n=38) 30-39y, Group C (n=5) ≥40y. Questionnaire and pure tone audiometry were used. **RESULTS:** 1. comparing mean hearing thresholds (HT) between left (LE) and right ear (RE), HT of RE is 14.19 dBHL and HT of LE is 11.41 dBHL at 8 kHz, HT of RE is higher than that of LE. The difference was statistically significant. Comparing among three groups, HTs of group A are 16.02±8.12 dBHL, 12.62±6.21 dBHL, 7.16±9.00 dBHL, 8.18±11.83 dBHL, 7.69±14.27 dBHL, 10.25±15.28 dBHL at 0.5, 1, 3, 4, 6, 8 kHz, HTs of group B are 18.88±8.51 dBHL, 14.80±7.41 dBHL, 10.66±10.81 dBHL, 15.20±14.64 dBHL, 13.36±16.07 dBHL, 15.92±17.00 dBHL at 0.5, 1, 3, 4, 6, 8 kHz. HTs of group C were 19.50±6.43 dBHL, 15.50±7.62 dBHL, 16.00±10.75 dBHL, 16.50±11.07 dBHL, 20.00±20.55 dBHL, 30.50±21.40 dBHL. HTs of group B were higher than those of group A, HTs of group C were higher than those of group B, the difference is statistically significant. Incidence rate of Hearing loss of single ear was, 16.13%, Incidence rate of hearing loss of bilateral ears was, 9.68%, overall incidence rate of hearing loss was 25.81%, 23 persons reported tinnitus. Incidence rate of tinnitus was 18.55%. Incidence rate of tinnitus group A was 12.34%, that of tinnitus of group B was 34.21%, that of tinnitus of group B higher than that of group A, that of Group C was 0. **DISCUSSION:** The longer exposure time of noise was, the heavier hearing loss became. Asymmetric hearing loss of bilateral ears existed in aircraft maintenance personnel. It suggests that noise induced hearing loss is not symmetrical. Tinnitus is not associated with hearing loss. Hearing Protection program should be set for maintenance personnel.

**Learning Objectives**

1. The audience will learn about the new finding about noise induced hearing loss of aircraft maintenance personnel. Asymmetric hearing loss of bilateral ears existed in aircraft maintenance personnel. The Study suggests that noise induced hearing loss is not symmetrical.
2. Tinnitus is not associated with hearing loss. Hearing Protection program should be set for maintenance personnel.
3. Every researchers should have New ideas and perspective about scientific investigation.

**[92] EFFECT OF NOISE AND HYPOXIA ON RISK TAKING BEHAVIOUR: A CAUSE FOR CONCERN IN AVIATORS?**

Devdeep Ghosh<sup>1</sup>, Deepak Gaur<sup>2</sup>, Biswajit Sinha<sup>1</sup>,  
B Aravindhakshan<sup>1</sup>

<sup>1</sup>Institute Of Aerospace Medicine, Indian Airforce, Bangalore, India;

<sup>2</sup>Command Hospital Airforce, Bangalore, Bangalore, India

**(Original Research)**

**INTRODUCTION:** Cognitive performance issues in pilots are pervasive in nature and have important flight safety implications. Larger Implicit Association Test (IAT) effect increases pilot's risk taking behavior that may lead to hazardous consequences in high risk situations. Deterioration of cognitive function due to hypoxia is a historically proven fact. The effect of noise on cognition is equivocal from detrimental to no effect, even improvement. Literature regarding the concurrent effect of these dual stressors on cognitive function are sparse. In this study, an effort has been made to assess the effect of white noise and simulated hypoxia of 14,000 ft altitude on human cognitive function independently as well as concurrently. **METHODS:** Cognitive performance viz. implicit association was assessed in 30 healthy volunteers sequentially in four different conditions- at ground level (Baseline condition without any stressors), ground level with 85 db (A) noise, 14,000 ft simulated altitude and 14,000 ft simulated altitude with 85 dB (A) noise. Explosive decompression chamber was used for altitude simulation and white noise was generated through software. Cognitive performance was assessed with Psychology Experiment Building Language (PEBL) test battery. Data were analyzed using descriptive statistics, Repeated measure ANOVA and Post-hoc test. **RESULTS:** The study revealed significant decrement of implicit reaction time at 14,000 ft altitude, 85 dB(A) noise as well as concurrent altitude and noise ( $p < 0.05$ ). Implicit correctness had statistically insignificant reduction in three study conditions. Decreased SpO<sub>2</sub> due to altitude exposure as well as increased heart rate in both noise and altitude exposure were the normal physiological responses of the human body. **DISCUSSION:** Noise and hypoxia both individually and concurrently may influence pilot's risk taking behavior and hence jeopardize flight safety. Proper installation of noise attenuating mechanisms to keep the noise level well within psychological comfort zone as per European Standard or Mil Std 1417D is essential. Awareness of the aircrew community about the potential psychological side effects of noise and hypoxia beyond the psychological comfort zone needs to be ensured.

**Learning Objectives**

1. The audience and aviation community will understand that noise and hypoxia may influence pilot's risk taking behavior.
2. Noise and hypoxia exposure beyond the zone of maximum adaptability have potential to jeopardize flight safety.
3. The audience will learn that proper installation of noise attenuating mechanism to keep the noise level well within psychological comfort zone is of enormous importance.

**[93] AIRCREW NOISE EXPOSURE AND HEARING PROTECTION ASSESSMENT ISSUES**

Soo James<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 Objective**

1. To understand how limited data can affect predictions of aircrew noise exposure and how more accurate measures may be achieved.

**Monday, 05/18/2020**  
**Centennial III**

**4:00 PM**

**[S-21]: SLIDE: SPACE ENVIRONMENTAL ISSUES**

**Chair: Kenneth Myers**

**Co-Chair: Amanda Lippert**

**[94] DECON IN DEEP SPACE: LESSONS FROM MICROBIAL MONITORING IN ISOLATED AND CONFINED ENVIRONMENTS**

Sheyna Gifford<sup>1</sup>, Benjamin Johnson<sup>2</sup>, Yajaira Sierra-Sastre<sup>3</sup>

<sup>1</sup>Washington University St. Louis, St. Louis, MO, USA; <sup>2</sup>Georgetown University, Washington, DC, District of Columbia, USA; <sup>3</sup>Science In Space, Rockville, MD, 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.

