

pilot to fly after the dental procedure. Additional features include, simplification of difficult surgical procedures, biopsies and tissue contouring that has minimal bleeding with little to no anesthetic, pain relief for acute phases of temporomandibular disorders, and the ability to treat periodontitis and peri-implantitis. As a clinician, we have a responsibility to offer our patients the safest, and most effective treatment available. Keeping abreast with the latest research, and evaluating modern technological advances, can increase the margin of safety for our pilots and minimize distractions during flight.

Learning Objectives

1. The participant will be able to identify what modern technological advances have improved safety for pilots and astronauts and why.
2. The participant will gain an understanding of how laser energy interacts with different tissues, and what wavelength works best for different applications.

WEDNESDAY, SEPTEMBER 1, 2021

Wednesday, 09/01/2021
Governor's Square 14

8:30 AM

[S-39]: PANEL: MAKING SENSE OF SPECIAL SENSES

Sponsored by 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.

[193] "DIZZYING TESTS" OR NEUROVESTIBULAR TESTING MADE EASY

David Schall¹

¹FAA, Colorado Springs, CO, USA

(Education - Tutorial / Review)

INTRODUCTION: This presentation will address neurovestibular testing for aviators. **TOPIC:** 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 ECOG are just a few of them. **APPLICATION:** 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" 2nd Edition, by Alan Desmond; Thieme, New York; 2011 ISBN 978-160406-361-5

Learning Objectives

1. The clinician will have a better understanding of what Neurovestibular tests are currently available.
2. The clinician will understand what these tests measure, when to use them, and pitfalls associated with using them.
3. The clinician will have understand what conditions can be diagnosed with these tests.

[194] TO THE COCHLEA AND BEYOND: PURE TONES ARE NOT THE WHOLE STORY

John Allen¹

¹NASA, Washington, DC, USA

(Education - Case Study)

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 Objectives

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

[195] VISION PERFORMANCE ISSUES: QUALITY OF VISION (QoV) AND COLOR VISION (CV) TESTING

Douglas Ivan¹

¹ADI Consultants, San Antonio, TX, USA

(Education - Tutorial / Review)

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.

[196] MAKING SENSE OF SPECIAL SENSES: ASSESSING RETINAL PATHOLOGY, CAN THE EYE FLY?

Harriet Lester¹

¹Federal Aviation Administration, Jamaica, NY, USA

(Education - Case Study)

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 exist. 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.

Wednesday, 09/01/2021

Governor's Square 15

8:30 AM

[S-40]: PANEL: APPLICATIONS AND LIMITATIONS OF PERSONALITY ASSESSMENTS IN AVIATION: WHAT DOES THE RESEARCH SAY?

Chair: Brennan Cox

Panel Overview: Personality assessments have a long-standing history of use in the evaluation and management of aviation personnel. In general terms, an individual's personality may be viewed as their characteristic pattern of behaviors, thoughts, and emotions. Consensus among theorists suggests personality is relatively stable over time, but also susceptible to environmental influences. Within the aviation environment, numerous efforts have attempted to characterize, understand, and make predictions based on the traits associated with the distinctive "pilot personality." Such efforts are enabled by a variety of personality assessments tools, with different measurement approaches being developed and/or employed to address specific personality-based questions or program needs. This panel includes five presentations on the applications and limitations of personality assessments in the aviation environment. The panel will begin with a historical overview on the use of personality assessments in aviation. This will be followed by presentations on the use of Big Five measures of personality in relation to aviator performance; the challenges and mitigation strategies with self-report personality assessments in high-stakes selection settings; the interplay between aviator personality and injury; and the assessment of aviator personality from the clinical perspective. The panel will conclude with a question and answer session with audience participation encouraged. Questions from the panel chair will address the unique qualities of different personality assessments; how to select the most appropriate measurement approach; benefits and limitations of personality data in the aviation environment; and remaining gaps and strategic direction on how to advance aerospace medicine through research on personality assessments.

[197] PERSONALITY ASSESSMENT IN PILOT SELECTION: A HISTORICAL REVIEW

Ray King¹

¹FAA, Washington, DC, USA

(Education - Tutorial / Review)

INTRODUCTION: To understand the history of personality in personnel selection is to understand the two flavors of selection. There were early (and continuing) efforts to define the "right stuff" for aviation. The first documented selection effort involved only two candidates, both qualified (having designed the aircraft) for the novel task and both Wright brothers. While a coin toss was the selection method, Wilbur stalled the aircraft and several days later Orville made the first flight. **TOPIC:** Selection efforts are comprised of "Select In" and have been the concern of leadership, and more recently, include I/O psychologists. Personality assessment, measuring desirable traits, has proven largely invalid for pilot selection across many nations. Candidates are typically highly motivated to enter training, thus impression management is a problem. Another problem is that personality tests were traditionally measuring psychopathology rather than positive traits. **APPLICATION:** The relatively recently developed five-factor model is more suitable for select in. As women increasingly join the ranks of aviators, they are being found to more closely resemble their male counterparts in their personality structure than women in the general population. A parallel effort is medical and focuses on whom should NOT fly. This "Select Out" approach is the domain of physicians, and more recently, also clinical psychologists. While aircraft were pressed into service for the World War 1, not much attention was paid to selecting who should pilot aircraft, but Germany, Italy, the UK, and the US began efforts to develop medical standards for pilots, including reaction to stress, using tests and physical stimuli. These standards were dependent on comparing successful aviators to those who were not successful. World War II provided more opportunities to perfect pilot personality selection techniques, and gave birth to the

Adaptability Rating for Military Aeronautics (ARMA) in the US. Military flight surgeons, via interview, attempted to identify candidates with positive qualities, such as “cheerful temperament” and “moderately impulsive,” and problematic characteristics, seen as “prolonged” enuresis, nail biting, “criminality in family.” The intent of the ARMA, while not always formally administered by flight surgeons, can be summarized by the impressionistic question: “Would I fly with this person?,” which evolved from “Would I fly with this man?”

Learning Objectives

1. Attendees will appreciate the two flavors of personnel selection and understand the role of personality testing in each.
2. Attendees will gain an understanding of the evolution of personality assessment in pilot selection.

[198] RELATIONS OF BIG FIVE PERSONALITY TRAITS TO AVIATOR PERFORMANCE: THE CRITERION MATTERS

Thomas Carretta¹, Bobbie Dirr²

¹Air Force Research Laboratory, Wright-Patterson AFB, OH, USA; ²Air Force Personnel Center, Randolph AFB, TX, USA

(Original Research)

The study of personality in aviation generally has employed three approaches: (1) job analysis, (2) comparison of personality profiles relative to the general population, and (3) criterion-related validation.

JOB ANALYSIS: In this approach, experienced aircrew rate the perceived importance of various traits along with skills, abilities, and other characteristics. Several personality traits have been identified as important for manned aircraft pilots including conscientiousness, emotional stability, cooperativeness, and openness. **PERSONALITY PROFILES:** Profile-based approaches typically compare norms for aircrew personnel (applicants, trainees, or crewmembers) to those for the adult population. Military aircrew norms are higher on the Big Five domains of emotional stability, extraversion, and conscientiousness, lower on agreeableness, and about the same on openness.

CRITERION-RELATED VALIDITY: The criterion-related validity of personality for aircrew training and job performance is generally low, but varies by the criterion. Personality scores have shown little predictive validity for training completion for both manned and unmanned aircraft training. Openness showed a small, but significant negative effect for pilot training completion. A closer examination of the data indicated the effect occurred only for high aptitude trainees. Openness also has shown significant negative relations to pilot training grades. A study that examined the relations of personality to reasons for training elimination reported small but statistically significant relations. Compared to those passing training, students who failed due to flying training deficiency were less extraverted and confident as well as more depressed and deferent. Compared to passing students, those who dropped on request were less aggressive, impulsive, and risk taking. In a study of personality and early-career ratings of pilot job performance, agreeableness, emotional stability, and extraversion scores collected prior to training were positively correlated with supervisor ratings on officer performance reports. One potential reason for the low predictive validity of personality to aircrew job performance is the construct validity of aircrew occupational criteria, which focus on measurement of technical proficiency as opposed to indicators of effort, discipline, leadership, or organizational commitment.

Learning Objectives

1. Understand the utility of personality for predicting US Air Force aircrew training and job performance.
2. Understand the job performance criteria used to validate US Air Force selection methods.

[199] RESEARCH ON ADAPTIVE, FORCED-CHOICE PERSONALITY ASSESSMENT AND ITS APPLICABILITY TO AVIATION SELECTION CONTEXTS

Heidi Keiser¹, Kenneth King¹, Sabrina Drollinger¹, Audrey Moore¹, Henry Phillips¹

¹Naval Aerospace Medical Institute, Pensacola, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Among the challenges inherent to high-stakes personality testing is the susceptibility of these tests to faking. The potential for applicants to fake good or engage in desirable but deceptive responding is well documented, particularly with use of single-stimulus Likert-style scales (e.g., Birkeland, Manson, Kismore, Brannick, & Smith, 2006; Hough et al., 1990; Mahar et al., 2006; Viswesvaran & Ones, 1999; White & Young, 1998; Zickar & Robie, 1999). Forced-choice (FC) personality tests provide an alternative approach that reduces faking potential, especially when response alternatives are equated in desirability (Christiansen, Burns, & Montgomery, 2005; Stark et al., 2014). For organizations engaged in high-stakes testing, minimizing the degree to which applicants misrepresent themselves is a top priority. **TOPIC:** This presentation will begin by discussing the history of FC personality assessments and the body of research surrounding their reliability, validity, and induced applicant reactions. We will then highlight the use of FC personality tests in aviation selection, focusing on the US Navy's Naval Aviation Trait Facet Inventory (NATFI), a FC personality test that has been used operationally for the selection of Naval aviators and flight officers since 2013. Reliability and validity evidence for the NATFI will be presented, including its potential to incrementally predict Naval aviation training performance above and beyond measures of cognitive ability. Lastly, unanswered questions surrounding FC personality assessments that must be addressed for their expanded use in aviation selection will be discussed. **APPLICATION:** Implications for future operational use of forced choice personality in aviation selection will be highlighted.

Learning Objectives

1. After this panel, attendees will have learned about the structure of forced-choice personality assessments and how they differ from traditional Likert-type tests.
2. After this panel, attendees will have learned about reliability and validity evidence for forced-choice personality tests.
3. After this panel, attendees will have learned about the potential for forced-choice personality assessments to improve the selection of civilian and military aviators.

[200] EXPLORING INDIVIDUAL PERSONALITY DIFFERENCES IN RELATION TO NECK MUSCLE ACTIVATION DURING PROLONGED 'HELO-HUNCH' SEATING

Peter Le¹, Charles Weisenbach², Emily Mills², Lanie Monforton⁴, Tatana Olson¹

¹Naval Medical Research Unit Dayton, WPAFB, OH, USA; ²Naval Medical Research Unit Dayton (ORISE), WPAFB, OH, USA; ³Naval Medical Research Unit Dayton (Parsons Corporation), WPAFB, OH, USA

(Original Research)

INTRODUCTION: While aviators and aircrew commonly report neck pain (NP), the etiology is complex and multi-faceted beyond physical loading. Individual differences add to this complexity, especially since some people appear less susceptible to NP. Psychosocial and personality factors have been known to play a role in increasing muscular tension in the neck. However, it is unclear how they interact with physical loading factors. The **objective** of the current study seeks to explore relationships between personality and biomechanical responses to physical and mental workload. **METHODS:** 2x2x2 counterbalanced design; n=16 subjects. This was a derivation of a larger study examining the effects of head posture, physical helmet load, and visual stress. Electromyography (EMG), head kinematics, a short version of the Big-Five Personality Inventory, and NASA-TLX were collected from each subject. For each testing condition, subjects remained still in a 'helo-hunch' posture for 30 minutes while completing a Tumbling 'E' task. **RESULTS:** EMG: Prolonged activity in the right cervical extensors were associated with higher levels of neuroticism (p=0.005), higher levels of conscientiousness (p=0.032), and higher visual stress (p=0.015). Kinematics: Helmet * visual * conscientiousness were associated with increased head yaw rotations (p=0.031). TLX Workload: Less conscientious individuals tended to report higher physical workload (p=0.009). Increased frustration was associated with openness to experience * posture (p=0.001). Higher overall workload was associated with posture*visual (p=0.037) and

visual*extraversion ($p=0.038$). Performance: Helmet * posture * visual * conscientiousness was associated with decreased errors ($p=0.030$).

DISCUSSION: More neurotic and more conscientious individuals had prolonged musculoskeletal tension in the neck across conditions. Less conscientious individuals had decreased performance likely due to being less attentive, reported higher levels of perceived physical workload, and tended to shift their head posture more throughout the prolonged seating session. Hence, more neurotic and conscientious individuals may be more susceptible to NP; however, further research is needed to confirm this hypothesis. The results of the current study serve as preliminary insight for a larger study evaluating personality, workload, and prolonged seating. Together, such studies may provide a more holistic view for aviator selection and optimization of training paradigms.

Learning Objectives

1. Recognize the complex interactions associated with neck pain including physical loading, mental loading, and individual differences.
2. Discuss potential mechanisms for how personality may affect musculoskeletal responses and could contribute to neck pain.
3. Postulate how understanding personality differences may help reduce neck pain by optimizing aviator selection, training, and the environment for the individual.

[201] CLINICAL APPLICATIONS OF PERSONALITY ASSESSMENT WITH AEROSPACE PERSONNEL

Chris Front¹

¹FAA, Washington, DC, USA

(Education - Program / Process Review)

The clinical application of personality assessment by clinical psychologists with specialty training in aerospace medicine frequently contributes to the evaluation of behavioral health disorders that are considered disqualifying in aerospace personnel. These specialty assessments are not widely understood by other aerospace medicine specialists. This presentation provides an overview of the clinical psychological assessments common in both civil and military aviation in the USA. There is empirical evidence that multimethod psychological assessment produces more valid results than reliance on psychiatric interview alone. Clinical psychological assessment is a complex, integrative process that includes a thorough review of records, psychosocial/clinical interview, mental status examination, and administration of psychological tests that have demonstrated efficacy in identifying psychopathology. Psychological assessments are required by regulators and the military services in the initial medical certification of pilots and other aerospace personnel when a history or indications of behavioral health problems are noted. The FAA and the military branches have specific mental health standards and assessment requirements for determining flight status qualification. Psychological assessments can substitute for or be combined with concurrent psychiatric evaluations. Clinical psychological assessments are also required by some airlines as part of their selection process, as well as fitness for duty evaluations of incumbent employees when concerns are raised about behavioral health problems. The Minnesota Multiphasic Personality Inventory and its revision (MMPI-2) have a long history of demonstrated efficacy in the identification of maladaptive personality traits, personality disorders, and other psychopathology that are considered disqualifying conditions by most aerospace authorities. Excellent normative data for both pilots and air traffic controllers are available for the MMPI-2 and it remains the most-used psychological test for identifying disqualifying psychopathology among aerospace personnel. Specialty training in aerospace clinical psychology is critical for achieving valid assessment results. In the absence of specialty training, erroneous findings occur, most frequently due to: failure to identify and manage positive impression management; failure to apply aerospace normative test scores; and failure to apply aerospace mental health regulatory standards.

Learning Objectives

1. The participant will be able to describe the role of personality assessment in the clinical evaluation of aerospace personnel.
2. The participant will be able to identify the personality inventory with extensive empirical validation in the clinical assessment of aerospace personnel.