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

Hansjorg Schwertz<sup>1</sup>, Lisa A. 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 (SFOC), Kennedy Space Center, FL, USA; <sup>3</sup>Integrated Mission Support Services (KEMCON), Kennedy Space Center, FL, USA

#### (Original Research)

**INTRODUCTION:** Hypergolic propellants, dinitrogen tetroxide ( $N_2O_4$ ) 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  $N_2O_4$  (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,  $NO_2$  off-gassing peaked at 0.5 ppm for a duration of 6 min, a value which does not exceed EPA acute exposure guideline level (AEGL-1) 8 h level limits. For the first hour, MMH off-gassing levels did not exceed 0.09 ppm, which is below AEGL-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 AEGL-2 30 min level limits of 1.8 ppm.

**DISCUSSION:** ACES II saturated with  $N_2O_4$  propellant did not exceed irritant levels 2 h after decontamination. MMH off-gassing was nearly undetectable in ACES II for the first hour after decontamination. However, MMH off-gassing subsequently peaked as the ACES II fabric dried out and could reach a hazardous level if confined inside a sealed vehicle. The results indicate that short decontamination times can be utilized provided that ACES II are either kept moist to prevent off-gassing, or removed prior to medical evacuation. Studies using the OCSS or commercial crew suits might be needed in the future.

#### Learning Objectives

1. The audience will learn about the risk posed by rocket propellant off-gassing to rescue crews.

2. The audience will learn about mechanisms of off-gassing of MMH.
3. The audience will learn about the general recommendations for decontamination operations after egress.

#### [96] SPACE RADIATION AND DEEP SPACE TRAVEL... WHAT'S THE HYPE? (A PRIMER FOR THE NON-ASTROPHYSICIST)

Stephen MacLean<sup>1</sup>

<sup>1</sup>Dalhousie Medical School/Dal University Halifax NS, Canada  
Ottawa, Ontario, Canada

#### (Education - Tutorial Proposal)

**INTRODUCTION:** Space missions to the International Space Station, the Moon and Mars have radiation exposure estimates in the range of 50 to 2000mSv. Extensive research on x-rays and gamma rays strongly supports that doses more than 50mSv are associated with an increased risk of cancer. Even though there are over 500 astronauts who have been to Low Earth Orbit (LEO), only twenty-four from the Apollo program have ventured outside of the Earth's protective radiation shields into deep space. Human data on space radiation exposure is therefore very limited. **TOPIC:** Space radiation composition is primarily a combination of galactic cosmic radiation (GCR) and solar radiation. This creates a complex soup of electromagnetic rays mixed in with a variety of particles, some with very high energy and velocity (e.g. HZE particles). Exposure on Earth is greatly dampened by the magnetosphere and the thick layers of the atmosphere that surround and protect living beings on the surface of the planet. In space conversely, natural protections are fewer to non-existent, and must be created artificially. Radiation concerns in space are generally not related to acute radiation poisoning (with some exceptions), where high doses can cause immediate tissue damage and lead to acute bone marrow suppression for instance. Long-term exposure is more worrisome. Ionizing radiation can directly or indirectly (through the formation of free radicals) damage tissues and DNA. This in turn can lead to errant function of genes, with resulting direct cell death, and/or increase the risk of cancer by the activation of various oncogenes. Long-term non-oncogenic effects are also problematic and becoming better recognized, with cognitive effects on the Central Nervous System of particular concern. All these effects are most relevant for longer missions to deep space, such as one-way or return missions to Mars. **APPLICATION:** The goal of this presentation is to broaden interest on a complex topic for the aerospace medicine community, by presenting an overview of the composition of space radiation, while reviewing current limitations in knowledge and research. This is especially relevant as space travel ambitions continue to grow dramatically around the world. **RESOURCES:** 1. Cucinotta, F. A., & Durante, M. (2009). NASA: Human research program space radiation element. *Human Health and Performance Risks of Space Exploration Missions*, NASA SP-2009-3405, 1-70.

#### Learning Objectives

1. To broaden interest on space radiation, which is a complex topic, for the aerospace medicine community.
2. To review the composition and origin of space radiation, and its importance in long-term travel into deep space.
3. To broadly review current knowledge and research, including existing challenges and limitations.

#### [97] WHAT IS A SAFE ELECTRICAL CURRENT TO CONDUCT THROUGH AN ASTRONAUT ON MARS?

Douglas Hamilton<sup>1</sup>

<sup>1</sup>University of Calgary, University of Alberta, 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 of electrical shock.
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.

#### [98] "BENEATH THE DIGNITY OF AN ASTRONAUT": THE ORIGIN AND DEVELOPMENT OF ASTRONAUT NEUTRAL BUOYANCY TRAINING IN THE US

John Charles<sup>1</sup>

<sup>1</sup>ACT4space, LLC, Houston, TX, USA

#### (Education - Tutorial Proposal)

**INTRODUCTION:** Underwater neutral buoyancy training for astronauts was not an obvious option early in the space age. Its progress was limited for several years before its value as a training modality was unequivocally established. **TOPIC:** Starting in 1964, Environmental Research Associates (ERA), a small consultancy near Baltimore, almost accidentally developed the key innovations in an obscure research project funded by NASA's Langley Research Center. The new NASA Manned Spacecraft Center dismissed it until a mid-1966 EVA crisis in the Gemini program, then rapidly took over operational implementation. In parallel, NASA Marshall Space Flight Center developed many of the same techniques, as did many large aerospace corporations. The long-run technological impact of corporate activity was minimal but ERA and Marshall's activities led to two long-running NASA training centers at Houston and Huntsville, with only a few extramural duplicators.

**APPLICATION:** Knowledge of the factors that guided development and adoption of neutral buoyancy astronaut training can inform current practitioners about new useful techniques and potential hazards to be avoided. **RESOURCES:** Neufeld MJ, Charles JB. 2015. "Practicing for space underwater: inventing neutral buoyancy training, 1963-1968." *Endeavour* 39 (3/4): 147-159. <https://www.sciencedirect.com/science/article/pii/S0160932715200567?via%3Dihub> (accessed Oct. 27, 2019).

#### Learning Objectives

1. The audience will be able to discriminate between the mythical and the factual accounts of early underwater astronaut training.
2. The audience will understand the role of serendipity in the development of neutral buoyancy for astronaut training.