Wednesday, 09/01/2021

Plaza A/B

8:30 AM

[S-41]: PANEL: DEVELOPING AN EXTREME ENVIRONMENT MEDICAL SYSTEM – LESSONS FROM THE ORION SPACECRAFT

Chair: David Reyes

Co-Chair: Douglas Ebert

Panel Overview: This panel provides an overview of the development process for the Orion spacecraft medical system with review of methods, lessons learned, and applicability to the design of medical capabilities for extreme and austere environments. NASA is mandated to return to the moon by 2024, and efforts to build the medical system for Artemis missions using the Orion vehicle are well under way. We will discuss the process of creating a medical kit for the first missions to depart the Earth for the Moon since the days of Apollo. The first panel presentation will provide an overview of the methods used to determine which medical conditions to treat and the resources required. A portion of that work is based on probabilistic risk assessment performed using NASA's Integrated Medical Model, which is the topic of our second report. Due to the short duration of the Artemis missions (< 21 days) and small cabin volume of the Orion vehicle, extremely unlikely medical events were excluded from modelling in order to optimize mass and volume savings. Exclusions and opportunities are detailed in the next presentation, where we discuss trade-offs amongst NASA requirements, treatment capabilities, and mass/volume constraints. In the fourth report, we discuss the integration of medical capability within the vehicle and the broader mission, using the example of medical water supply. Finally, a contingency scenario is discussed, where we review the medical considerations of a sustained cabin depressurization event. This panel will be useful for those persons planning medical care for extreme environments such as expeditions, far forward deployed military and commercial spaceflights.

[202] A SEMI-QUANTITATIVE APPROACH TO BUILDING THE ORION SPACECRAFT MEDICAL KIT

David Rubin¹, Doug Ebert¹, Christopher Haas², James Pavela³, Derek Nusbaum², Josef Schmid³, Christopher Van Velson¹, David Alexander³, David Reyes²

¹KBR, Houston, TX, USA; ²University of Texas Medical Branch, Galveston, TX, USA; ³Johnson Space Center, NASA, Houston, TX, USA

(Original Research)

INTRODUCTION: The Orion spacecraft needs a comprehensive medical system to support its crewmembers during upcoming Artemis moon missions. Identification of this system's components requires an understanding of substantial mission constraints and likely medical conditions. A combination of modeling, subject matter expertise, and historical analysis was used to define the medical system components. **METHODS:** Medical conditions from NASA's Exploration Medical Conditions List, augmented by subject matter expertise, were ranked based on 1) metrics that incorporate the probability of that condition occurring during the mission, 2) the complexity of treating the condition, and 3) the futility of attempting to treat the condition. From this ranking, a "plan to treat" condition list was developed and resources for the diagnosis and treatment of those conditions were identified. A final resource list was determined by including only resources that treated the selected conditions and met expected vehicle and crew skill constraints. **RESULTS:** Of 216 conditions considered ("best case" and "worst case" of 108 unique conditions), 109 "best case" and 52 "worst case" conditions were selected to be included on the "plan to treat" list. Across these 161 condition cases, 479 unique resources were considered for inclusion in the Orion medical system and 168 resources were ultimately selected. **DISCUSSION:** The identification of spacecraft medical capabilities and associated resources is a function of 1) potential medical events, 2) the ability of crewmembers to use the selected medical equipment, and 3) mass, volume, and power constraints dictated by the vehicle and mission. Even a well-provisioned medical system does not guarantee that all medical conditions during a mission can be diagnosed and treated; the goal is to minimize medical risk, recognizing that risk cannot be fully eliminated given mission constraints. The methodology used to identify Orion medical system resources provides flight surgeons with an

effective framework on which to make informed resource choices, document decisions, and minimize risk. The outcome of this methodology was not simply a resource list, but a record of the step-by-step decision making and justification process. The process developed during this work can be used to design medical systems for future missions and may also be useful for the design of medical kits used in other austere environments.

Learning Objectives

1. Learn about a semi-quantitative process for identifying medical resources to build medical kits for extreme environments.
2. Understand how mission constraints limit the selection of a medical capability for spaceflight.

[203] USING PROBABILISTIC RISK ASSESSMENT TO INFORM THE DESIGN OF THE ORION MEDICAL KIT

Erik Kerstman¹, John Arellano², Lynn Boley³, David Reyes¹

¹University of Texas Medical Branch, Galveston, TX, USA; ²MEI Technologies, Houston, TX, USA; ³KBR, Houston, TX, USA

(Original Research)

INTRODUCTION: As the National Aeronautics and Space Administration plans for human exploration missions, the mass and volume constraints of new vehicles present challenges in design of medical kits. A lunar orbital mission designated as Artemis II (A2) is planned for 2022 using the Orion vehicle. The Integrated Medical Model (IMM) is an evidence-based decision support tool using probabilistic risk assessment (PRA) methods that can assess mission risk due to in-flight medical events. The IMM was used to inform the preliminary design of a medical kit for A2 (IMM Service Request S-20180815-406). **METHODS:** The IMM generated optimized medical kits for a 21-day A2 mission with four crew. Since the IMM is baselined to the International Space Station, it was modified to better reflect the Orion vehicle. The IMM optimization routine was set to generate two medical kits that maximized crew health, given: 1) a mass constraint of 9.07 kg and no volume constraint, and 2) a mass constraint of 9.07 kg and volume constraint of 13,721 cm³. Primary outputs were a list of medical resources for the optimized medical kits and the probabilities of medical events. Additional outputs included Crew Health Index (CHI, the inverse of quality mission time lost), the probability (0 to 1) of medical Evacuation (pEVAC), probability of medical Loss of Crew Life (pLOCL), and a list of influential medical conditions. **RESULTS:** Over the 21-days the optimized medical kit with only a mass constraint resulted in a mean CHI of 97.20%. The mean pEVAC was 0.0065 and the mean pLOCL was 0.0005. The optimized medical kit with both mass and volume constraints resulted in a mean CHI of 97.20%, mean pEVAC of 0.0074 and mean pLOCL of 0.0005. A list of influential conditions and resources used for both medical kits was also generated. **DISCUSSION:** The IMM-generated lists of medical resources and probabilities of medical events were used to inform the preliminary design of a medical kit for the A2 mission. Additional subject matter expertise and operational experience was applied to address IMM kit limitations. The next iteration will use the current derived medical kit resource list as IMM input to reassess outcomes. Further refinement of the Orion medical kit may be considered based on these results. This work demonstrates the utility of PRA to provide quantitative estimates of medical risk and resource utilization that may be useful for mission medical planning in other austere environments.

Learning Objectives

1. Learn about the use of probabilistic risk assessment as a tool to form a starting place for building medical systems used in extreme austere environments.
2. Understand the limitations of probabilistic risk assessment for prediction of medical events, and the need for subject matter expert interpretation.

[204] TURNING LIMITATIONS INTO OPPORTUNITIES IN THE DEVELOPMENT OF THE ORION MEDICAL KIT

David Reyes¹, Doug Ebert², David Rubin², Christopher Haas¹, James Pavela³, Josef Schmid³, Derek Nusbaum¹, Christopher Van Velson²

¹University of Texas Medical Branch, Galveston, TX, USA; ²KBR, Houston, TX, USA; ³Johnson Space Center, NASA, Houston, TX, USA

(Original Research)

INTRODUCTION: Determining what not to treat with the Orion medical system is as important as defining what will be treated. In this work we review the interplay between NASA requirements, constraints, and opportunities for synergy during the development of the Orion medical system. **METHODS:** NASA's required Levels of Care (LOC) for different types of missions (e.g., low earth orbit (LEO) versus lunar) were cross-referenced with medical conditions (primarily drawn from NASA's Exploration Medical Conditions List), and the resources required to address those conditions (baselined to the International Space Station medical capability). Some medical resources were excluded from the Orion system to comply with mass and volume limits, while other resources that could be applied across multiple conditions were prioritized for inclusion. Ideas for integration of multiple medical devices into a single platform were explored. Mission stakeholders (astronauts, flight surgeons, managers) were involved in the process. **RESULTS:** The Orion team identified 50 conditions for exclusion from an initial list of 216, including 17 conditions mitigated by prevention and screening, 15 for which mass and volume constraints limit worst-case treatment capability, 14 for which the vehicle volume limits the probability of trauma, and 4 that are precluded by short mission duration. Remaining conditions with a 'plan to treat' designation were optimally matched with medical resources – for example antibiotics with broad spectrum activity were identified for inclusion, while anticoagulants were de-prioritized given short mission duration and low likelihood of need. Inclusions and exclusions were also examined in light of the LOC standards. A 'hackathon' challenge was entered to generate concepts for combining medical devices into a single app-based tablet (sound level monitoring, ultrasound, electrocardiogram, etc.). **DISCUSSION:** Significant savings in mass and volume are achieved by examining which conditions are improbable, and what resources are necessary versus desired. Opportunities for additional savings and capability in austere environment medical planning are found in screening, prevention, prioritizing capabilities that treat multiple conditions, inclusion of stakeholders in planning, and involving personnel outside the primary development team to bring in fresh ideas.

Learning Objectives

1. Understand the interplay between mass, volume, skill and other constraints on the selection of medical kit contents for austere environments.
2. Learn about opportunities for synergy where limitations might otherwise exist in the development of medical capabilities for extreme austere environments.

[205] EARLY SYSTEMS INTEGRATION STRENGTHENS ORION MEDICAL CAPABILITIES

Christopher Haas¹, Kevin Rosenquist², Christopher Van Velson³, David Rubin³, David Reyes¹

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(Original Research)

INTRODUCTION: The Orion spacecraft has significant mass and volume constraints, which limit items that can be provided for medical use. Sharing of resources between vehicle systems is therefore required to meet design requirements. This presentation will illustrate resource sharing within the Orion vehicle using medical water drawn from the potable water system as a case study. **METHODS:** Vehicle water is stored aft of the crew compartment in the Orion Service Module tanks and is delivered through the Potable Water Dispenser (PWD). Water for medical purposes must be kept at an appropriate temperature; however, thermal analysis shows that water may be too hot for immediate medical use when initially dispensed. Meeting requirements for water quality, medical use, storage, and disposal during the Orion mission relied on collaboration between multiple vehicle system stakeholders. **RESULTS:** A commercial water bag previously selected to store drinking water was identified as an appropriate method to store water early in the mission and allow it to equilibrate to cabin temperature. This solution resolved the temperature issue but challenged water quality standards. Water quality issues were resolved through identification of potential contaminants and the conclusion that they were benign given the short mission duration. Disposal of the medical water before re-entry was deemed unnecessary because medical contingency water usage would be

collected in towels; therefore, a contribution to landing mass would still occur. Materials testing revealed that the water bag is flammable in elevated oxygen environments, but these concerns were resolved by using non-flammable containment. **DISCUSSION:** A traditional development flow often designs vehicles first, then introduces human systems integration later in the cycle, putting medical systems at a disadvantage. Early connections between crew health stakeholders and other development teams have reduced costs and schedule overruns, while providing the best medical capabilities possible. Logistics planning for austere environment missions should include medical stakeholders from the beginning so that the best medical capability can be provided.

Learning Objectives

1. Understand the interplay between different systems and stakeholders to optimize medical capabilities in an austere vehicle environment.
2. Early and frequent communication between stakeholders results in expedient and optimal development of medical capabilities for austere environments.

[206] MEDICAL CARE DURING CONTINGENCY SUITED RETURN FOR THE ORION ARTEMIS MISSIONS

Christopher Van Velson¹, Tina Bayuse¹, David Rubin¹, Kevin Rosenquist², Doug Ebert¹, James Pavela³, Derek Nusbaum⁴, David Reyes⁴, David Alexander³

¹KBR, Houston, TX, USA; ²JES Tech, Houston, TX, USA; ³Johnson Space Center, NASA, Houston, TX, USA; ⁴University of Texas Medical Branch, Galveston, TX, USA

(Original Research)

INTRODUCTION: If the Orion spacecraft were to suffer an unrecoverable cabin depressurization, the capsule would be uninhabitable; the crew would be required to remain wearing pressure suits for up to 6 days (144 hours) for return to Earth. The medical team needs to predict and manage impacts to crew health during this scenario. **METHODS:** NASA flight surgeons determined a list of likely medical conditions during a 144-hour suited return scenario. Conditions were then ranked according to their medical and mission impact. Considering the constraints of the suit, depressurized cabin, and pharmacologic limitations, NASA pharmacists and flight surgeons developed a matrix of potential medications and delivery methods to address these conditions. Options were presented to Orion Program boards, and solutions were determined based on overall mission risk. **RESULTS:** Skin breakdown, infection, anxiety, insomnia, nausea, vomiting, and other conditions were deemed likely in this scenario. To address these and other conditions, medications and their delivery methods (injection, liquids, crushed pills, unaltered pills, compounding, etc.) were assessed for feasibility and effectiveness. Limitations of the suit, the depressurized environment, coupled with drawbacks associated with altering medication and the stability of compounded medications drove the development of a tool to deliver unaltered pills through the existing suit helmet drink port. The physical dimensions of medications appropriate to the treatment of the indicated conditions were measured, and medications were down-selected based on the dimensions of the helmet port. Medications that treat multiple conditions were preferred. **DISCUSSION:** Due to the constraints of medication administration methods at vacuum, pharmacology, and cost of redesigning the suit system, delivering unaltered pills through the existing helmet port was chosen. This method does not allow treatment to a terrestrial standard of care given the extreme austerity of this contingency, but the goal was simultaneous minimization of medical and overall mission risks. Future drug formulations may improve our limited medication options. The process used to determine the components of care in this scenario demonstrate the interplay between medical and mission constraints, engineering, and risk management, and may be useful for persons designing medical capabilities for extreme survival situations in austere environments.

Learning Objectives

1. Learn about the methods used to address crew health during an extreme environment contingency situation.
2. Understand the complex medical issues that must be dealt with during prolonged wearing of a spacesuit.

Wednesday, 09/01/2021
Plaza D/E

8:30 AM

[S-42]: PANEL: GARRISON COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Douglas Files

Co-Chair: Bryant Martin

Co-Chair: Cady Blasser

Panel Overview: Aerospace medicine professionals face many threats for their aircrew and other patients. Some of this occurs in deployed settings and some is in garrison back home. Through shop visits, sanitation assessments, human factors briefings and fatigue countermeasures, flight surgeons defend aircrew from these health risks. This panel will engage participants with hands-on interactive experiences addressing a single unit's experiences. Participants will consider a scenario which will involve food and workplace safety as well as briefings and measures combatting fatigue. The session format will include updated didactic material addressing each step in the sequence, but attendees will engage directly in the deployment sequence by splitting into groups (as appropriate) and working through each of the four sections using pictorial examples of findings on the inspections and site visits. At the conclusion, attendees will have improved their ability to defend against various contingencies in a garrison setting.

[207] GARRISON SANITATION AND FOOD SAFETY

Javier Nieves¹, Douglas Files¹

¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review)

MOTIVATION: Aerospace medicine professionals oversee public health and preventive medicine operations at their worksites. Food and water vulnerability assessments are often assigned tasks. However, some flight surgeons struggle to perform enough assessments. This presentation will assist aerospace medicine professionals to maintain currency by participating in a prototypical virtual food/water vulnerability inspection.