#### [99] HISTORY OF JAPANESE SIMULATION WATER TANK (WETS) FOR ISS EVA

Koshi Yokota<sup>1</sup>, Kazuhito Shimada<sup>2</sup>

<sup>1</sup>Japan Aerospace Exploration Agency, Tsukuba, Ibaraki, Japan;

<sup>2</sup>Tsukuba Koken, Tsukuba, Ibaraki, Japan

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

**BACKGROUND:** Japanese space agency (JAXA) encountered EVA (ExtraVehicular Activity) for the first time, when it joined the International Space Station (ISS) Program. JAXA started from building a new cylindrical water tank (diameter 16m, depth 10.5m), then trained their air SCUBA divers, dive test controllers, dive safety controllers, camera operators, pool deck personnel, and diving medical officers. External physicians and nurses were invited for the assistance also. We will review, in this session, how a new ground operation started and how it concluded successfully.

**OVERVIEW:** To make sure that new Japanese Experiment Module (JEM) to ISS is compatible with EVA tools/suit, and procedures, JAXA built its Weightless Environment Test System (WETS) in 1993, commissioned its tank in 1999. After the launch of JEM, the tank was dismantled in 2013. There are two basic principles applied to EVA simulation tanks. One is the Russian Hydrolab type, in which a punch-hole floor moves up and down. Mockup modules can be placed onto the floor, then be submerged with the movable floor. In the other type of tank, mockups are assembled in water on the bottom of tank floor, with much diving time. JAXA water tank had no moving floor, for its sample model was NASA's Neutral Buoyancy Simulator (NBL). To start a new test center, new personnel group had to be trained. Before WETS was built, tests for JEM started at NBL, and JAXA contractor divers were dispatched to NBL to learn water operations. Those divers became instructors for divers who assist an astronaut in a water version EVA suit. Recreational SCUBA instructors were able to master use of lifting air balloon in a couple of weeks, and newly trained SCUBA divers were assigned as camera operators and other in-water personnel. To accommodate an Arterial Gas Embolism case, a multiplace hyperbaric chamber capable of US Navy Treatment Table 6A recompression was installed. It took longer to train chamber operators and diving medical officers. For preparation, one of the authors was certified for hyperbaric medicine in addition to aerospace medicine. **DISCUSSION:** In order to start a ground operation that assists human space activities, many specialized personnel are required. Operation should be given enough lead time to train those specialized personnel. Overview of the birth and decommissioning of the EVA simulation pool at JAXA Tsukuba Space Center is a good case to review and study.

#### Learning Objective

1. The audience will learn about establishing process of a new astronaut training facility, and why training health specialists should be planned early.

Monday, 05/18/2020

4:00 PM

#### Centennial IV

### [S-22]: PANEL: OPTIMIZING AIRCREW SCREENING AND SELECTION THROUGH NON-INVASIVE METHODS OF CARDIAC SCREENING - GREAT DEBATES IN AEROSPACE CARDIOLOGY

Chair: Eddie Davenport

Co-Chair: Joanna d'Arcy

**PANEL OVERVIEW:** Should all aircrew get a screening ECG? How about a screening Echocardiogram? If cardiovascular disease is the leading cause of death and loss of licensure in aircrew, then should we be screening all aircrew with an exercise or imaging stress test with or without a coronary calcium score? Why not just get a CT coronary angiogram or cardiac MRI? These are some of the great debates in aerospace cardiology that span all races, genders, and nationalities. Since 2015 the NATO sponsored Aerospace/Operational Cardiology Working group (HFM 251 then 316) brought together specialists from over 7 countries to reach a consensus on aircrew disposition regarding all aspects of cardiovascular disease. The purpose of this panel is to have three debates regarding possible screening policies between members of the group. This fun and educational debate with focus on areas of cardiovascular screening to include ECG, Echocardiogram, exercise stress testing, coronary calcium scores, and CT coronary angiography. One country member will present their evidence-based rationale for or against a given topic then the other member will take the opposing view

followed by the original presenter having time for rebuttal. The evidence-based group consensus will also be discussed. There will be ample time after all presentations for the audience to ask questions to the entire 7-nation panel.

### [100] EXERCISE STRESS TEST AND CORONARY CALCIUM SCORING WAS GREAT 20 YEARS AGO, BUT NOW WE HAVE CT CORONARY ANGIOGRAPHY

Eddie Davenport<sup>1</sup>, Edward Nicol<sup>2</sup>, Joanna d'Arcy<sup>3</sup>

<sup>1</sup>USA Air Force, Wright Patterson AFB, OH, USA; <sup>2</sup>RAF Centre of Aviation Medicine, Henlow, Bedfordshire, United Kingdom; <sup>3</sup>RAF Centre of Aviation Medicine, Henlow, Bedfordshire, United Kingdom

(Education - Program / Process Review Proposal)

**BACKGROUND:** Cardiovascular (CVD) disease is a leading cause of death and attributed to over 19 million deaths a year globally and has increased by 14.5% in the last 10 years. The most common presenting symptom of severe coronary artery disease (CAD) is sudden cardiac death thus making CAD a leading cause of disqualification or denial of licensure in both civilian and military aircrew. Optimal screening for CAD is very controversial and must be evidence based. **OVERVIEW:** Screening ECG and echocardiogram as well as exercise stress testing with or without imaging are very poor predictors of CAD with a positive predictive value of 16%. A global cardiac risk score is a better predictor of risk for major adverse cardiovascular event (MACE) however, it is also limited in an asymptomatic population with a false positive and false negative rate that exceeds true positives. Coronary artery calcium scoring (CACS) has emerged as a way to further characterize cardiac risk with a sensitivity and specificity over 90% for MACE over 10 years. However, CACS is still a limited assessment of the coronary artery anatomy and can miss significant coronary artery disease. CT coronary angiography (CTCA) provides a complete assessment of degree of CVD and thus perhaps the best screening modality for aircrew and all high risk occupations. **DISCUSSION:** A thorough investigation including aircrew data on the sensitivity, specificity, and positive and negative predictive values of stress testing with CACS versus CTCA will be presented. Only invasive catheterization and coronary artery angiography image the coronary artery lumen better than CTCA. There is emerging data that a non-invasive CTCA may even perform better than invasive angiography for prognostic information in all degrees of CAD.

#### Learning Objectives

1. Understand the limitations of Cardiovascular Global Risk Scores and Cardiac Stress Testing (with or without imaging) in aircrew.
2. Learn the importance of coronary artery calcium scoring and CT coronary angiography in the assessment of asymptomatic coronary artery disease.
3. Learn an evidence based approach to screening for coronary artery disease in asymptomatic aircrew.

### [101] ROUTINE ECG SCREENING FOR AIRCREW - CON

Norbert Guettler<sup>1</sup>, Rienk Rienks<sup>2</sup>, Edward Nicol<sup>3</sup>, Thomas Syburra<sup>4</sup>, Denis Bron<sup>5</sup>, Olivier Manen<sup>6</sup>, Eddie Davenport<sup>7</sup>, Joanna D'Arcy<sup>3</sup>

<sup>1</sup>Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>2</sup>Royal Netherlands Air Force Military Hospital, Utrecht, Netherlands; <sup>3</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom; <sup>4</sup>Swiss Air Force and Cardiac Surgery Department Luzerner Kantonsspital, Luzern, Switzerland; <sup>5</sup>Swiss Air Force, Aeromedical Center, Dubendorf, Switzerland; <sup>6</sup>French Health Military Service, Percy Training Hospital of the Armies, Clamart, France; <sup>7</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** A 12-lead resting ECG is the only routinely performed machine-aided cardiological examination in a flight physical exam. It provides information about rhythm, axis, atrioventricular conduction, bundle branch blocks, hypertrophy, ventricular preexcitation, possible ischemia, and inherited channelopathies. ECG screening of young individuals mainly concentrates on the detection of inherited channelopathies, delta waves or signs for cardiomyopathies, whereas in individuals above age 40, it focuses on the diagnosis of coronary artery

disease. Currently, it is a point of discussion as to what age and how often a resting ECG should be carried out as a routine examination without a specific clinical indication. This abstract presents the disadvantages of frequent routine ECGs and their limited use. **OVERVIEW:** According to the FAA guide for AMEs, a 12-lead resting ECG is required for first-class medical certification at the first application after reaching the 35<sup>th</sup> birthday, on an annual basis after reaching the 40<sup>th</sup> birthday, and on indication. For second-class and third-class medical certification a routine ECG without clinical indication is not required. The European Union requires an ECG for a flight medical exam, if clinically indicated, for a class 1 medical certificate, at the initial examination, then every 5 years until age 30, every 2 years until age 40, annually until age 50, and at all revalidation or renewal examinations thereafter. For a class 2 medical certificate, it has to be carried out at the initial examination, at the first examination after age 40, at the first examination after age 50, and every 2 years thereafter. **DISCUSSION:** There have been reports of considerable interobserver variability in the interpretations of screening ECGs. This resulted in a number of false-positive and false-negative results, reducing the effectiveness and increasing the social and economic costs by suggested follow-up investigations. Labeling individuals with an uncertain diagnosis originating from a false-positive ECG finding can lead to psychological effects, as well as possible impacts on insurance policies and employment. Studies analyzing ECG screening for aircrew found out that the vast majority of those ECGs were entirely normal or represented likely normal physiological changes. Changes in the same individual over time were rare. In another study, ECG screening had no effect on the incidence of sudden cardiac death of athletes.

#### Learning Objectives

1. Learn that a 12-lead resting ECG is the only routinely performed machine-aided cardiological examination in a flight physical exam and that it provides information depending on the age of the individual.
2. Learn that there are differences between agency regulations regarding the intervals between resting ECGs.
3. Learn the social and economic disadvantages and the limited effectiveness of too frequent resting ECGs.

### [102] DEBATE: EXERCISE STRESS TEST AND CALCIUM SCORING IS ALL THAT IS NEEDED FOR CV RISK ASSESSMENT IN AIRCREW

Edward Nicol<sup>1</sup>, Joanne d'Arcy<sup>1</sup>

<sup>1</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom

(Education - Program / Process Review Proposal)

**BACKGROUND:** Cardiovascular disease is the leading cause of restriction to flying in both civil and military professional flying. Background rates of aircraft loss secondary to cardiovascular disease however is low, mainly due to the exclusion of those with abnormal family history, resting EKG, mild symptoms or abnormal exercise EKG. Evidence would suggest that the current strategy of cardiovascular risk assessment is adequate to maintain flight safety. **OVERVIEW:** Exercise stress testing (ExEKG) has been the cornerstone of cardiovascular risk assessment in aircrew for decades. It provides a comprehensive assessment of cardiovascular health and exercising to 9 minutes of the Bruce Protocol has an excellent prognostic outcome. Whilst some may argue that the sensitivity of the positive predictive value of the ExEKG is limited, combining it with a coronary artery calcium score (CACS) provides a potent combination that will exclude prognostically important coronary artery disease in virtually all aircrew. **DISCUSSION:** The speaker will present evidence for both ExEKG and CACS for the exclusion of significant coronary artery disease and argue that this is sufficient for cardiovascular screening in professional flying, maintains flight safety and allows truly non-invasive assessment of cardiovascular risk.

#### Learning Objectives

1. Delegates will be able to understand the strengths and limitations of the exercise stress test (ExEKG) in cardiovascular risk assessment.
2. Delegates will be able to understand the strengths and limitations of coronary artery calcium scoring (CACS) in cardiovascular risk assessment.
3. Delegates will be able to understand the strengths and limitations of CACS in combination with the ExEKG cardiovascular risk assessment.



**[103] ECHOCARDIOGRAPHIC SCREENING FOR AIRCREW: HOW DARE YOU?**Thomas Syburra<sup>1</sup>, Eddie Davenport<sup>2</sup>, Joanna d'Arcy<sup>3</sup><sup>1</sup>Luzerner Kantonsspital, Luzern, Switzerland; <sup>2</sup>USAF, Centerville, OH, USA; <sup>3</sup>UK Royal Air Force, Oxford, United Kingdom*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Small air forces, like Switzerland, favor echocardiographic screening of all aircrew candidates. The rationale behind it is to avoid a costly drop-out after training completion. A large air force like the USAF does not perform systematic echocardiographic screening of their aircrew candidates, due to the sheer amount of screening which would be required, which is likely to be out of proportion to the benefit of avoiding the drop-out of a trained aircrew member due to cardiac and aortic surgery. **OVERVIEW:** Screening is a process – one that begins with invitation to participate and ends with treatment for appropriately identified individuals. The screening test (e.g. echocardiography) is characterized by its sensitivity and specificity. It is all about the ability to rule in or out a specific feature (e.g. bicuspid aortic valve). The most accurate test is neither 100% sensitive nor 100% specific, but somewhere in-between. However, the use of such an approach does not clearly apply to aircrew. Systematic echocardiographic screening before aircrew selection is not looking for a specific disorder. In the absence of a leading clinical condition, it puts this population at risk of false positive findings and unnecessary subsequent testing, without clear therapeutic benefit. This is the result of the lack of a clear pre-test likelihood when keeping the example of the bicuspid aortic valve in mind, with a maximal prevalence of 2% in the population, leaving 98% of screening tests pointless. Additionally, as only a minority of bicuspid aortic valves will ever require surgery during a typical active flying career, carrying out undifferentiated systematic echocardiographic screening wastes time, money and energy.