OVERVIEW: The safety and health of their patient populations is part of the duty of flight medicine providers in garrison. These experts perform sanitation and food/water vulnerability assessments in order to ensure maximal mission completion and safety in the air. This program will update aeromedical and allied professionals on sanitation and food/water vulnerability inspection issues through individuals participating in a virtual inspection regarding a water safety case. **SIGNIFICANCE:** Food and water vulnerability inspections should be performed regularly at airfields and other workplaces. Failure to do so can affect flying safety and other goals. This session offers preventive medicine and occupational health personnel an opportunity to learn the latest techniques to perform water and food inspections. International colleagues will gain insight into United States food and water standards and how performing these inspections might positively affect airfield safety and health in their own countries. Thus, professionals from all services and all nations can benefit from food and water inspection cases.

Learning Objectives

1. Participants will state the factors involved with conducting a water inspection in conjunction with bioenvironmental engineers.
2. Participants will discuss food and water standards in the U.S. Air Force.

[208] GARRISON SHOP VISITS

Douglas Files¹

¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, U.S.

(Education - Program / Process Review)

MOTIVATION: Health hazards are common around flight line worksites including toxins, ergonomic hazards, infectious agents and threats of injury. Aerospace medicine professionals often serve in an occupational medicine capacity with a focus on preventing workplace injuries and illnesses.

OVERVIEW: Many industrial hazards occur on a flight line, and investigating

physical and chemical hazards can prevent illness and injury. Professionals in occupational medicine should not overlook common threats such as hygienic conditions, airborne dust, and worksite smoking. Participants in the current exercise will discuss potential hazards in aviation and maintenance environments and what might be done to mitigate those hazards.

SIGNIFICANCE: Performing a worksite visit can link physical manifestations with environmental hazards. Aerospace medicine professionals from multiple disciplines and countries can benefit in obtaining comprehensive medical readiness skills delivered during this session.

Learning Objectives

1. Participants will discuss common pitfalls in worksite shop visits in garrison aviation workplaces.
2. Participants will learn some of the common toxins and workplace hazards to seek while on shop visits in garrison.

[209] GARRISON HUMAN FACTORS BRIEFINGS

Jeffrey Lawson¹, Douglas Files¹

¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review)

MOTIVATION: Providers in aerospace medicine clinics present briefings regarding safety, human factors, etc. to aircrew and other staff. This presentation will assist professionals to maintain currency by participating in a human factors briefing. **OVERVIEW:** Aerospace medicine professionals often present medical topics to aviators. This can occur during instrument refresher training, during safety briefings, HUD (Head-up Display) tape reviews, etc. This program will reinforce techniques to aid flight surgeons in presenting human factors topics by providing an opportunity for individuals to participate in a human factors briefing regarding spatial disorientation risks. **SIGNIFICANCE:** Aerospace medicine professionals' role in the aviation community involves promoting health and safety in the communities we serve. As such we present medical topics to aviators. The U.S. Air Force has determined that currency in human factors briefings should be performed on a recurring basis. Attendees will discuss factors regarding how to improve one's briefing style, for example about spatial disorientation.

Learning Objectives

1. Participants will be able to present a spatial disorientation scenario to laypeople using risk communication skills.
2. Participants will share tips on giving an efficient and successful briefing.

[210] GARRISON FATIGUE COUNTERMEASURES

Michael Richards¹, Douglas Files¹

¹U.S. Air Force School of Aerospace Medicine, Wright-Patterson Air Force Base, OH, USA;

(Education - Program / Process Review)

MOTIVATION: Aerospace medicine professionals sustain maximal aviator performance in various ways. One potential way to achieve this involves the use of medications. Flight surgeons prescribe hypnotics to help aviators sleep prior to some operational missions and in some circumstances prescribe stimulants to improve performance during critical phases of flight. This presentation will instruct aerospace medicine professionals in the operational usage of performance-enhancing medications for aviators.

OVERVIEW: Aerospace medicine professionals study the physiologic effects and risks of flight. In order to ensure mission completion, flying safety, and health flight surgeons sometimes prescribe medication for use. At times, hypnotics assist aircrew to sleep prior to a mission while other medications improve pilot alertness during critical phases of flight. This program will update flight surgeons on medical and other fatigue countermeasures.

SIGNIFICANCE: The U. S. Air Force requires annual training regarding the use of performance enhancing medication. Many other military services also use performance-enhancing medication. This program will model techniques and will aid all AsMA attendees participating in the session

Learning Objectives

1. Participants will discuss the types of operational performance-enhancing medications used in the U.S. Air Force
2. Participants will model how to safely use performance-enhancing medications in an operational setting.

Wednesday, 09/01/2021

Plaza F

8:30 AM

[S-43]: PANEL: DILEMMAS OF AN ETHICAL NATURE IN AEROSPACE MEDICINE- A PANEL DISCUSSION BY ASAMS

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Jeffrey Jones

[211] PANEL OVERVIEW: DILEMMAS OF AN ETHICAL NATURE IN AEROSPACE MEDICINE- A PANEL DISCUSSION by ASAMS

Jeffrey Jones¹, Al Parmet², Keith Ruskin³, Bruce K Bohnker⁴, Petra Illig⁵, Geoffrey W McCarthy⁶, Eduardo Ricuarte⁷, Nora Johnson⁸

¹Baylor College of Medicine, Houston, TX, USA; ²Aviation Safety & Security, University of Southern California, Kansas City, MO, USA; ³Univ Chicago, Chicago, IL, USA; ⁴COMBI, Clearwater, FL, USA; ⁵Aviation Medical Service of AK, Anchorage, AK, USA; ⁶AvMedSafe, Portland, OR, USA; ⁷VENESCO, LLC in support of Aerospace Medical Research Division, FAA, Oklahoma City, OK, USA; ⁸USAFR, Retired, Austin, TX, USA

(Education - Case Study)

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.

BACKGROUND: 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. **CASE PRESENTATION:** 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. **DISCUSSION:** 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.

Wednesday, 09/01/2021

Governor's Square 12

8:30 AM

[S-44]: PANEL: SPECIFIC ASPECTS OF CIVILIAN AND MILITARY AVIATION MEDICINE IN GERMANY

Chair: Jochen Hinkelbein

Panel Overview: This session is sponsored and run by the German Society of Aerospace Medicine (DGLRM). The session is in German language with slides in English language. Five experts of German aviation and space medicine speak about specific aspects of civilian and military aviation medicine in Germany.

[212] CHALLENGING REQUIREMENTS FOR FLIGHT STUDENTS, PILOTS AND ASTRONAUTS – A RADIOLOGIC PROSPECT ABOUT THE NEXT GENERATION MISSIONS

Hans-Jürgen Noble¹, Sven-Erik Sönksen¹, Josef Ehling¹, Heinz Knopf¹

¹German Air Force Center of Aerospace Medicine, Fürstentfeldbruck, Germany

(Education - Program / Process Review)

BACKGROUND: Early detection of clinically relevant variations and abnormalities can save lives. To prevent fatal complications in aerospace due to heart attacks or spontaneous intracranial hemorrhage, it is crucial to minimize the risk by regulated screening. **OVERVIEW:** Every year over 340,000 people die from cardiovascular diseases and about 16,000 from spontaneous subarachnoid hemorrhages in Germany. Many result in sudden incapacitation with immediate unconsciousness and the resulting inability to act. Since it can be assumed that the number of unrecognized coronary heart disease, aneurysm carriers in aircrews or unknown malignancies is comparable to the normal collective of the population, it is highly relevant to detect these pathologies in advance. This applies especially to first time applicants for flight duty and to active pilots or astronauts before a longtime space mission, both for safety reasons to avoid disastrous aircraft accidents and from an economic and preventive point of view. **DISCUSSION:** In the German Air Force Center of Aerospace Medicine Department of Radiology, we challenge these in the screening program performed in Fürstentfeldbruck. We have to balance between medical assessment, clinical aviation medicine and prevention. With the 3T MRI scanner we can easily produce a high-resolution non-invasive overview of the skull base arteries (Time of flight – MR-Angiography), functional heart diagnostics or screening of the prostate. Preformed aneurysms, malignancies, bleedings or other findings can thus be detected very reliably. However, with new sequence protocols it has been possible to find acoustic neuroma, aneurysm and cavernoma carriers in a cohort of approx. 1500 examinations within the scope of applicant screening over the last three and a half years. "Going to extremes" is a statement about the new challenging requirements for Human Performance Optimization. Other techniques like low-dose computer tomography are necessary to investigate non-invasive coronary heart disease. We cannot disregard safety reasons in the changed spectrum of clinical assessment. Furthermore, this may also affect manned spaceflight considerably, especially since an increased vulnerability of aneurysms or tumor growing in microgravity cannot be excluded.

Learning Objectives

1. The audience will learn about possible methods for visualizing relevant pathologies at early stages, which may lead to sudden incapacitation.
2. The audience will learn about MRI techniques in a screening program.

[213] MEDICAL EMERGENCIES DURING SPACE FLIGHT

Jochen Hinkelbein¹

¹UK Koeln, Cologne, Germany

(Education - Tutorial / Review)

BACKGROUND: During the next years, long-duration space missions will take place and will also be a medical challenge for mankind. Human spaceflight is inherently risky and results in unique problems for emergency medical treatment. On a calculatory basis, 1 emergency will occur in 2.5 years in a crew of 6 astronauts. With increased duration of missions and distance from Earth, medical and surgical events will become inevitable. To enable long-term space-flights, emergency medical concepts for emergency treatment, anesthesia, and critical care must be developed and are of utmost importance. **OVERVIEW:** In the last years, several papers were published analyzing the probability for different types of emergencies for spaceflight. During the space shuttle flights from 1981 to 1998, N=1867 in-flight medical events occurred but did not result in any fatalities. In this context, medical events are considered relevant but not critical or fatal. From another author, N=17 medical emergencies were reported from 1961 to 1999. However, although no fatalities occurred so far during spaceflight, Trauma (n=2), cardiopulmonary (n=7), internal medicine (n=3), and genitourinary emergencies (n=5) were reported most often and could be the

challenges during the next decades. **DISCUSSION:** Using this recent data, it may give an idea what emergencies could be relevant also for long-term spaceflight. Since ground-based medical support will no longer be adequate, it is of utmost importance to develop specific both emergency and autonomous medical concepts when return to Earth is not an option.

Learning Objectives

1. Learn to understand what relevant emergencies could happen during spaceflight.
2. Learn the probability of emergencies during spaceflights and calculate the risk.
3. Learn what organs may be affected for in-flight emergencies during spaceflight.

[214] GENOMIC REPRESENTATION OF SENSITIVITY TO GRAVITATIONAL FORCES

Oliver Ullrich¹, Cora Sandra Thiel¹

¹University of Zurich, Zurich, Switzerland

(Original Research)

INTRODUCTION: The immune system deteriorates during long-term space flights, probably contributing to an increased susceptibility to infection, autoimmunity, and cancer during exploration class missions. Thus, it is a need to understand the cellular and molecular mechanisms by which altered gravity changes the genomic stability and gene regulation homeostasis and to assess the cellular capacity and mechanisms for adaptation to a new gravitational environment. **METHODS:** In our studies, we investigated signal transduction cascades, adhesion molecules, metabolism, functional parameters, gene expression responses and cytoskeletal dynamics in human lymphocytes and macrophages in different gravity environments through multi-platform approaches (parabolic flights, suborbital ballistic rockets, International Space Station and 2D clinostat and centrifuge experiments), including rigorous control experiments. A multi-platform approach not only allows for cross-validation of findings in independent experiment platforms, but also for understanding the time-course of mechanisms. Our aim was to investigate the biological cellular phenotype in the force-free conditions of microgravity, potential molecular candidates of the force transduction chain and potential target parameters for mechanistic and functional studies.

RESULTS: We discovered a rapid adaptation of the oxidative burst reaction in macrophages after 42s, a general high stability of gene expression in altered gravity and rapid initial response after 20s and subsequent adaptation of the transcriptome after 5min altered gravity, which was independent from ion channel function. We identified gravity-regulated genes (e.g. ATP6V1) as well as highly stable reference genes (ABCA5, GAPDH), cross-validated in different platforms and cell types. We found that gene expression changes are not randomly distributed in the chromatin, but clustered in highly stable and responsive loci, which are associated with the geometric position. **DISCUSSION:** The ultra-fast response and adaptation to altered gravity suggests the existence of rapid force transduction processes. Due to the fact, that spatial repositioning of chromosome territories is accompanied by altered transcriptional activity and that chromosome territories are sensitive to mechanical forces, it can be hypothesized that gravity-induced force transduction directly regulates chromatin organization and therefore gene expression.

Learning Objectives

1. To understand that cells of the human immune system can respond and adapt rapidly to altered gravity.
2. To understand that gene expression responses to altered gravitational forces are clustered in highly stable and responsive loci in cells of the immune system.

[215] RANDOMIZED CONTROLLED COMPARISON OF TWO NEW METHODS FOR CPR IN MICROGRAVITY

Jan Schmitz¹, Jochen Hinkelbein¹

¹University Hospital of Cologne, Cologne, Germany

(Original Research)

BACKGROUND: The risk of a severe medical event during long-duration spaceflight is significant and can endanger both the crew and

the mission. These critical events include cardiac arrest, which would require cardiopulmonary resuscitation (CPR). So far, five techniques to perform CPR in microgravity have been proposed. The aim of the present study was to describe and gather data for two new CPR techniques in microgravity. **MATERIAL AND METHODS:** A double-randomized cross-over trial (RCT) comparing two new techniques for CPR in a free-floating underwater condition. Volunteers were required to perform CPR on a manikin (Ambu Man, Ambu, Germany) using two new techniques in a free-floating position underwater. The first technique (Schmitz-Hinkelbein-Knee-Method) is similar to conventional CPR, with the patient in a supine position, lying on the operator's knees for stabilization. The second technique (Schmitz-Hinkelbein-Elbow-Method) is similar to the first, but chest compressions are conducted with the right elbow. The main outcome parameters were total number of chest compressions (n) during 1 min CPR (compression rate), the rate of correct chest compressions (%), the no-flow-time (s), and the self-satisfaction score (rating scale, 1-3 points= low, 4-6 points=moderate, 7-10 points=high) of participants. The study was registered on clinicaltrials.gov (NCT04354883). **RESULTS:** 15 volunteers (age 31 ± 8.8 years, height 180 ± 7.5 cm, weight 84.1 ± 13.2 kg) participated in this study. Compared to the Schmitz-Hinkelbein-Elbow-Method, the Schmitz-Hinkelbein-Knee-Method showed superiority in the compression rate (100.5 ± 14.4 compressions/min), correct compression rate (72.1 ± 26.8 compressions/minute), correct compression depth ($65 \pm 23\%$) and overall high rates of correct thorax release after compression (66% high, 20% moderate, 13.3% low). The Schmitz-Hinkelbein-Elbow-Method showed correct depth rates ($28 \pm 27\%$) but was associated with a lower mean compression rate (73.87 ± 25.5 /min) and with low rates of correct thorax release (20% high, 6.7% moderate, 73.7% low). **CONCLUSIONS:** Both techniques are feasible without any equipment and could enable immediate CPR after cardiac arrest in microgravity, even in a single-helper scenario. The Schmitz-Hinkelbein-Knee-Method appears superior and could allow the delivery of high-quality CPR.

Learning Objectives

1. Overview of current methods (including evidence) for Resuscitation (CPR) in space.
2. Presentation of two new methods for CPR in space and evidence in a free-floating model
3. Limitations for CPR in space.