**DISCUSSION:** The 2013 Tromsø study concluded that “Echocardiographic screening for structural and valvular heart disease in the general population provided no benefit for mortality or for the risk of myocardial infarction or stroke”. Therefore a similar use of echocardiographic screening in aircrew is likely to be a waste of resources. Only where there is a positive likelihood of a finding based on clinical knowledge, does low-threshold echocardiographic investigation (and not screening) make sense. Clinicians shall praise their great clinical judgment again instead of following blindly pre-set routines.

**Learning Objective**

1. To understand why echocardiographic screening is pointless.

**[104] THE USE OF ECHOCARDIOGRAPHIC SCREENING FOR OPTIMISING RISK STRATIFICATION IN AIRCREW – WORTH IT EVERY TIME!**Joanna d'Arcy<sup>1</sup>, Thomas Syburra<sup>2</sup><sup>1</sup>Royal Air Force, Henlow, United Kingdom; <sup>2</sup>Swiss Air Force, Lucerne, Switzerland*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Many cardiac conditions, such as cardiomyopathies and valve disease, may be asymptomatic and with no physical signs in the early stages. These conditions may expose aircrew to increased risk of distraction or incapacitation in flight, and may be incompatible with unrestricted flight duties, or a bar to entry to flight training. To avoid adverse outcomes for aircrew, and to protect organizations' investments in their training, detecting these conditions as early as possible is an attractive option. Using transthoracic echocardiography (TTE) as a screening tool may meet this need.

**OVERVIEW:** TTE is a non-invasive, accessible, low-cost, and reproducible method for assessing the heart. It can be used to detect valve defects or congenital anomalies, and quantify systolic function. It can be used for risk stratification, by quantifying valve disease and chamber dilatation, measuring hypertrophy or detecting outflow tract obstruction. Conversely, a structurally normal heart on screening with TTE can provide a very high degree of reassurance. As well as direct effects of structural abnormalities, which may affect G tolerance or cause symptoms, cardiomyopathies or advanced valve disease may

trigger arrhythmias, which in turn might impact on flight safety. Despite our reliance on physical examination for picking up cases of valve disease in particular, there is ample evidence that even “expert” cardiologists do not reliably detect heart murmurs. Bicuspid aortic valve disease, which is a bar to entry into training in some organizations, will have normal physical findings if the valve function is normal, or only mildly abnormal. Likewise, early phenotypes of cardiomyopathy are very likely to be missed on examination, and ECG appearances may be completely normal. TTE screening would detect the majority of such cases, potentially saving time and money for employers, as well as potentially preventing morbidity and mortality in would-be aviators. It might even be considered a useful addition to periodic cardiac screening, as degenerative valve conditions and occult cardiomyopathy may be detected later on in an aviator's career.

**DISCUSSION:** TTE is an effective, low cost, and accessible tool for screening for many structural heart diseases. Wider use of it may improve risk stratification and optimize flight safety for aviators and employers alike. This presentation will present the argument for wider use of echocardiographic screening.

**Learning Objectives**

1. To understand how screening echocardiography might be used to detect asymptomatic cardiac disease.
2. To understand the types of cardiac conditions which are best detected using screening echocardiography.
3. To understand the potential benefits and pitfalls of using echocardiography to screen for cardiac conditions in aviators.

**[105] AIRCREW SCREENING WITH ECG**Rienk Rienks<sup>1</sup>, Norbert Guettler<sup>2</sup>, Eddie Davenport<sup>3</sup>, Thomas Syburra<sup>4</sup>,Denis Bron<sup>5</sup>, Olivier Manen<sup>6</sup>, Gary Gray<sup>7</sup>, Ed Nicol<sup>8</sup>, Joanna d'Arcy<sup>8</sup>

<sup>1</sup>Central Military Hospital, Utrecht, Netherlands; <sup>2</sup>German Air Force, Center of Aerospace Medicine, Fürstenfeldbruck, Germany; <sup>3</sup>Aeromedical Consult Service, USAF School of Aerospace Medicine, Dayton, OH, USA; <sup>4</sup>Heart Center, Luzerner Kantonsspital, Lucerne, Switzerland; <sup>5</sup>Aeromedical Institute, Swiss Air Force, Dübendorf, Switzerland; <sup>6</sup>Aviation Medicine Department, Percy Military Hospital, Clamart, France; <sup>7</sup>Canadian Forces Environmental Medical Establishment, Toronto, Canada; <sup>8</sup>Clinical Aviation Medicine Service, Royal Air Force, Henlow, United Kingdom

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** The electrocardiogram (ECG) has been part of the screening process of asymptomatic aircrew for a long time. However, recently its usefulness for the screening process is being questioned.

**OVERVIEW:** an ECG is a noninvasive, simple, rapid, reproducible, cheap and reliable way to look for cardiac diseases that carry the risk of life-threatening arrhythmias. This includes channelopathies (long QT and Brugada syndromes), cardiomyopathies (hypertrophic and dilated cardiomyopathy, arrhythmogenic (right) ventricular cardiomyopathy, A(R)VC) and conduction abnormalities (like Wolff Parkinson White, left bundle branch block). Although ECG is not the primary tool to diagnose coronary artery disease (CAD), it may very well diagnose its consequences, like a silent myocardial infarction. ECGs may also contribute to risk stratification (left ventricular hypertrophy, presence of frequent and complex premature ventricular contractions), and to the determination of the severity of valvular disease (left and right atrial dilatation, left and right ventricular hypertrophy). The physical and aeromedical demands that are part of some functions (particularly hypoxia and above all G forces in high performance aircrafts) may increase the vulnerability of the aircrew as a triggering factor for potentially life threatening arrhythmias and thus the finding of an abnormal ECG may save lives. Finally, in the case of HCM and/or A(R)VC, exposure to heavy exercise, as is often the case in a military function, might even accelerate the cardiac deterioration, which makes an applicant unfit for such a function. **DISCUSSION:** the ECG remains an interesting tool with many advantages to find cardiac disease with the risk of potentially life-threatening arrhythmias and other cardiac conditions. It may save lives and should therefore remain a cornerstone of the screening in asymptomatic aircrew.

**Learning Objective**

1. The participants will be able to understand better the role of an ECG in the screening process of aviators.

**Monday, 05/18/2020**  
**Regency 6**

**4:00 PM**

### **[S-23]: PANEL: DILEMMAS OF AN ETHICAL NATURE IN AEROSPACE MEDICINE- A PANEL DISCUSSION**

**Chair: Jeffrey Jones**

**Co-Chair: Al Parmet**

#### **[106] DILEMMAS OF AN ETHICAL NATURE IN AEROSPACE MEDICINE- A PANEL DISCUSSION**

Jeffrey Jones<sup>1</sup>, Bruce Bohnker<sup>2</sup>, Geff McCarthy<sup>3</sup>, Petra Illig<sup>4</sup>, Nora Johnson<sup>5</sup>, Eduard Ricaurte<sup>6</sup>, Keith Ruskin<sup>7</sup>, Allen Parmet<sup>8</sup>  
<sup>1</sup>Baylor College of Medicine, Houston, TX, USA; <sup>2</sup>COMBI, Clearwater, FL, USA; <sup>3</sup>AvSafeMed, Portland, OR, USA; <sup>4</sup>Aviation Medical Services of AK, Anchorage, AK, USA; <sup>5</sup>USAFR (Ret), Austin, TX, USA; <sup>6</sup>VENESCO LLC, Oklahoma City, OK, USA; <sup>7</sup>University of Chicago, Chicago, IL, USA; <sup>8</sup>Aviation Safety and Security, Kansas City, MO, USA

(Education - Tutorial Proposal)

**INTRODUCTION:** Practitioners of Aerospace Medicine may encounter scenarios, which require skill sets outside of what is taught in standard general preventive medicine and aerospace medicine curricula. The aerospace medicine provider should consider how best to handle such cases in a manner that employs the ethical standards of not only the Aerospace Medical Association but all professional associations. **TOPIC:** The panel will first review the principles of ethical principle in medicine and then discuss some recent cases which affect the aerospace medicine practitioner. Reviewing these cases should assist the flight surgeon and aviation medicine examiner in recognizing potential ethical conflict of interest, as well potential ethical pitfalls. There is an expectation that providers of aerospace medicine practice their specialty according to the highest ethical standards of the medical profession; as well as according to federal, state, local, and potentially international bodies which provide oversight and guidelines for medical practice. **APPLICATION:** The planned case studies are selected to invoke discussion of the recognition tools of ethical dilemmas and the possible means to manage and mitigate them. There will be cases brought forth by airmen as well as those of employees in the aerospace medicine industry. After participation, the attendee of the session should be better able to understand many types of ethical challenges, and feel better prepared to manage them as they may occur in their practice. **RESOURCES:** WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects World Medical Association, 1975

#### **Learning Objectives**

1. To develop possible methods to utilize when ethical dilemmas arise.
2. To measure how ethical stressors affect the practitioner's relationship with airman and professional organizations.
3. To mention some potential resources to assist the aeromedical practitioner when faced with ethical dilemmas.

**Monday, 05/18/2020**  
**Regency 8**

**4:00 PM**

### **[S-24]: PANEL: WOMEN'S HEALTH CONSIDERATIONS FOR EXPLORATION SPACEFLIGHT**

**Chair: Rebecca Blue**

**Co-Chair: Jonathan Steller**

**PANEL OVERVIEW:** As NASA and its international partners, as well as the commercial spaceflight industry, prepare for missions of increasing duration and venturing outside of low-Earth orbit, mitigation of medical risk is of high priority. Gynecologic considerations constitute one facet of

medical risk for female astronauts. This panel will review considerations for reducing gynecologic and reproductive risks in female astronauts and discuss management and mitigation opportunities. Further topics will address medical systems integration with systems engineering and vehicular design architecture as well as the practical aspects of health and hygiene while living and working aboard space vehicles.

#### **[107] 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>GeoControl, Inc, Houston, TX, USA; <sup>2</sup>Baylor College of Medicine, Houston, TX, USA; <sup>3</sup>University of Colorado, Denver, CO, USA

(Education - Tutorial Proposal)

**INTRODUCTION:** Exploration vehicle design constraints impose limits on mass, volume, and power allowances for medical resource architecture. One approach to address onboard resource limitations is through the use of additive manufacturing for equipment that otherwise might be excluded from onboard medical kits, such as gynecological speculums. Here, we will discuss additive manufacturing of a gynecological speculum, the implications of lessons learned, and where and how physicians can appropriately influence the integration of medical system capabilities throughout a system design process. **TOPIC:** To demonstrate the challenges inherent to the potential use of additive manufacturing in printing a specialized medical tool, 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 the engineering life cycle 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. The audience will learn about medical system integration into vehicle and engineering architecture including timelines and system development constraints.
2. The audience will learn about challenges associated with just-in-time additive manufacturing of specialized medical equipment during a long-duration exploration spaceflight.

#### **[108] HISTORICAL CHALLENGES FOR WOMEN IN SPACE**

Richard Jennings<sup>1</sup>, Rebecca Blue<sup>2</sup>, Serena Aunon<sup>1</sup>  
<sup>1</sup>University of Texas Medical Branch, Galveston, TX, USA; <sup>2</sup>GeoControl Systems, Inc, Houston, TX, USA;

(Education - Tutorial Proposal)

**INTRODUCTION:** Women have made and continue to make important contributions to the aerospace field. However, historically, their participation has been limited secondary to sex-based biases including anecdotal information from early accidents and hypothesized physiological/psychological limitations and limited tolerance of aerospace-related stressors. This discussion reviews these biases and the more recent evidence to alleviate such concerns. **TOPIC:** Sex-related concerns have

been raised regarding women's capabilities within the aerospace environment since the beginning of human powered flight. Concerns regarding tolerance to physiological stressors, such as acceleration or motion sickness, or limitations related to sex-based anthropometry and strength differences have been prevalent in the aerospace community for decades. Further, additional limitations were historically placed on women given limitations in appropriately fitting equipment and concerns regarding the risks of menstruation, gynecological pathology, and pregnancy. As women have demonstrated their ability to succeed in the aerospace environment, such concerns have largely been ameliorated. This presentation will address these historical concerns and current sex-based biases in aerospace medicine 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 based on aeronautical ability independent of sex.

#### Learning Objective

1. Determine medical and administrative constraints that have impaired women's ability to participate as crewmembers in aerospace operations and understand the current status of integrating women in space flight crews.