[216] RECOMMENDATIONS ON VACCINATIONS IN INTERNATIONAL TRAVEL

Peter W. Frank¹

¹German Society of Aviation Space and Travel Medicine, Groebenzell, Germany

(Education - Tutorial / Review)

INTRODUCTION: Preparing travel to the globe means careful examination of requirements and regulations of the countries / areas / continents that are planned to be visited. At the same time the immunization status of the travelling individual can be regulated, and vaccinations can be administered to update to basic national recommendations on vaccinations. **TOPIC:** Recommended specific add-on vaccinations can be planned, depending on the timeframe of the journey and the duration of the stay. The needs of backpackers, expatriates or business travelers will each be different. The earlier in advance of the trip that preparations are made, the better, since there is a need to separate inoculation with some live vaccines from inactivated ones. **APPLICATION:** This presentation will specify the most readily available sources of information that the advising physician can use to gain accurate knowledge of mandatory or recommended vaccinations e.g. CDC, Ministry of Foreign Affairs and / or special software on travel medicine. No less important is advice on cultural differences of the various destinations, the need to prepare a first aid kit, and how to avoid infection by communicable diseases that are not preventable by vaccinations, like dengue or malaria.

Learning Objectives

1. The audience will learn that preparing a journey outside the US needs time and planning for vaccinations.
2. The participant will learn where to gain information for a healthy trip stay and safe return.

Wednesday, 09/01/2021

Exhibit Hall

10:00 AM

[S-45]: POSTER: CLINICAL MEDICINE

Chair: Cheryl Lowry

Co-Chair: Satyam Patel

[217] THAT'S NUTS! A CASE OF POSTERIOR NUTCRACKER SYNDROME REVEALED IN THE AEROSPACE ENVIRONMENT

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(Education - Case Study)

INTRODUCTION: This case study explores how an otherwise undiscovered rare condition of posterior nutcracker syndrome became symptomatic and subsequently diagnosed under the unique stressors of the military aviation environment. **BACKGROUND:** Nutcracker syndrome is caused by a rare anatomic variant where the left renal vein is trapped between the aorta and the superior mesenteric artery. Posterior nutcracker syndrome is an even rarer entity, characterized by the retro-aortic positioning of the renal vein, causing compression between the aorta and spinal vertebrae. Symptoms include microscopic or frank hematuria, flank/abdominal pain, varicocele, and pelvic congestion syndrome. A literature search did not reveal prior cases of nutcracker syndrome that became symptomatic and diagnosed secondary to the unique stressors of high gravitational force (G-force) in the aviation environment. **CASE PRESENTATION:** A 25-year-old man F-16 flight test engineer presented to the flight surgeon for worsening left scrotal/testicular pain, hematuria, and varicocele. Symptoms initially started after flying higher G sorties (7-9 Gz) that resolved between flights and did not occur with lower G sorties (<7 Gz). After several months, his symptoms became more persistent and present in between flights. The pain was described as a constant dull ache with intermittent exacerbations with activity and heavy lifting. Additionally, he started to develop intermittent gross hematuria without clots after flying higher G sorties (7-9 Gz). After an extensive workup, he was diagnosed with posterior nutcracker syndrome and underwent a left varicocele ligation with spermatic cord denervation. He was eventually able to be returned to flying duties with the limitation to non-high-performance aircraft. **DISCUSSION:** This case is particularly unique as its diagnosis was dependent on exposure to high G-force conditions that may have otherwise remained asymptomatic without this environmental stressor. Education on the diagnosis of nutcracker syndrome as a differential in the setting of hematuria and pain is an important lesson learned. This case also illustrates the necessity of considering the effects of high G-forces on even overall healthy individuals. Fortunately, due to the collaboration of medical-surgical expertise and familiarity with the requirements for operational readiness, this patient was able to resume his aviation career, albeit in a different capacity compatible with his condition.

Learning Objectives

1. Nutcracker syndrome is a rare, but potential etiology for hematuria and varicocele under elevated gravitational force.
2. High gravitational force can cause stress on overall healthy individuals. The anti-G straining maneuvers (AGSM) improve cerebral perfusion, increase intrathoracic pressure, and increases venous pressure in the variceal veins.

[218] THE IMPACT OF MRI IN IDENTIFICATION OF RADICULAR ODONTOGENIC CYSTS

Claudia Lorenz¹, Frank Jakobs¹

¹German Air Force Centre of Aerospace Medicine, Fürstentfeldbruck, Germany

(Education - Case Study)

INTRODUCTION: Radicular cysts are the most common odontogenic cystic lesions arising from inflammatory pulp. Being developed at root apices of involved teeth, they tend to enlarge and infect not only bone and neighboring teeth, but also the maxillary cavity, usually being detected or verified by radiological assessment. **CASE DESCRIPTION:**

We report a well- documented case of a radicular odontogenic cyst affecting an upper molar in a 41-year-old flight surgeon. Symptoms with presence of intermittent dull pain were first determined two years after root filling. In spite of dental X-ray, the issue had not been clarified for ten years until the use of a pressure chamber leading into throbbing pain. Diagnosis was then made by magnetic resonance imaging (MRI) and confirmed by digital volume tomography. The attempt of root filling's revision resulted in flaring up of the cyst, causing massive pain, visual impairment alongside a swollen face as well as the urge of immediate surgery. Following extraction of infected tooth and cleaning of maxillary cavity, the patient had no longer complaints and continued to fly as a flight surgeon. **DISCUSSION:** Our case documents that in the aviation dentistry environment, radicular odontogenic cysts may cause unfit assessment which can be detected by MRI and be resolved by surgical means. Furthermore, it points out the value of MRI versus X-ray imaging.

Learning Objectives

1. Participants will be able to respond to patients facing toothache.
2. Participants will be able to understand the necessity of MRI.

[219] CLOT IN THE ACT: SVT IN FLIGHT

Jeremy Berger¹

¹U.S. Air Force, Jacksonville, AR, USA

(Education - Case Study)

INTRODUCTION: After three days of extended flight, a military loadmaster developed right sided calf pain and was found to have a superficial venous thrombosis (SVT). This case presentation describes the deliberation whether to treat or not treat an SVT. **BACKGROUND:** Superficial venous thrombosis is a challenging clinical entity that does not always require medical management. Flight surgeons may be hesitant to treat with anticoagulation since this medically disqualifies flyers and requires an aeromedical waiver to resume flying duties. **CASE PRESENTATION:** This presentation includes a case vignette where a painful clot developed in the right calf of a loadmaster after three days of long flights. Upon landing at her home station, the loadmaster presented to Flight Medicine and underwent a thorough examination. She had a palpable cord in her right calf that was investigated by doppler ultrasound and found to be a superficial venous thrombosis. The patient's pain was controlled with medication and she was referred to a hematologist. The patient did not meet initial criteria to start anticoagulation therapy. However, the clot began to propagate towards the saphenofemoral junction, increasing the risk for deep vein thrombosis. To mitigate this risk, the patient was initiated on a direct oral anticoagulant and monitored for side effects. After completing 6 weeks of treatment on this regimen, the clot regressed, and the medication was discontinued. **DISCUSSION:** This case highlights the need for flight medicine physicians to work closely with hematologists to determine the need for anticoagulation in superficial venous thrombosis. If anticoagulation is initiated, the patient with be medically disqualified from flying. Aeromedically, a patient can be returned to flight if an underlying risk factor is found and the SVT is considered provoked. Flight surgeons can make this determination by taking a thorough history and considering risk factors such as smoking, immobilization from extended flight, and oral contraceptive use. By mitigating these risk factors, flyers can be medically returned to flight.

Learning Objectives

1. The audience will learn about the importance of history taking in determining the underlying factors leading to superficial venous thrombosis.
2. The audience will learn about the criteria used to treat superficial venous thrombosis.

[220] IN-FLIGHT PRESYNCOPE IN A FIGHTER PILOT AND THE INTEREST OF THE AUTONOMIC NERVOUS SYSTEM EXPLORATION : A CASE REPORT

Mouna El Ghazi¹, Houda Echchachoui², Fahd Bennani Smires¹, Meryem Zerrik¹, Zakaria Ilabaghmane¹, Mohamed Chems²

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(Education - Case Study)

INTRODUCTION: This case report describes a fighter pilot who presented an in-flight presyncope. The autonomic nervous system exploration by Ewing's tests revealed a vagal hyperactivity associated with an alpha sympathetic deficiency, suggesting the vasovagal mechanism of syncope. **BACKGROUND:** The Autonomic Nervous System is highly solicited during +Gz accelerations on high performance aircraft, hence the interest of its exploration by Ewing's cardiovascular reactivity tests which give the complete autonomic profile. Vasovagal syncope is generally benign, but in aviation environment, the association with dysautonomia, can seriously affect the flight safety. **CASE REPORT:** A 27-year-old fighter pilot, with 870 total flying hours, and Without medical history, presented an in-flight presyncope on Alphajet. The initial clinical examination was normal, as well as the cardiovascular and biological check-ups. The exploration of the Autonomic Nervous System by Ewing's tests revealed hypervagotonia, with an alpha sympathetic central and peripheral deficiency. Furthermore, this pilot reports some professional conflicts with psychosocial repercussions on his motivation. **DISCUSSION:** The presyncope is a minor equivalent of syncope and requires the same diagnostic approach. The dysautonomic profile of the pilot as well as the autonomic activation prodromes, that preceded the malaise, suggest a vasovagal origin of this presyncope, especially since, on board a fighter aircraft, +Gz accelerations reproduce an extreme orthostatic stress situation, often implicated in the physiopathology of vasovagal syncope. In addition, non-specific aeronautical factors, like aviation stress and fatigue, affect the response of the sympathetic system. Psychosocial factors also seem to be involved in triggering these vasovagal reactions. In view of this dysautonomic background and the association with psychological disorders, the pilot was declared unfit to fly. This observation highlights the importance of Ewing's cardiovascular reactivity tests, to identify the autonomic profile of aircrew, especially fighter pilots, whose autonomic nervous system is constantly solicited. Psychological evaluation also seems important in case of a vasovagal syncope in aircrew.

Learning Objectives

1. Understand the interest of exploration of the autonomic nervous system in a presyncope.
2. Ewing's test represents the best method to explore the autonomic nervous system.

[221] INNOVASPACE AEROSPACE MEDICINE HUB (IAMH) - A REMOTE TEACHING EXPERIENCE DURING THE COVID-19 PANDEMIC

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(Education - Tutorial / Review)

InnovaSpace is a British Think Tank company operating in the fields of Space Life Sciences, Aviation Medicine, Aerospace Physiology, Extreme Environments, Telemedicine and Digital Health, having a global, inclusive and disruptive vision. Through its work, InnovaSpace conducts innovative activities in teaching and research, provides technical and scientific consultancy and has established a network of professionals, researchers, entrepreneurs and students, linked by the common theme of the human presence in extreme environments, such as astronauts on orbital/ interplanetary missions and aviators/crewmembers in aeronautical activities. The IAMH is the InnovaSpace Hub that organizes and promotes educational and research activities in the Aerospace Physiology/Aviation Medicine areas. Restrictions on in-person activities imposed by the COVID-19 pandemic have led the IAMH to develop a series of webinars for Portuguese speaking countries, including Angola, Brazil and Portugal. Webinars have addressed several topics related to Human Physiology in the Aerospace Environment, Aerospace Medicine, Interface between Medicine and Commercial Aviation, and Space Physiology. Digital platforms, such as Teams, Google Meet, Zoom and Webex were utilized, with each open-event webinar plus Q&A session lasting approximately 180 min. The IAMH webinars had the participation of 2 or 3 experts in a defined area, who presented a 40-60 min lecture. The open-access webinars were attended by students, professors, researchers and professionals from multiple fields, including medicine, nursing, pharmacy,

physiotherapy, speech therapy, physical education, information technology, artificial intelligence and engineering. A total of 10 IAMH webinars have taken place since June 2020 during courses and scientific events in partnership with universities, aviation and space associations and research centers, with an average attendance of 50 people per webinar. Physical distance did not preclude the establishment of interdisciplinary and multiprofessional interaction, suggesting that these meetings may contribute to knowledge dissemination and provide opportunities for interaction between apparently different areas. This interaction provided access to concepts and knowledge exchange, which, we believe, contributes to lifelong learning, professional qualification and the safety of flight operations as a whole. Considering the good response to these virtual webinars, we are continuing this activity.

Learning Objectives

1. To promote an interdisciplinary and multiprofessional discussion of topics related to the effects of the aerospace environment on human physiology.
2. To provide an open access virtual platform for the debate of aspects linked to aviation medicine, focusing on passenger health and wellbeing, professional qualification and flight safety.

[222] "CRUNCH SITUATION": DIAGNOSTIC CHALLENGE IN A FIGHTER AIRCREW WITH ACUTE UPPER ABDOMINAL PAIN

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(Education - Case Study)

INTRODUCTION: A fighter pilot presented with severe abdominal pain and was finally diagnosed to have 'abdominal crunch syndrome' (ACS). This is the first ever report of this condition in an aircrew.

BACKGROUND: Abdominal pain is one of the commonest emergencies presenting to the ER. There are uncommon causes of upper abdominal pain and in such cases, there is usually additional time taken before a definitive diagnosis can be reached. An abdominal wall condition leading to upper abdominal pain is exceedingly rare and is not entertained as a possibility in the initial evaluation. We report this interesting case of a fighter pilot presenting with acute upper abdominal pain which perplexed many clinicians before making the right diagnosis of ACS.

CASE PRESENTATION: A pilot in the fighter stream presented with history of severe upper abdominal pain with sweating of 12 hours duration. Clinically, he was afebrile with a pulse rate of 64/minute which fell to 36/minute on admission but was normotensive. Abdominal examination revealed tenderness in epigastric region with guarding but no rigidity. He was admitted to ICCU with a provisional diagnosis of acute coronary syndrome but on investigations was found to have no evidence of myocardial ischemia. His blood investigations showed deranged LFT and high CKMB at this time, the differential diagnosis considered were acute pulmonary thromboembolism, acute viral hepatitis, acute pancreatitis, mesenteric ischemia, acute intermittent porphyria and hemolytic anemia. Further investigations ruled out these causes. With the diagnosis being elusive, a gastrointestinal surgery consult was sought. The raised CK, LDH and transaminitis caught our attention. Further, the CKMB/CK relative index was less than 3 which indicated a skeletal muscle source. This was the tipping point which prompted us to take history of any unaccustomed exercise and the pilot confirmed our suspicion. Based on the above, a diagnosis of exercise induced abdominal wall rhabdomyolysis (abdominal crunch syndrome) was made. After making an uneventful recovery he was returned straight to active flying.

DISCUSSION: Clinicians and aircrew should be aware that vigorous unaccustomed exercise can lead to ACS and can be a cause for abdominal pain. From the aero-medical safety aspect, had he flown with the pain, it would have been exacerbated by the pressure of g force/g suit causing worsening of pain and sudden in-flight incapacitation.

Learning Objectives

1. The audience will learn that abdominal pain is a pandora's box with many differential diagnoses and uncommon conditions result in additional investigations and time taken to reach the correct diagnosis.
2. The audience will learn that sudden, vigorous and unaccustomed exercise can lead to exertional rhabdomyolysis that can be life

threatening and that, when the abdominal muscles are involved, can be a cause for severe abdominal pain.

3. The clinicians will learn that abdominal crunch syndrome is a possibility in patients presenting with abdominal pain

[223] A 3-YEAR REVIEW OF 829 NAVY AIR EVACUATION PATIENT ENCOUNTERS WITH A FOCUS ON ENLISTED EN-ROUTE CARE PROVIDERS

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(Original Research)

INTRODUCTION: There are no formal Navy En-Route Care (ERC) guidelines, and remains an ad hoc mission based on Department of Defense (DoD) Directive 5100.0. No research on Aviation Air Rescue Swimmers (AIRR) performing ERC is available, even though many Search and Rescue (SAR) missions fly without designated medical personnel onboard. This study sought to illuminate the type of provider involved in ERC Naval SAR missions and the types of cases involved. **METHODS:** A descriptive study was completed, involving a 3-year review of 829 air evacuations performed by Navy Search and Rescue flight crews from 2016 to 2019. A five-way comparison across provider types was done comparing Teams, Flight Surgeon (FS) only, SAR Medical Technicians (SMT) only, other (RN, APN, PA, IDC) only, or Aviation Air Rescue Swimmer (AIRR) only. These provider types were assessed for the type of transport including patient type: Medical or Trauma, Civilian or Military, age and gender of patient, diagnosis categories, and transport time. The interventions performed by provider type were recorded as ALS/BLS, IV/IO, airway, O₂, meds, monitor, and whether the patients were ambulatory. **RESULTS:** Of 829 cases reviewed, median transport time was 35min (2-370min) and median age of patient was 33 years old (1-95 years; transport involved active duty in 51% of cases and civilian in 47%, and there were 2.5 times more males than female patients. There were nearly equal amounts of trauma (54%) and medical (43%) patients transported. BLS (60%) was required twice as much as ALS (28%) level care, SMTs and AIRR alone provide 83% of ERC with AIRRs doing 33% of all ERC missions alone. Ortho/Trauma made up 35.4 % of all missions, followed by medical other (18.7%), environmental (13.7%), and cardiac/stroke (11.1%). **DISCUSSION:** The results of this study are in contrast to previous ERC studies, where AIRR only transports were excluded from the data. This highlights the importance of training AIRR as well as the SMTs to a higher level of care. Misfortune on the high seas is a dangerous circumstance and having adequate levels of medical training for responding personnel is paramount to protecting the life of survivors.

Learning Objectives

1. The audience will note the importance of training Aviation Air Rescue Swimmers (AIRR) as well as the SAR Medical Technicians SMTs to a higher level of care, since it is they who do a majority of en-route care (ERC) and AIRR often missions fly without designated medical personnel onboard.
2. The audience will appreciate the importance of Navy Search and Rescue (SAR) and note the recent trends in en-route care to include the populations they serve and the medical requirements of those treated.

[224] ARMY AEROMEDICAL POLICY UPDATE FOR GASTRO-ESOPHAGEAL REFLUX DISEASE

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(Original Research)

INTRODUCTION: The purpose of this study was to review demographics and other de-identified data to determine the prevalence of GERD and reflux esophagitis as it pertains to personnel on flight status across the military service branches. This study focused on Army personnel in order to quantify the need for an Army Aeromedical Policy Letter (APL) update. **METHODS:** A review of literature since the 2006/2007 APL as well as data pull of military GERD diagnosis and

descriptive statistics analysis was performed. Defense Medical Epidemiology Database (DMED) data was used to test the hypothesis: H_0 - Age, flight status, military branch, military job, gender, and rank will not increase or decrease the prevalence of GERD diagnosis ($\alpha = .05$). Additionally, odds ratios were conducted to assess for the strength of the relationships between these variables and GERD. **RESULTS:** Despite significant changes in the demographics, particularly with regard to age and gender, as well as understanding of GERD as a medical condition since 2006/2007, GERD diagnosis and treatment did not appear to significantly impact Army aviation safety of flight. **DISCUSSION:** GERD's impacts did not warrant the levels of expenditure in time and resources as outlined in the current APL. Therefore, a revision of the APL on GERD liberalizing management requirements to list currently over the counter agents as "information only" (no waiver needed) and render further evaluation part of routine laboratory and imaging analysis was indicated.

Learning Objectives

1. Review the potential aviation safety implications of Gastroesophageal Reflux Disease (GERD).
2. Describe the role of medical therapy in the management of aviation personnel with GERD.

[225] DEGENERATIVE CERVICAL SPINE CHANGES AMONG FINNISH FIGHTER PILOTS IN A 5-YEAR FOLLOW-UP

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(Original Research)

INTRODUCTION: Neck pain often causes disability among Finnish Air Force (FINAF) fighter pilots and may lead to reduced cervical functional ability and thereby to flight duty limitations. It has been suggested that degenerative changes of the cervical spine may be related to neck pain. Thus, the aim of the study was to determine the association between G exposure and degenerative cervical spine changes among fighter pilots. **METHODS:** The study population consisted of 56 volunteered FINAF male fighter pilots (mean age 20 ± 0.7 years at baseline) and 56 Army and Navy cadets (mean age 21 ± 1.2 years at baseline) as controls. Degenerative changes in the cervical spine were assessed by magnetic resonance imaging (MRI) performed at baseline and at 5-year follow-up for both pilots and controls. Degenerative changes evaluated from MRI (all levels combined) included intervertebral disc (IVD) degeneration, disc herniations, uncovertebral arthrosis, Schmorl's nodes, Modic changes, spinal canal stenosis, kyphosis and scoliosis. The subjects also responded to a questionnaire on physical activity, musculoskeletal pain and lifestyle. Prevalences are reported per person except per IVD level for disc herniations. The significances were evaluated with chi-square and Mann-Whitney. **RESULTS:** The prevalence of disc herniations was higher among pilots than controls at baseline (3.9% vs. 0.9%, $p=0.015$). The prevalence of disc herniations increased over the follow-up among both groups (7.4%, $p=0.032$ for pilots and 4.2%, $p=0.024$ for controls at follow-up), with no between-group difference. IVD degeneration (Pfirrmann score 4-5) showed no significant difference between the groups at baseline (3.6% vs. 16.1%, $p=0.053$). Over the follow-up, IVD degeneration increased among pilots (prevalence at follow-up 21%, $p=0.008$) but not among controls (29%, $p=0.116$). No between-group difference was found in the incidence of IVD degeneration or in the prevalence or incidence of other degenerative changes. No associations were found between pain symptoms and MRI findings. **DISCUSSION:** We found an increase in the prevalence of disc herniations among both groups, but progression of IVD degeneration only among pilots over the 5-year follow-up. Our scarce findings may be explained by the relatively low G exposure during the first five years of a pilot's career.

Learning Objectives

1. To acquire a better understanding on the relation between G exposure and cervical spine degenerative changes.
2. The audience will learn about how degenerative changes of the cervical spine can appear in MRI.

[226] AN OPEN-CIRCUIT AIR SCUBA DIVER WITH DYSPNEA AND HEMOPTYSIS

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(Education - Case Study)

A 43-year-old female presented to the Emergency Department with complaints of dyspnea, cough and hemoptysis after open-circuit SCUBA diving in cold oceanwater. While the detailed dive profile, history and presentation were strongly suggestive of immersion pulmonary edema with a likely component of pulmonary barotrauma, a broad differential is required for any diver presenting with dyspnea. The diver's past medical history was significant for a MTHFR mutation elevating her risk for cardiovascular and thromboembolic disease. This was especially concerning for this diver who presented with elevated troponin. This case presentation is accompanied by a discussion of MTHFR mutations and their influence over cardiovascular and thromboembolic disease. Subsequently, pulmonary barotrauma is discussed including the importance of comprehensive serial neurological exams for ruling out the most subtle presentations of air gas embolism. Finally, the physiology of immersion pulmonary edema is discussed within the context of myocardial dysfunction and cold-water immersion physiology. This case report and discussion related to pulmonary barotrauma and cold-water immersion are pertinent in both undersea and aerospace applications.

Learning Objectives

1. Pulmonary barotrauma may result in hemoptysis, pneumothorax, or pneumomediastinum; but may also result in air gas embolus (AGE). Very subtle presentation including proprioceptive deficits, aphasia, or spatial neglect are documented and would necessitate emergent therapeutic re-compression.
2. Immersion pulmonary edema (IPE) is an acute process largely orchestrated by autonomic and cardiopulmonary responses which drive pulmonary capillary hydrostatic pressure in excess of the plasma oncotic pressure. This physiology is discussed within the context of cold water immersion & myocardial dysfunction.
3. Mutations in the MTHFR gene are the most common inherited risk factor for hyperhomocysteinemia. Increased risk of atherosclerosis, myocardial infarction, stroke, and venous thrombosis are specifically associated with hyperhomocysteinemia.

[227] MEDICAL LESSONS FROM THE NEPTUNE MISSION

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(Education - Case Study)

INTRODUCTION: Underwater habitats offer several medical challenges owing to their isolation, confinement, resource-limitedness, risk, and space/power constraints. During the NEPTUNE (Nautical Experiments in Physiology, Technology and Underwater Exploration) scientific mission, 5 individuals performed studies in a dive saturation complex at a depth of 22 feet over 5 days. In the present study, we review the medical approach to anticipating, packing for, incidence of, and treatment of medical issues in such an environment. **METHODS:** Five subjects (4M, 1F; ages 18-65) self-selected to take part in a 115-hour scientific aquanautic mission in an underwater dive complex at a depth of 22 feet. As preventative measures, the crew physician surveilled all members as to their dive history, medical history, medications, and allergies prior to the mission. The crew was briefed on the evacuation plan in case of fire. During the mission, each crew member applied a 50-50 acetic acid-isopropyl alcohol mixture nightly to prevent otitis externa. The crew medical supplies across the crew physician's medical kit, the habitat's first aid kit, and crew members' personal medical effects included basic first aid materials, and analgesics, decongestants, antihistamines, antiseptics and antibiotics. All medical incidents were recorded, treated and anonymized. Data collection was previously

approved by IRB. **RESULTS:** Documented medical pathologies included headache (incidence=1), abrasion/minor cuts (i=9), bruises/contusions (i=5) congestion (i=7), back pain (i=1), bite/sting (i=3) and insomnia (i=5). All pathologies were treated in-situ. No medical issues necessitated evacuation or intervention from surface support. **DISCUSSION:** All medical incidents on this mission were successfully treated with the medications and supplies on hand. Medical kits for longer and/or larger missions should increase the quantity of both supplies and medications. Based on the pathologies seen, a basic medication kit should include antibiotics, analgesics, decongestants, antihistamines, antiemetics, and sleep aids. In this particular mission, severe pathology would result in immediate evacuation and mission termination for the affected crew member, as the habitat depth of 22 feet did not require a decompression period prior to surfacing. For habitats where a decompression time is required due to the habitat depth, more advanced in-situ medical capabilities are recommended.

Learning Objectives

1. The audience will learn about the challenges associated with packing a medical kit for an isolated, confined and austere environment, in this case, an aquanautic mission.
2. The audience will learn about the most common medical pathologies encountered while living and working in an underwater habitat.

[228] ADAPTATION DURING SEVERE SUSTAINED HYPOXIA TRAINING IN CENTRAL NERVOUS SYSTEM – FINDINGS IN 3T-CMRI SCANS

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(Original Research)

INTRODUCTION: Knowledge about high altitude exposure and hypoxia training has been fundamentally increased due to cerebral magnetic resonance imaging (cMRI). [1-3] cMRI revealed alteration in human central nervous system like subclinical edema formations and subtle brain findings. Yet, brain structure alterations and recovery after adaptation to high altitude have barely been investigated. **METHODS:** We enrolled two healthy professional mountaineers for a 35-day (Subject A and B) exposure to normobaric hypoxia. We performed seven cMRI at baseline (BL), acclimatization phase (AP), three times during stable hypoxia (H1, H2, H3) and at recovery examination after one (R1) and four (R4) months at normoxia. cMRI included morphological sequences, Time of Flight angiography (ToF) and Diffusion Tensor techniques (DTI). **RESULTS:** Hypoxia decreased arterial partial pressure of oxygen to a minimum of 36 mmHg in A and 33 mmHg in B. Both subjects experienced high-altitude sickness symptoms. However, none progressed to cerebral edema. Both subjects showed increased white matter volumes (max.: A: 4.3% (H2; B: 4.5% (H2)) and decreased grey matter volumes (A: -3.1% (R1; B: -3.9% (R1)) and CSF volumes (A: -2.7 (H2; B: -5.9% (H1)) from AP to R1. The number (A: 26 (BL) to 126 (H3; B: 11 (BL) to 17 (H1-3)) and volumes (A: 285%; B: 140%) of white matter lesions (WMH) increased in hypoxia but had fully vanished on R4. Diffusion values (FA, MD, RD, AD) tended to alter in hypoxia. The intracranial arterial volume increased considerably during hypoxia (max.: A: 8.1 % (H2; B: 5.1 % (H3)) and had recovered at R1. Sustained hypoxia was associated to increased cerebral venous volumes. **DISCUSSION:** The acclimatized human brain demonstrates remarkable hypoxia tolerance by maintaining its functionality at arterial oxygen partial pressures as low as 20 mmHg. [5] However, our findings suggest morphological cerebrovascular alterations emerge in severe, sustained hypoxia. [4] A massive increase in number and volume of reversible WMH, likely caused by collapse of the capillary barrier [1], uncovered brain areas of subclinical microangiopathic damage. Whether sustained hypoxia may serve as a stress test of the brain to early uncover cerebral morphological markers of pathological processes should be further investigated. **REFERENCES:** [1] Idorishvili et al. 2019. [2] McGuire et al. 2019. [3] Hoffmann et al. 2020. [4] Kuehn et al. 2019. [5] Bailey et al. 2017

Learning Objectives

1. The participant will learn about reversible adaption of central nervous system.
2. The audience will learn about normobaric hypoxia effects detected on cMRI scans before, during acclimatization and recovery phase. Our reportings are linked to recent trends in aviation medicine.

[229] A RETROSPECTIVE ANALYSIS OF THE LONGITUDINAL CHANGES IN THE BODY MASS INDEX OF BRITISH ARMY PILOTS

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(Original Research)

INTRODUCTION: Components of military and civilian aircraft are manufactured according to design parameters that account for the physical characteristics of the occupant(s). In light of emerging patterns in the general population, we sought to examine the longitudinal trends of Body Mass Index among Army pilots. Although data related to individual changes in BMI with age are available in the peer-reviewed medical literature, the generalizability of this data to military populations could be challenging. **METHODS:** Written informed consent was obtained from 106 participants to extract height and weight data from their electronic medical record within the Defence Medical Information Capability Programme (DMICP). The enrolled study population was entirely male, with a mean age of 33.4 years (SD 6.4). Apache (n=72), Wildcat (n=14), and Gazelle (n=10) pilots composed the majority of the sampled population. The mean length of service was 8.6 years (SD 4.7 years). Height and weight data from aircrew medical screening encounters was entered into a de-identified data base, and paired T-tests were used to compare "initial" and "final" data points. Regression analysis was used to explore the relationship between an individual's length of service compared to their change in BMI. **RESULTS:** The mean change in weight for the enrolled population was 4.6 kg (SD 7.3 kg). The mean change in height was 0.6 cm (SD 1.9 cm). The mean change in BMI was 1.3 kg/m (SD 2.4 kg/m). Regression analysis on the collected data suggests that the change of BMI is equal to 0.23 times the number of years served as a pilot. However, this regression analysis accounts for approximately 24% of the variability between the two variables (as defined by the resultant R² value). **DISCUSSION:** The results of this study should be used to inform future policy formulation related to the body composition of Army aviation applicants, the retention of previously qualified personnel, and acquisition programs that require insights associated with the anthropometry of pilots.

Learning Objectives

1. Understand the potential changes in anthropometry that are associated with normal human aging.
2. Understand the impacts of trends of the prevalence of overweight / obesity on military aviation selection standards.