### [109] REPRODUCTIVE CONSIDERATIONS IN FEMALE ASTRONAUTS

Jon Steller<sup>1</sup>, Rebecca Blue<sup>2</sup>, Richard Jennings<sup>3</sup>

<sup>1</sup>University of California, Irvine, Irvine, CA, USA; <sup>2</sup>GeoControl Systems, Inc, Houston, TX, USA; <sup>3</sup>University of Texas Medical Branch, Retired, Galveston, TX, USA

#### (Education - Tutorial Proposal)

**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. The audience will learn about current pre-flight and post-flight reproductive concerns of female astronauts.
2. The audience will learn about current contraceptive concerns of female astronauts.

3. The audience will learn about current research evaluating the effects of the cosmic environment on reproductive outcomes.

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

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>, Michele Blackwell<sup>6</sup>, Varsha Jain<sup>7</sup>, Richard Jennings<sup>8</sup>

<sup>1</sup>University of California, Irvine, Irvine, CA, USA; <sup>2</sup>GeoControl Systems, Inc, Houston, TX, USA; <sup>3</sup>Stanford University School of Medicine, Palo Alto, CA, USA; <sup>4</sup>KBR, Houston, TX, USA; <sup>5</sup>NASA Johnson Space Center, Houston, TX, USA; <sup>6</sup>Michele MD Comprehensive Gynecology, Webster, TX, USA; <sup>7</sup>King's College London, London, United Kingdom; <sup>8</sup>University of Texas Medical Branch, Retired, Galveston, TX, USA

#### (Education - Tutorial Proposal)

**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 pre-flight gynecologic and reproductive risk assessment and management considerations.
2. The audience will learn about in-flight gynecologic and reproductive risk assessment and management considerations.
3. The audience will learn about post-flight gynecologic and reproductive risk assessment and management considerations.

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

Serena Aunon-Chancellor<sup>1</sup>, Rebecca Blue<sup>2</sup>

<sup>1</sup>Louisiana State University, Baton Rouge, LA, USA; <sup>2</sup>GeoControl Inc, Houston, TX, USA

#### (Education - Tutorial Proposal)

**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 Objective

1. The participant will be able to explain some of the challenges related to health and hygiene on board the International Space Station.

**Monday, 05/18/2020**

**4:00 PM**

**Regency 5**

### [S-25]: PANEL: PERSPECTIVES ON SAFETY CULTURE AND TRAINING INTERVENTIONS FOR MILITARY AND CIVILIAN AVIATION

**Chair: Chris Brill**

**Co-Chair: Mattie Milner**

**PANEL OVERVIEW:** The purpose of this panel is to explore the impact of safety and punitive cultures on aircraft operations and aviation mishaps. Panelists were selected from diverse backgrounds to represent US Air Force, Navy, and civilian perspectives. The panel chair will frame the discussion with an overview covering the history and depictions of safety and punitive cultures in aviation. The first panel speaker will present a study on civilian rotorcraft mishaps Human Factors Analysis and Classification System (HFACS). The presentation will discuss the need for improved documentation of organizational cultural factors in mishap reports to facilitate better longitudinal analyses and training gaps. The second panelist will discuss the normalization of deviance in Naval aviation mishap reports. The third panelist will discuss how safety culture has influenced reporting of unexpected physiological events in USAF operations. Lastly, the fourth panelist will discuss pilots' versus consumers' perceptions of punitive culture. Following brief presentations from the panelist, the chair will facilitate discussion using prepared and audience questions.

#### [112] IMPACT OF POORLY MANAGED SAFETY CULTURE ON PILOT'S RISK-TAKING BEHAVIOR

Mattie Milner<sup>1</sup>, John Brill<sup>2</sup>, Stephen Rice<sup>1</sup>

<sup>1</sup>Embry-Riddle Aeronautical University, Daytona Beach, FL, USA;

<sup>2</sup>Wright-Patterson AFB, OH, USA

*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** This case report describes a civilian pilot who failed to complete appropriate safety checks before flight, ultimately resulting in a fatal accident. General aviation comprises a large number of aviation-related mishaps, many of which are caused by human error. Human error can include any type of behavior that negatively impacts performance; however, it can often be combatted with a strong safety culture. A high-functioning safety culture promotes several different initiatives, including clearly defined and communicated types of valued safety behavior, strong hazard reporting culture, lack of repeat safety incidents, employees comply with procedures when supervisors aren't watching, etc. When organizations fail to prioritize safety culture, otherwise preventable accidents may begin occurring. **METHODS:** A case study from the NTSB database involving a 64-year old male working with Air Methods Corporation. He was an experienced pilot with over 13,000 total flight hours as the pilot in command and over 5,000 total flight hours on this specific Airbus Helicopter. Visual meteorological conditions prevailed at the time of the incident when the pilot and two flight nurses left the heliport. According to the NTSB investigation, the pilot performed a "preflight hydraulic check, which subsequently depleted hydraulic

pressure in the tail rotor hydraulic circuit". Furthermore, the aircraft was not equipped with salient cuing, which may have alerted the pilot to the lack of hydraulic pressure. Although it is not clear why, the pilot failed to perform a routine hover check from a safe altitude after liftoff, "which would have alerted him to the pedal control anomaly". **RESULTS:** A combination of these factors contributed to the helicopter crash about 300 feet from the ground-based helipad. The pilot was fatally injured in the accident and the two flight nurses were seriously injured. **DISCUSSION:** Although there were several contributory factors, this case highlights the dangers of a poor safety culture, such that employees don't comply with procedures at all times. It is unclear why the pilot elected to forego the standard procedure of checking the hydraulic pressure. Perhaps he felt either self-induced or external pressure to complete the transportation as quickly as possible or perhaps he simply forgot to perform the routine procedure and the company didn't emphasize using a checklist.