[230] ASSESSING CHARACTERISTICS OF ACTIVE AIRMEN TRANSITIONING TO BASICMED

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(Original Research)

INTRODUCTION: Medical conditions and special issuance (SI) status in the active third-class US civil airmen population changed drastically in 2018 when compared with 2016. BasicMed became effective May 1, 2017, and this study's objective was to determine how the change in active third-class airmen has shifted to the BasicMed population. **METHODS:** Medical certification records from 2011-2018 were selected from the Federal Aviation Administration's (FAA) Document Imaging Workflow System (DIWS). Medical data were abstracted from the most recent medical examinations, with the exception of medical conditions that

were historical and current. Medical certificate validity was determined as of 12/31/2016 and again as of 12/31/2018. Those airmen that held a valid medical at the end of 2016 but not in 2018 were considered no longer active. This group of non-active airmen was then merged with the FAA Civil Aviation Registry Airmen Certification Branch dataset to determine who had declared the intention to fly under BasicMed. **RESULTS:** In 2016, there were 243,400 active third-class airmen with an average age of 44.7 (STD=18.0). In 2018 this number decreased to 205,144, with an average age of 42.4 (STD=17.8). Of those active in 2016, 101,317 (41.6%) were no longer active in 2018, and of these 25,923 (25.6%) declared the intention to fly under BasicMed. The average age of those who transitioned from the 2016 active group to the BasicMed group was 61.0 (STD=11.4), while the remaining group that became inactive was only 48.8 (STD=18.1). In 2016, 7.7% of active airmen held an SI, and this percentage decreased to 5.8% in the 2018 active group. However, 27.4% of the study's BasicMed group held an SI in 2016. The number of airmen who reported medication-controlled diabetes in 2016 was 4,659. This decreased to 2,861 in 2018, while 1,926 airmen with diabetes were shifted to the BasicMed group. For myocardial infarctions, the number in 2016 changed from 1,798 in 2016 to 947 in 2018, with 894 from the 2016 active airman population shifting to the BasicMed group. **DISCUSSION:** The change of the active third-class population's medical conditions and SIs can be, at least in part, attributed to BasicMed. Many of the medical conditions that require an SI have numbers that have been reduced by half in just a two-year time span. This may represent a hazard to the National Airspace System. This data will contribute to the required Congressional report.

Learning Objectives

1. The audience will be able to assess some of the impact that the implementation of BasicMed policy has had on the third class airmen population demographics.
2. The audience will be able to describe the basic demographics of both the third class and BasicMed airmen populations.

[231] METABOLIC DISORDER IN US ARMY AVIATORS

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(Original Research)

INTRODUCTION: Recent epidemiological studies of U.S. Army aviators have suggested higher than anticipated rates of hyperlipidemia and metabolic disorder. The goal of this study was to determine whether this finding had persisted in 2016-2018 and whether this required further evaluation in the military aviation/aeromedical communities. **METHODS:** Using appropriate ICD-10 codes, data on rates and percentages of hyperlipidemia and metabolic disorder in U.S. Army aviators during the period 2016-2018 were requested from the U.S. Army Aeromedical Electronic Resource Office (AERO) and the Defense Medical Surveillance System (DMSS). Age stratified rates for these conditions were also sought from DMSS. Descriptive statistics were used to present the results. No formal analyses were conducted. **RESULTS:** Results from DMSS showed overall rates of hyperlipidemia ranging from 3.18 to 6.83 per 1000 person-years and for metabolic syndrome from 0.16 to 0.69 per 1000 person-years. This compares to previously reported rates of 4.05 and 0.43, respectively. The age stratified rates increased proportionally with age. AERO data showed a range of 0.8 to 1.5% of aviators had hyperlipidemia and for metabolic syndrome this ranged from 0.31 to 0.45%, compared to 3.9 and 3.4%, respectively, from another of the previous studies.

DISCUSSION: The figures from DMSS and AERO do not portray an increasing trend of these two diagnoses in the aviator population. Additionally, the age stratified rates are generally consistent with those expected with aging in the general population. This suggests that further evaluation or exploration by the aeromedical community is not necessary. While the exact cause is unknown, the higher rates seen previously may be down to screening and detection bias. Limitations include incomplete matching of search criteria to the previous studies and reliance on correct data entry into DMSS and AERO.

Learning Objectives

1. The audience will be able to understand whether this hyperlipidemia finding had persisted in 2016-2018.
2. The audience will learn about new hyperlipidemia results and how it compares to previously reported rates.

[232] OPERATION BLOOD RAIN: THE EFFECT OF AIRDROP ON FRESH WHOLE BLOOD

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(Original Research)

INTRODUCTION: Comprehensive mortality studies of the Afghanistan and Iraq conflicts suggest that 91% of all potentially survivable deaths are related to hemorrhage. Mortality increases by 5% with every minute of delay in the administration of blood products, suggesting that even 15 minutes may be too long for many critically injured patients. Administration of fresh whole blood (FWB) is a life-saving treatment that prolongs life until definitive surgical intervention can be performed; however, collecting FWB is a time consuming and resource-intensive process. Furthermore, it may be difficult to collect sufficient FWB to treat critically wounded patients or multiple hemorrhaging casualties. This study describes the effect of airdrop on FWB and explores the possibility of using airdrop to deliver FWB to combat medics treating casualties in the pre-hospital setting when FDA approved cold stored blood products are not readily available. Prior studies on the effect of airdrop on blood products are limited and focused on Packed Red Blood Cells and French lyophilized plasma. The only previous study which described airdropping whole blood was completed in 1968 and was limited by the fragility of CPD collection bags of the time. **METHODS:** Four units of FWB were collected from volunteer donors and then loaded into a blood cooler which was dropped from a fixed-wing aircraft under a Standard Airdrop Training Bundle (SATB) parachute at an altitude of 200 ft air ground level (AGL) flying at an airspeed of 100 nautical miles per hour approximately four hours after collection. A control group of 4 units of FWB was stored in a blood cooler which was not dropped. Baseline and post-intervention labs were measured in both airdropped and control units, including full blood counts, PT/PTT/INR, pH, lactate, potassium, indirect bilirubin, glucose, fibrinogen, lactate dehydrogenase, and peripheral blood smears. **RESULTS:** The blood cooler, cooling bags, and all 4 FWB units did not sustain any damage from the airdrop. There was no evidence of hemolysis. All air dropped blood met parameters for transfusion per the JTS Whole Blood Clinical Practice Guidelines. **DISCUSSION:** Airdrop of FWB may be a viable way of delivering blood products to combat medics treating hemorrhaging patients in the pre-hospital setting, though further research is needed to fully validate the safety of this method. Unmanned Aerial Vehicles (UAV's) provide yet another means to deliver supplies.

Learning Objectives

1. The audience will learn that airdrop is a potential method to deliver whole blood to combat medics treating massively hemorrhaging patients in the austere pre-hospital setting,
2. The audience will learn that unmanned aerial vehicles (UAV's) may be able to provide yet another means to deliver blood products in both wilderness medicine and military operations.

[233] NONPHARMACOLOGICAL PAIN MANAGEMENT ON A REMOTE ENVIRONMENT EXPEDITION USING ASYNCHRONOUS TELEMEDICINE: A CASE SERIES USING AURICULAR ACUPRESSURE

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(Original Research)

INTRODUCTION: Pain management in remote settings is complicated by pharmaceutical degradation from extreme environments, medication expiration dates, limited storage space, and adverse reactions. Auricular Battlefield Acupuncture (BFA) may decrease pain without the need for pharmaceuticals, however, it requires specialized training. This article describes a pilot study in the use of Just in Time Training (JITT) and Asynchronous Telemedicine (AT) to guide an inexperienced practitioner applying acupressure via the BFA protocol (ABFA) to treat acute pain in crew members on a remote expedition. **METHODS:** Six crew members with various acute pain syndromes received auricular acupressure with white crystal beads using the BFA protocol. Each patient reported their

pain using a 10cm visual Analogue Scale (VAS) immediately pre-treatment, at 30 minutes, at 60 minutes, and approximately 24 hours after intervention. Patients were instructed to use over the counter pain medications as usual if needed. ABFA was administered by a board-certified emergency physician guided by JITT who had received 60 minutes of in person ABFA training prior to the expedition. Photographs were taken and transmitted to a physician certified in medical acupuncture who edited the images to correct bead placement. The images were transmitted back to the on-site physician to make any needed adjustments.

RESULTS: JITT provided sufficient guidance to achieve pain reduction. AT worked well, but the average time to guidance of 3.5 days was too long to affect clinical outcome. An average pain reduction of 46% at 30 minutes, 63% at 60 minutes, and 92% at 24 hours was recorded for these cases, with only 1 patient requiring medication added to the ABFA. **DISCUSSION:** This proof of concept for JITT and AT demonstrates that a nonexpert practitioner can be successfully guided through the application of ABFA using JITT in a remote setting. AT was able to provide effective feedback despite distance and time limitations, but the delay in this feedback prevented any meaningful effect on clinical outcomes. The methods used and apparent pain reduction achieved with this case series serves as a pilot study for larger trials of this intervention, suggesting that JITT and AT guided ABFA may be useful in remote environments without real time support when pharmacological stability, storage, and adverse reactions are a concern.

Learning Objectives

1. The participant will better understand how asynchronous telemedicine can be used to provide effective feedback for clinicians in remote environments.
2. The participant will understand the potential of acupressure via the Battlefield Acupuncture protocol for pain management in remote environments.

Wednesday, 09/01/2021
Governor's Square 14

10:30 AM

[S-46]: PANEL: DEGRADED VISION IN THE AEROSPACE ENVIRONMENT

Chair: Micah Kinney

Panel Overview: This panel presents new research on an assortment of degraded vision topics in various aerospace environments. Degraded vision can result from weather, night, hypoxia, or an ocular injury or disease. Understanding the operational impact that reduced vision has on the aviator leads to better training, mishap prevention, and improved vision standards. The first presentation in this panel comes from collaborative research between the Naval Medical Research Unit Dayton and the U.S. Army Aeromedical Research Laboratory. Researchers explored the relationship between spatial disorientation and mental workload. As pilots followed a lead aircraft into a cloud deck, all visual reference was removed and workloads were varied to better understand how spatial disorientation can be effected with increased mental tasking. Second, researchers from the Naval Medical Research Unit Dayton present data on a common nighttime visual illusion, the black hole (BH) approach. Findings from this human performance study suggest that incorrect True Aimpoint (TAP) selection, and the failure to recognize, leads to more BH errors. Next, with an increase in reported physiological episodes, a novel study from the Naval Medical Research Unit Dayton explored visual performance and photoreceptor physiology in a normobaric hypoxia environment using a more sensitive computerized cone contrast test. Finally, a collaborative data driven initiative between the Naval Medical Research Unit Dayton and the Naval Aerospace Medical Institute used operationally relevant human performance to help guide updates to U.S. Navy aviation vision standards and waiver policy.

[234] AN EXPLORATORY STUDY ON THE INTERACTIONS BETWEEN PHYSICAL AND VISUAL STRESSORS, NECK PAIN, AND TASK PERFORMANCE DURING PROLONGED 'HELO-HUNCH' SEATING

Peter Le¹, Charles Weisenbach², Jacob Jadischke², Lanie Monforton³, Emily Mills², Micah Kinney¹

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(Original Research)

INTRODUCTION: Neck pain (NP) has been associated with a substantial number of distracted/hurried flights. Given likely impacts to mission effectiveness and readiness, our study seeks to explore a potential progression from biomechanical changes to NP to performance decrements through the interaction of physical and cognitive factors. Visual display contrast has been associated with increased mental loading and increased muscular tension in the neck. However, we do not know how visual stressors may influence biomechanical changes as an interaction with posture and physical loading from a helmet and the overall influence on task performance. The objective was to investigate these factors as a function of interactions between visual stressors and physical loading during prolonged seating in a 'helo-hunch' posture.

METHODS: 2x2x2 counterbalanced design; eight conditions total. Independent variables were helmet (H) (none (H0) vs. donned (H1)), posture (P) (symmetric (P0) vs. asymmetric (P1)), and visual stress (V) (low (V0) vs. high contrast (V1)). Each condition was tested for 30 minutes with rest between conditions. Measurements included kinematics and electromyography. Performance was evaluated through a Tumbling "E" task at two visual contrasts based on the assigned condition (V0, V1).

RESULTS: The interaction of P1xV1 resulted in 4° of increased head extension compared to P0xV0 ($p = 0.0490$), and V1 had more intermittent axial head rotations ($p = 0.0319$). V1 induced slower reaction times ($p = 0.0144$) and increased errors ($p = 0.0362$). The interaction of H1xP1 exhibited faster reaction times relative to H0xP0 ($p = 0.0148$). However, an increase in errors was seen for H1xP1, H1xP0, and H0xP1 compared to H0xP0 ($p = 0.0395$). Reports of subjective neck discomfort were also higher for H1xP1, H1xP0, and H0xP1 compared to H0xP0 ($p = 0.0298$).

DISCUSSION: Visual stressors may influence posture and muscle activity when adapting to an environment. In conjunction with postural or physical discomfort, this may result in hurried responses and increased errors. These findings may support a need for further investigations on possible links between biomechanical loads, physical discomfort, and task performance, which may provide insight for near-term administrative controls (i.e., visual adjustments) and potentially guide downstream engineering controls (i.e., design or training/selection).

Learning Objectives

1. Recognize that musculoskeletal loads endured in the occupational environment are multifactorial in nature and dependent on the interaction of multiple factors (physical, cognitive/psychosocial, and individual).
2. Understand that discomfort and/or pain resulting from those loads may also have effects on task performance. Although some of these factors may include areas outside of the common purview, such as physical loads (i.e., vibration, armor, head-supported mass),
3. Explore the idea of the 'systems-perspective' which may give us better insight on areas that we can control/adjust in the near-term and inform future areas of design, training (i.e., work-hardening), and/or personnel selection.

[235] EFFECTS OF VARIOUS TYPES OF COCKPIT WORKLOAD ON INCIDENCE OF SPATIAL DISORIENTATION IN SIMULATED FLIGHT

Henry Williams¹, Dain Horning¹, Benton Lawson², Charles Powell¹, Frederick Patterson¹

¹Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, USA;

²Naval Submarine Medical Research Laboratory, Groton, CT, USA

(Original Research)

INTRODUCTION: Spatial disorientation (SD) refers to a pilot's misperception of the attitude, position, or motion of his/her aircraft, with respect to the Earth, gravitational vertical, and/or other objects, including other aircraft. SD is one of the leading causes of fatal mishaps in military and civilian aviation. While several studies have examined the effects of SD on cognition or have linked increased cockpit workload to SD, few specifically and systematically compared how various types of workload interfere with maintenance of spatial orientation. **METHODS:**

Twenty-four pilots flew simulated flights, following a lead aircraft. Each flight started above a cloud deck but then descended into the clouds where the lead aircraft eventually disappeared while in a turn. Participants were instructed to level their wings when the lead disappeared. Six flights were flown in each of four different workload conditions. The baseline condition presented no additional workload, while the other conditions added either a verbal working memory task, a spatial mental rotation task, or a spatial variable-following-distance task. Measures of SD included the number of control reversal errors (CREs) and percentage of time spent in unusual attitudes (UAs) while in the clouds.

RESULTS: The verbal working memory task condition resulted in a statistically significant threefold increase in the number of CREs, while the mental rotation and variable-following-distance task conditions yielded significant increases in UAs. **DISCUSSION:** The elevated number of CREs in the working memory condition shows that cockpit workload need not be spatial in nature to interfere with maintenance of spatial orientation. However, the increase in UAs in the two spatial workload conditions provides evidence of competition for spatial resources. The results will be discussed from attentional resource and task interference perspectives, and the importance of using different SD measures will be emphasized.

Learning Objectives

1. The audience will learn that SD is one of the leading causes of fatal mishaps in military and civilian aviation.
2. The audience will learn that secondary cockpit tasks and workload drivers need not be spatial in nature to increase the probability of SD.
3. The audience will learn that when possible, it is usually advisable to employ more than one measure of SD to detect an SD event.

[236] APPROACH INITIATION AIMPOINT ERRORS AS A CAUSAL FACTOR OF BLACK HOLE ILLUSION

Frederick Patterson¹, Henry Williams¹, Richard Folga¹, Sarah Sherwood¹

¹Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Pilot surveys and accident statistics document Black Hole Illusion (BHI) as a leading form of spatial disorientation that results in dangerously low approach paths during night landings. The existent literature supports the link between runway visual illusions and BHI, with particular emphasis on the role of unfamiliar visual angles of runway perimeter lights as a primary causal factor of BHI. However, these studies also suggest that BHI is unlikely to occur at distances greater than 4.5 nm, where the relatively small retinal image of the runway lights is presumed to be below the BHI visual threshold. Since mishap data document BHI errors at runway distances greater than 4.5 nm, this research effort hypothesized BHI may also be caused by perceptual problems unrelated to visual angle variances of runway size or slope. **METHODS:** To investigate the possibility of BHI perceptual problems originating at distances greater than 4.5 nm, 26 pilot participants flew a series of simulated day and night landing approaches from a starting distance of 8.0 nm. **RESULTS:** In general, pilots flew significantly lower landing approaches during simulated nighttime conditions than daytime conditions. Of the 26 participants, 24 (92%) demonstrated BHI approach characteristics during simulated nighttime conditions. Results supported three sequential BHI error components that began 8 nm from the runway: (1) *BHI I*, excess push-over; (2) *BHI II*, improper True Aimpoint (TAP) selection; and (3) *BHI III*, failure to recognize incorrect TAP position. *BHI I* and *BHI II* errors were of short duration (4.5 and 9.0 sec., on average, respectively) and occurred within the first few seconds of approach initiation. In contrast, *BHI III* errors took place over a period of several minutes. **DISCUSSION:** BHI can be caused by incorrect TAP placement at distances where unfamiliar runway dimensions have little to no visual effect. Consequently, without proper instrumentation (ILS/PAPI lights), small errors in initial aim point placement are difficult to recognize during the first few minutes of visual night landing approaches and can result in BHI.

Learning Objectives

1. The audience will learn about the Black Hole Illusion (BHI), a common form of spatial disorientation that results in dangerously low approach paths during night landings.
2. Participants will be able to understand how improper initial True Aimpoint selection can result in BHI.

[237] CONE CONTRAST THRESHOLDS: A MORE SENSITIVE MEASURE OF VISUAL DECLINE IN HYPOXIC CONDITIONS

Matt Funke¹, Micah Kinney², Dustin Huber³

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(Original Research)

INTRODUCTION: Of the physiological systems distressed by hypoxia, among the most demanding is the visual system, which requires a high level of oxygen due to the consumption requirements of those tissues involved. In the event of a failure in the equipment designed to maintain a physiological equilibrium in an aerospace platform, the pilot or aircrew within could be exposed to a hypoxic environment. As such, insufficient levels of breathable oxygen would result in numerous perceptual and cognitive impairments for those affected. Normal color vision is achieved by long- (L), medium- (M), and short- (S) wavelength sensitive cone photoreceptors. Traditional color vision tests (e.g. pseudoisochromatic plates) are not precise enough to measure individual differences in cone sensitivities, and as a result have not proven useful in hypoxia research. With the new Rabin Cone Contrast Test (CCT), a rapid, reliable, and sensitive test is now available to detect individual differences in color vision performance thresholds and may be shown to be effective in this realm. **METHODS:** Participants performed the CCT under normal conditions to establish a performance baseline. The CCT consisted of a four-choice colored Landolt C only visible to L, M, or S cones in a decreasing staircase of cone contrasts to determine individual thresholds, which was able to be achieved in under three minutes. Using the Reduced Oxygen Breathing Environment, cone thresholds were measured during four sequential time periods while participants were exposed to a 9.7% oxygen concentration. Recovery from the low-oxygen exposure was also measured following the administration of 21% O₂ to participants. **RESULTS:** Findings indicated a relatively steady performance in participants' contrast thresholds in the L- and M-cone photoreceptors but showed evidence of a rapid decline following a period of stability in the S-cone photoreceptors. Additionally, contrast thresholds for all stimulus types returned to baseline levels upon the administration of 21% O₂. **CONCLUSIONS:** In the presence of a hypoxic environment, as expected, short-wavelength cone photoreceptors were the first to be negatively affected. Given this finding, several approaches could be adopted to mitigate changes in S-cone sensitivity, such as making use of adaptive displays to accommodate the artificial deficiency in color vision created by hypoxia or altering in-cockpit displays to incorporate elements of more easily seen color symbology.

Learning Objectives

1. The audience will learn about the effects of hypoxia on cone contrast thresholds.
2. The audience will learn about the new Rabin Cone Contrast Test.

[238] IMPACT OF REDUCED VISION IN ONE EYE ON PILOT LANDING PERFORMANCE

Micah Kinney¹, Kevin McGowan², Dain Horning³

¹Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; ²Naval Aerospace Medical Institute, Pensacola, FL, USA; ³Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Vision standards have long been used in pilot selection and retention in both civilian and military aviation. Visual acuity for the U.S. Navy and Marine Corps remains one of the strictest of the services. This study aimed to evaluate pilot performance with simulated reduced vision in one eye to establish operationally-based vision standards and data-driven waiver policy. **METHODS:** Thirty-two military pilots performed vision tasks under normal visual conditions and with reduced monocular vision using Bangerter foils over either the right or left eye of standard issue clear flight glasses. The experimental design was totally within subjects and participants were divided equally between dominant and non-dominant blurred vision with each task counterbalanced. Vision tasks were distant visual acuity, contrast acuity, stereopsis, and ocular dominance. Simulated approaches in the T-6A

Texan II (Flite Advantage) were flown using a high fidelity cockpit with three 65" OLED 4K out-the-window displays. Measures of flight performance included root mean square error (RMSE) in altitude variance and glideslope deviation. **RESULTS:** Native binocular visual acuity averaged a Snellen equivalent of 20/14 (LogMAR -0.14, SD 0.05). Binocular vision utilizing a monocular Bangerter foil averaged a Snellen equivalent of 20/16 (LogMAR -0.10, SD 0.07). Foil reduced vision in either the dominant or non-dominant eye averaged a Snellen equivalent of 20/44 (LogMAR 0.34, SD 0.07). No significant interactions were found between dominant or non-dominant eye blur in RMSE altitude variance ($p = 0.1$) or glideslope deviation ($p = 0.27$). Overall, no significant difference was observed in performance between control and test conditions for RMSE altitude variance ($p = 0.58$) or glideslope deviation ($p = 0.47$).

DISCUSSION: Mildly reduced monocular vision does not show a significant degradation in landing and binocular visual performance of experienced pilots. While visual acuity is an important measure of the visual system, learned skills such as flying may not be impacted significantly by a mild reduction in only one eye. Study results will be discussed from a vision standards standpoint and the importance of data-driven operationally relevant waiver policy.

Learning Objectives

1. Understand how current US Navy and Marine Corps visual acuity standards impact pilot selection and retention.
2. Discuss current research efforts in understanding pilot performance with mildly reduced vision in one eye.

Wednesday, 09/01/2021

10:30 AM

Governor's Square 15

[S-47]: SLIDE: COGNITIVE PERFORMANCE AND WORKLOAD

Chair: Ilaria Cinelli

Co-Chair: Matthew Cooper

[239] PUPIL DIAMETER AS AN INDEX OF COGNITIVE WORKLOAD

Christopher Aura¹, Leonard Temme¹, Paul St. Onge¹, Aaron McAtee¹, Amanda Hayes¹, Kevin O'Brien¹, Bobby Bowers¹, Kevin Baugher¹, Michael Wilson¹

¹U. S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Effects of light on pupil diameter (PD) are dramatic and well known. Less well known and dramatic are the effects psychophysiological states have on PD. Recent literature describes characteristic pupillary behavior as a promising objective biomarker of mental workload (MWL). One challenge is to differentiate the pupil's MWL response from its response to light. The findings reported here describe the pupil's response to three levels of MWL under several temporally modulating lighting conditions. **METHODS:** A commercial, off-the-shelf eye tracker binocularly recorded PD at 500 Hz (EyeLink 1000+, SR Research) in 20 volunteers as they performed 30 seconds of a standard MWL task involving short-term, numeric auditory memory and recall; i.e., the Delayed Digit Recall, or N-Back task. Three levels of N-Back were used: 0, 1, and 2 or more. During the N-Back tasks, volunteers viewed the center of a large homogeneous visual field of low (0.1 cd/m²), moderate (8.0 cd/m²), or high (80.0 cd/m²) photopic luminance, each with a + 25% temporal modulation frequency of 1.0, 0.2, 0.1, or 0.0 Hz. Before beginning each N-Back task, volunteers adapted to the non-varying luminance to provide PD reference baselines. A linear regression model was used to evaluate the statistical significance of PD change from baseline for luminance, modulation frequency, N-Back level, and eye. **RESULTS:** Mean PD (standard error of the mean [SEM]) at the low, moderate, and high luminance respectively was: 1841.19 (28.93), 933.58 (18.65), and 445.71 (7.02) pixels. Mean (SEM) PD at N-Back 0, 1, and 2 or more was: 931.72 (30.32), 1099.27 (33.25), and 1189.10 (35.13), respectively. Post hoc contrasts showed PD changes were significantly different for all pairwise N-Back comparisons and luminance comparisons. Change in PD was significantly different for all temporal modulation frequency pairwise comparisons except between 0.1 and 0.2 Hz. Also, left

eye PD was consistently larger than right eye PD for all N-Back comparisons. **DISCUSSION:** These results confirm that the PD reflects MWL as well as luminance. Amazingly, the effects of MWL were sufficiently robust to be evident in the PD averaged over the N-Back task without any signal processing or filtering.

Learning Objectives

1. The audience will learn about some of the relevant analysis techniques for characterizing and quantifying the different responses of the human pupil
2. The audience will learn about the differential effects on pupil diameter of cognitive workload vs. level of ambient luminance.

[240] PROMOTING COGNITIVE HEALTH FOR PILOTS USING VIRTUAL REALITY: COLLABORATION BETWEEN RESEARCHERS, PILOT REPRESENTATIVES, AND CIVIL AVIATION MEDICINE

Kathleen Van Benthem¹, Christine Gervais², Chris Herdman¹

¹Carleton University, Ottawa, Ontario, Canada; ²Canadian Owner and Pilots Association, Ottawa, Ontario, Canada

(Original Research)

INTRODUCTION: The world's aging population along with the current global pilot shortage, has resulted in the current commercial and general aviation pilots being the oldest cohort of pilots in aviation history. The civil aviation medicine community has accepted standards and protocols for assessing the medical fitness of pilots across the lifespan, but there is a lack of ecologically valid assessment and remediation tools for pilot cognitive health. Accident analysis and flight simulation research highlight cognitive function as the most significant factor associated with accidents and critical incidents during flight.

METHODS: In consultation with stakeholders from civil aviation medicine and general aviation pilot representatives, a cognitive engineering research team developed a prototype virtual reality (VR) cognitive screening and intervention tool for general aviation pilots – "CANFLY". General acceptance of the VR tool from the aviation community was assessed via a national online survey. User experience was tested via a laboratory-based flight simulation experiment using the CANFLY (N=47).

RESULTS: We report on the user experience of licensed pilots regarding this VR tool. We also present the findings of an online survey geared towards gauging acceptance of a VR tool for cognitive health screening in general aviation by pilots and the aviation medicine community.

Preliminary survey results show support from a range of stakeholders for the VR platform as a method for cognitive health screening and intervention. User experience reports from pilots who flew the CANFLY strongly support its relevance and suitability within the pilot population.

DISCUSSION: Implications of a VR cognitive health screening tool for pilots are presented from the stance of research, pilot, and medical community stakeholders.

Learning Objectives

1. The participant will learn about the purpose and utility of a prototype cognitive health screening tool for pilots, including user experience from a laboratory-based experiment.
2. The participant will learn about the acceptance of virtual reality for pilot cognitive screening, including its benefits and challenges.

[241] A REAL-TIME ACHIEVABILITY LIMIT DISPLAY FOR A PROPELLENT-CONSTRAINED, PILOTED, PLANETARY LANDER

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(Original Research)

INTRODUCTION: Providing real-time achievability limit information to the pilot has been proposed as a means to reduce pilot workload, improve situation awareness, and increase safety during lunar landings. The piloted lunar landing task requires the determination of a suitable LS (landing site) while maintaining vehicle attitude control. Suitable LS selection includes proximity to points of scientific interest, vehicle performance, and hazard avoidance. During Apollo, most of the LS selection decisions were made in a 2-minute window leading up to the landing. In this time-constrained environment, determining landing point achievability is critical for safe LS selection. Thus, an achievability limit

algorithm was developed that combines a behavioral model of the pilot and physical models of the vehicle and environmental dynamics to predict the propellant required to reach any potential LS. **METHODS:** A human-subject study was conducted on a ground-based flight simulator to evaluate the impact of the real-time display of achievability limit information on LS selection performance. Subjects completed simulated lunar landing trials where they were asked to maintain manual control of the vehicle's pitch and roll through joystick inputs. Half the subjects were provided real-time achievability limit information, the other half did not have this display element. In each trial the subject was tasked to select the optimum landing site that was 1) achievable 2) minimized hazards and 3) was closest to three points of scientific interest. LS selection information was provided on an ego-centric top-down horizontal situation display. **RESULTS:** Our results from LS selection with real-time achievability limit information indicate an improvement to task performance (20% increase in optimal landings), a reduction in workload ratings (100% low-medium workload ratings using the Revised Bedford Workload Scale), and an increase in situation awareness (10% improvement in an embedded situation awareness task). **DISCUSSION:** The factors that define LS achievability often behave and interact in a nonintuitive manner such that even experienced pilots may struggle to accurately estimate the achievable limits. When this information becomes critical for LS selection subjects display common decision-making biases. Providing a real-time display of the achievability limit can help mitigate these decision biases and result in more optimal LS selection decisions.

Learning Objectives

1. The audience will learn about the various human performance challenges still present in piloted lunar landings.
2. The audience will be introduced to new Human System Integration predictive display technologies for use in piloted lunar landing vehicles.