#### Learning Objective

1. Understand the causal factors that ultimately contributed to the accident.

#### [113] WHAT'S IN A NAME? NORMALIZATION OF DEVIANCE IN U.S. NAVAL AVIATION MISHAPS

Andrew Miranda<sup>1</sup>

<sup>1</sup>Naval Safety Center, Norfolk, VA, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Across high-risk industries, whether it be aviation, oil and gas, or military operations, there is an emphasis for strong and effective safety culture. Specifically, efforts to increase the awareness adverse culture-traps—such as normalization of deviance—are among the highest priorities of safety professionals, as well as their higher-level leadership. Despite the increased awareness, adverse events still occur in which safety culture plays a role. **OVERVIEW:** Over the last several years, there has been an increase in the number of U.S. Naval aviation mishaps that cite normalization of deviance as being among the multitude of causal factors involved in the event. The current process review involved a systematic examination of these particular mishaps, with the intent to identify common and meaningful attributes and characteristics across the events. We were interested in reviewing the mishaps for common themes that existing, or were perhaps absent, within the safety culture programs within each aviation squadron, with the goal to better understand how investigators consider and scrutinize safety culture during investigations. Though a variety of interesting themes were uncovered, the review revealed an overemphasis on the deviance aspect and an overall lack of meaningful discussion on the normalization aspect. The process review, its development, challenges, successes, and lessons learned will be presented, as well as meaningful discussion of how safety culture plays a role in mishap investigation. **DISCUSSION:** Though safety culture, and the specific organizational phenomenon normalization of deviance, are popular terms used across various industries, the current project presents a view of how they are understood and applied by mishap investigation teams working within specific U.S. Navy aviation squadrons and units. This work is of broad interest to aerospace safety professionals, especially those in a position to apply safety culture lessons within their respective organizations.

#### Learning Objective

1. The audience will learn about how the U.S. Navy investigates safety culture following an aviation mishap.

#### [114] SAFETY CULTURE AND REPORTING OF PHYSIOLOGICAL INCIDENTS IN U.S. AIR FORCE FIGHTER AIRCREW

Heather Tevebaugh<sup>1</sup>, Stuart Sauls<sup>2</sup>, Rachael Falcon<sup>1</sup>

<sup>1</sup>Air Force Safety Center, Kirtland AFB, NM, USA; <sup>2</sup>USAFSAM, Wright-Patterson AFB, OH, USA

*(Original Research)*

**INTRODUCTION:** The stresses inherent in fighter aviation cause higher risk of physiological incidents, and require greater resilience in aircrew, than other types of aircraft. According to Air Force policy, all physiological incidents must be reported. Nonetheless, aircrew may sometimes fail to report physiological incidents for a variety of reasons,

including misunderstandings about the reporting policy, or fear of losing their flying status. While safety culture should be negatively related to safety incidents overall, we hypothesize that aspects of safety culture will be positively related to the reporting of those physiological incidents that could potentially go unreported. This abstract contributes to the Air Force Safety Center's research using the Air Force Combined Mishap Reduction System (AFCMRS) and Air Force Safety Automated System (AFSAS).

**METHODS:** We analyzed US Air Force aviation, physiological incidents from Fiscal Years 2010 – 2019 in squadrons that fly fighter/attack aircraft. A subject matter expert categorized incidents by whether or not they could go unreported. Safety culture was measured with an anonymous, web-based survey. Regressions were used to determine the effect of various aspects of safety culture on reporting, controlling for overall level of safety incidents. **RESULTS:** The direction of the relationship between safety culture and reporting depends on the aspect of safety culture being measured, and on the other variables that are controlled for in the model. The pattern of relationships provides insight about the underlying reasons for non-reporting of physiological incidents in fighter aircrew. **DISCUSSION:** Not only does safety culture predict the occurrence of safety incidents, but also reporting of those incidents. Accurate analysis of safety incident data for mishap prevention purposes requires complete, accurate, and unbiased reporting. This study provides insights into the underlying reasons for non-reporting of incidents that may be used to target educational measures to most effectively ensure accurate reporting and improve safety.

#### Learning Objective

1. The audience will understand the aspects of safety culture that relate to reporting of physiological safety incidents.

#### [115] CONSUMERS' VS. PILOTS' PERCEPTIONS OF PUNITIVE CULTURE IN AVIATION

Stephen Rice<sup>1</sup>, Scott Winter<sup>1</sup>

<sup>1</sup>Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Program / Process Review Proposal)

**INTRODUCTION:** The aviation industry takes a different approach to safety compared to many other industries. For example, when things go wrong in the medical industry, hospitals and providers tend to "circle the wagons" for fear of lawsuits and other punitive damages. The aviation industry, on the other hand, actively seeks voluntary safety reporting. The premise here is that participants (pilots, flight crew, or other members of the organization) should feel comfortable submitting voluntary safety reports in cases of accidents, incidents or the presence of other safety hazards. This safety culture is not present in all countries, however. Some countries already inflict punitive measures on persons who have been deemed responsible for these events, including prison terms in some cases. Over the past decade, we have seen a rise in calls by the American public for criminalization of those who might be perceived as being responsible for accidents, particularly for ones that result in loss of life. This trend is a growing concern for those of us in the safety profession, as we believe that the short-term demand for punishment will become a significant deterrent to the long-term safety goals of the aviation industry. When flight crew fear criminal prosecution or career-ending punitive damages, they will be far less likely to provide voluntary reports or cooperate with investigations aimed at finding the root cause of accidents with the goal of preventing future accidents.

**METHODS:** The purpose of the current study was to experimentally examine perceptions of both aviation consumers and pilots in order to determine their level of agreement with the criminalization of pilots in a variety of specific cases that may or may not have resulted in loss of life.

**RESULTS:** Our results indicate that there are significant differences in attitudes toward criminalization, with consumers being much more likely to demand punitive measures compared to their pilot counterparts.

**DISCUSSION:** In all cases, pilots were generally opposed to criminalization regardless of blame, while consumers were supportive of criminalization when they felt that the pilot was in error. Neither group was supportive of criminalization when the accident was beyond the pilot's control.

#### Learning Objective

1. Understand the different perceptions toward punitive culture pilots and consumers.

**TUESDAY, MAY 19, 2020**

Tuesday, 05/19/2020

8:00 AM

Centennial Ballroom II/III/IV

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

James C. McEachen, M.D., ME, M.P.H., and

Anthony P. Tvaryanas, M.D., Ph.D.

#### "The Flight Path Toward Precision-Based Aeromedical Decision Making"

Tuesday, 05/19/2020

10:30 AM

Centennial I

#### [S-26]: PANEL: FAA AEROMEDICAL RISK ASSESSMENT OF THE NEUROCOGNITIVE IMPLICATIONS OF HIV SEROPOSITIVITY – INTEGRATING CURRENT RESEARCH AND MEDICAL KNOWLEDGE

Endorsed by the American Society of Aerospace Medicine Specialists

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 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.

#### [116] FAA HIV NEUROPSYCHOLOGICAL EVALUATION SPECIFICATIONS

Randy Georgemiller<sup>1</sup>

<sup>1</sup>FAA, Washington, DC, USA

(Education - Tutorial Proposal)

**INTRODUCTION:** This presentation will discuss FAA Neuropsychological Evaluation Specification updates for people living with HIV