[242] COMPARISON OF PHYSIOLOGICAL AND COGNITIVE PERFORMANCE IN HIGH PERFORMANCE PILOTS DURING DAY AND NIGHT FLYING: A PILOT STUDY

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(Original Research)

BACKGROUND: Pilots routinely transition to night flying to maintain night currency and proficiency. The physiological toll as a result of this transition is not understood. This research investigated the changes in physiological markers of stress and cognitive performance as high-performance pilots transitioned short-term to night-flying weeks using salivary cortisol, wrist activity monitors, the National Aeronautics and Space Administration-Task Load Index (NASA-TLX), and a go/no-go (GNG) developed by Naval Medical Research Unit at Dayton. **METHODS:** Seventeen fully qualified high-performance pilots took part in a two-week data collection using salivary swabs, wrist worn activity monitors, the NASA-TLX, and a GNG test. **RESULTS:** No differences were found in GNG reaction time or accuracy, NASA-TLX scores, or sleep quantity as participant's transition to night-flying weeks. Salivary cortisol levels were significantly higher than civilian levels in all experimental conditions and control days. Unique participant salivary cortisol curves were fitted and we found higher-than-predicted participant salivary cortisol levels post-flight in the day-flying condition and lower-than-predicted participant levels post-flight in the night-flying condition. Two negative relationships; aircraft hours by magnitude of cortisol change (pre- to post-flight) in the day-flying condition and age by Perceived Stress Survey scores suggested stress adaptation in the pilot community. **DISCUSSION:** We hypothesized that the night-flying environment would be more stressful, but our results disputed this claim. Our results suggest day-flying elicits more of a stress response; however, a larger sample size is required to verify results.

Learning Objectives

1. The audience will learn about field cortisol collection in a pilot community.
2. The audience will learn about the development of the unique sample cortisol curve that differed from the general population.

[243] ESTIMATION AND PREDICTION OF OPERATOR COGNITIVE STATES BASED ON EMBEDDED MEASURES OF TRUST, MENTAL WORKLOAD, AND SITUATION AWARENESS

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¹University of Colorado Boulder, Boulder, CO, USA

(Original Research)

INTRODUCTION: Questionnaire methods for measuring human cognitive states such as trust, mental workload, and situation awareness (henceforth "TWSA") that are typically used in laboratory experiments are obtrusive or impractical to administer in operational contexts. Previous research has investigated using unobtrusive "embedded measures" of TWSA and found them to be useful in querying TWSA. If these embedded measures can be validated and then used by an autonomous system to estimate and predict TWSA, then the system can adapt to best improve its own performance and the performance of human operators.

METHODS: 15 participants (9 male, 6 female) from the CU Boulder community were enrolled in an experiment in the Aerospace Research Simulator at CU Boulder. Participants completed 12 trials of a space-flight-relevant task that elicited changing levels of TWSA while embedded measures were collected during the task. Responses to well-validated and commonly used ("gold standard") questionnaires (the System Trust Scale, a modified Bedford workload scale, and the SART) were collected from participants after each trial. General linear models were fit to validate the ability of the embedded measures to predict questionnaire responses on each trial. The experiment was conducted with the approval of the CU Boulder Institutional Review Board. **RESULTS:** Embedded measures of TWSA were found to have significant correlations with questionnaire responses ($p=0.019$, $p=0.020$, and $p<0.0005$ for the respective states). The inclusion of embedded measure data improved the general linear model estimate of questionnaire responses. Models were evaluated and predictor variables were selected based on the Akaike Information Criterion, the Bayesian Information Criterion, and R^2 .

DISCUSSION: Validated embedded measures allow for cognitive state measurement without disrupting experiments or operations, keeping the operators in the loop and engaged with tasks. The ability to estimate and predict cognitive states enables future adaptive autonomous systems. Rapidly understanding and predicting human operator states will be critical for future autonomous space habitats, especially in arrival scenarios or off-nominal scenarios, and this capability will make improvements in both the performance of the human and the performance of the autonomous system possible. This work was supported by a Space Technology Research Institutes grant from NASA's Space Technology Research Grants Program.

Learning Objectives

1. The audience will understand the need for validation of embedded measures of cognitive states against gold standard measurement methods.
2. The audience will learn about the utility of both embedded measures of cognitive states and cognitive state estimation for adaptive autonomy.

[244] VALIDATION AND ESTIMATION OF HUMAN COGNITIVE STATE THROUGH PSYCHOPHYSIOLOGICAL SIGNAL ANALYSIS FOR AEROSPACE SYSTEMS

Johnny Zhang¹, Neil Banerjee¹, Jacob Kintz¹, Torin Clark¹, Allison Anderson¹

¹University of Colorado Boulder, Boulder, CO, USA

(Original Research)

INTRODUCTION: Mental workload is a critical human cognitive state of interest in aerospace environments. Historically, this has been best assessed in laboratory experiments through questionnaires after the test subject has interacted with the aerospace vehicle. These questionnaires are obtrusive and do not permit real-time assessment of mental workload. Psychophysiological signals measured from the autonomic nervous system can offer insight into an operator's mental workload. Previous approaches have focused on capturing operator taskload, as opposed to validating against gold-standard questionnaire assessments of the cognitive state of mental workload. **METHODS:** We performed a human experiment with 15 participants (6 female, 9 male) performing a

simulated spacecraft docking task. Participants each completed 12 docking trials in which experimental variables (e.g., piloting difficulty) were varied to yield changes in mental workload. Electrocardiogram (ECG), electrodermal activity, respiratory activity, and eye-tracking data were collected. A gold-standard questionnaire (a modified Bedford Workload Scale) was administered after each trial. Generalized linear models were fit to subject-specific data to assess the accuracy of psychophysiological features in predicting questionnaire responses.

RESULTS: A model incorporating several psychophysiological measures found heart rate, and measures of heart rate variability (SDNN, pNN50) were significant predictors of subjective workload across all subjects (Adj. R²: 0.85 (\pm 0.23)). Even for subjects (n=3) where ECG signal quality was poor, modeled estimates of workload remained predictive (Adj. R²: 0.69 (\pm 0.37)). **DISCUSSION:** Our results enable a high-quality estimate of human mental workload incorporating physiological signals taken from the heart. This research can be leveraged to improve operator state assessment and human autonomy teaming future aerospace applications. This material is based upon work supported by NASA under grant or cooperative agreement award number 80NSSC19K1052.

Learning Objectives

1. The audience will understand the need for validation of psychophysiological measures of mental workload.
2. The audience will understand the need for validation of psychophysiological measures of mental workload.

Wednesday, 09/01/2021

10:30 AM

Plaza A/B

[S-48]: PANEL: RECENT SPACEFLIGHT LIFE SUPPORT RESEARCH UPDATES FROM THE AIAA LIFE SCIENCES AND SYSTEMS TECHNICAL COMMITTEE

Chair: Daniel Buckland

Panel Overview: The American Institute of Aeronautics and Astronautics (AIAA) Life Sciences and Systems Technical Committee (LS&S TC) represents the AIAA's official interface with the space medicine community. This panel presents a range of recent research and engineering developments that the TC feels are important to present and discuss with clinicians and space medicine operations researchers. It will focus on Life Support Engineering topics such as sampling of air quality in the ISS, the results of international workshops on changes in planetary microbial protection policies necessary for crewed flights to Mars, material sciences advances that could improve CO₂ absorption in the ISS, and recent findings that can impact radiation risk mitigation profiles in exploration spaceflight. These presentations will be followed by an open discussion that will hopefully enhance and produce AIAA and AsMA member collaborations and knowledge exchange.

[245] AIR QUALITY – AEROSOLS IN THE SPACECRAFT CABIN

Marit Meyer¹

¹Washington University in St. Louis, Cleveland, OH, USA

(Original Research)

INTRODUCTION: The International Space Station (ISS) is a unique indoor environment that has been both home and workplace to a crew of six people since 2009. While gaseous pollutants have been continuously monitored, particles have only recently been investigated. The first aerosol experiment captured airborne particles and brought them back to Earth for analysis. **METHODS:** Two types of samplers were deployed on ISS. Passive Samplers were placed on the edges of air intakes of the ventilation system to capture large particles from air entering the cabin filters. Active Samplers (commercial samplers) captured particles as small as 10 nm. **RESULTS:** Particles were analyzed by computer-controlled scanning electron microscopy with energy dispersive x-ray spectroscopy. A database of 80,000 metal particles gives the ability to search and plot ISS aerosol results by elemental composition, size, abundance by location, roundness, aspect ratio, and by proportion of all particles sampled (weight or number %). The smallest particles collected with the

Active Sampler (300 nm and below) were relatively sparse. Two notable particle types in this size range include titanium dioxide and agglomerated metal fume particles, with primary particle sizes ranging from 3 to 20 nm. The storage area of ISS was the cleanest, while the exercise and hygiene area was the dirtiest. Crew members exercise for two hours per day, which produces three particle types that dominated the samples: lint (clothing fibers), human skin flakes and antiperspirant particles.

DISCUSSION: Human presence and activities dictate the quantities of particles in different areas. Laundry does not exist due to the scarcity of water, so the crew must wear their clothing multiple days before discarding them. This results in repeated clothing changes and antiperspirant applications each day. When the particle-laden clothing is agitated during changing and exercising, the lint, skin flakes and Al-Cl-Zr particles are emitted in quantity. The samples contained 27 different metals, many not typically found in indoor environments on Earth. This can be attributed to the many experiment payloads, which are the chief activities of astronauts in their waking hours. Sources of certain unique metals have not been identified, however, many stainless steel and aluminum wear particles are recognizable and are more abundant near exercise equipment.

Learning Objectives

1. Understand the unique behavior of aerosols in the microgravity environment.
2. Understand aerosol emissions that come from human occupants of spacecraft
3. Understand that exercise equipment creates mechanically generated metal wear particles during crew exercise

[246] MICROBIAL MONITORING ASPECTS OF PLANETARY PROTECTION FOR CREWED MISSIONS TO MARS

James (Andy) Spry¹

¹SETI Institute, Mountain View, CA, USA

(Education - Program / Process Review)

INTRODUCTION: In current exploration planning, NASA has committed to "push the boundaries of human exploration forward to the Moon and on to Mars". While the Moon is not of great concern from the point of view of harmful contamination as a result of exploration, or the threat of adverse changes to the Earth resulting from introduction of returned extraterrestrial materials, Mars is. Mars may have had, or still have, an indigenous biosphere. First, this drives efforts to ensure that Mars is not exposed to uncontrolled levels of contaminating terrestrial bioorganic materials, before we understand it. Second, until we better understand the martian environment, consensus scientific opinion is that we need to ensure that martian materials returned by sample return mission(s) are contained to a high level of stringency, preventing their uncontrolled release into the terrestrial environment. This two-fold control of interplanetary transfer is the discipline called planetary protection. **OVERVIEW:** While approaches for these are manageable and affordable for robotic missions, it is widely agreed that once humans travel from Earth to the surface of the red planet, such partitioning of the two planetary environments becomes impracticable. NASA, and more recently COSPAR (Committee on Space Research, the organization charged by the United Nations with maintaining planetary protection policy), have over the last several years, held a series of workshops to develop a transition pathway from current robotic mission planetary protection approaches, to a new planetary protection paradigm for crewed missions. The workshop series generated a set of knowledge gaps associated with planetary protection; refined and prioritized them; identified destinations and opportunities for addressing them; and in the latest in person and virtual meetings, described the instruments and measurements necessary to close the knowledge gaps. These findings are documented in a report series, and a timeline for addressing the knowledge gaps before the first "boots on the ground" in the mid-2030s is described. **DISCUSSION:** During the workshop discussions, the knowledge gaps were grouped into three areas: Microbial and human health monitoring; Natural transport of contamination on Mars; and Technology and operations for contamination control, linking strongly to ongoing microbial monitoring technology developments and activities in the space medicine and life support systems communities.

Learning Objectives

1. The audience will learn about plans and approaches to protect Mars and astronauts from microbial cross-contamination, the discipline of planetary protection.
2. The audience will learn about opportunities for integrating/aligning their own space medicine research interests with the ongoing planetary protection planning.

[247] NOVEL SORBENTS FOR CO₂ REMOVAL FROM SPACE-CRAFT CABIN ATMOSPHERESJames Nabity¹¹University of Colorado Boulder, Boulder, CO, USA*(Original Research)*

INTRODUCTION: Human spaceflight poses many challenges to regenerable environmental control and life support (ECLS) and *In Situ* Resource Utilization (ISRU). In particular, robust systems for atmosphere revitalization are still being sought. Long-term continuous exposure to elevated CO₂ concentrations has been hypothesized to adversely affect crew performance and contribute to crew physiological issues (headaches, vision impairment, and intracranial pressure). Astronaut performance and comfort can begin to degrade at levels from 2.3 to 2.7 mm Hg ppCO₂ which are below the maximum allowable level on ISS of 4 mm Hg ppCO₂. Therefore, astronauts and physicians have advocated for even lower levels with goal to reduce the partial pressure of CO₂ to below 2 mmHg; a level that has not historically been met by the zeolite sorbent used in the Carbon Dioxide Removal Assembly (CDRA). To meet this need, solid amines and room temperature ionic liquids (RTILs) are being researched as regenerable sorbents for CO₂ removal as well as for humidity control of cabin atmospheres. Both have promise, although the ionic liquids have unique properties that make them attractive for human spaceflight, which are negligible vapor pressure, thermal and chemical stability, and little or no risk of toxicity to the crew. These novel sorbents have the potential to control CO₂ to levels below 2 mmHg. **METHODS:** The engineering implementation of these sorbents along with results from engineering design, analyses from first principles and experiments will be presented. A solid amine has been tested onboard the International Space Station (ISS). Supported Ionic Liquid Membranes have been tested in the laboratory. **RESULTS:** A CAMRAS demonstrator, the CO₂ And Moisture Removal Amine Swing-bed system, has been on-orbit since 2013. There are also plans to launch the Carbon Dioxide Removal by Ionic Liquid Sorbent (CDRILS) System to the ISS within the next two years. Results and lessons learned from laboratory and flight experiments will be presented. **DISCUSSION:** Experimental results show that both solid amine and RTIL sorbents are quite promising. In this panel discussion, I will relate the results to the atmosphere quality needed in support of crew health.

Learning Objectives

1. Understand the influence of elevated CO₂ levels on human performance.
2. Learn about the operation, capabilities and limitations of state-of-the-art CO₂ removal technologies.
3. Learn about novel technologies with promise to lower CO₂ levels in space habitats.

[248] TOOLS AND TECHNIQUES FOR RADIATION RISK MITIGATION IN AN ERA OF EXPLORATIONRonald Turner¹¹Analytic Services Inc (ANSER), Falls Church, VA, USA*(Education - Tutorial / Review)*

INTRODUCTION: Radiation exposure poses a significant risk to astronauts. The natural radiation threat to exploration missions beyond the Earth's geosphere comes in two varieties: the steady and highly penetrating Galactic Cosmic Radiation (GCR) and the intense but more moderately energetic Solar Particle Events (SPE). This presentation focuses on the tools and techniques available to NASA to help mitigate the risk from radiation exposure. It provides an update on the state of the art in dosimetry and particle detectors; shielding materials useful to moderate the radiation environment inside a vehicle or habitat; and instruments and models used to forecast SPEs and GCR intensity. The common theme to these diverse

technologies is they each contribute to an overarching radiation risk mitigation strategy, whether the exploration context is short duration lunar missions or long duration missions to Mars. **RESULTS:** Modern tools and capabilities to monitor and reduce the risk of space radiation are built on over fifty years of evolving operational experience at NASA. Observations of the particle environment is grounded by heritage instruments on GOES but supplemented with sensors on science and operational platforms such as DSCOVR, SOHO, and SDO. These observations provide near real time characterization of the particle flux from tens to hundreds of MeV/nucleon. Dosimetry has advanced from passive film detectors to active, real-time readout personal dosimeters distributed throughout a spacecraft and habitat. NASA recognizes that to reduce the neutron flux within spacecraft and habitats, that synergistic, not parasitic, composite low Z materials should be used where they are reasonable. Finally, while GCR characterization is generally adequate for forecasting months or years in advance, GCR forecasting will be improved as experience is accrued in currently historically low solar activity. However, forecasts of SPEs have not improved and still limit NASA operational flexibility. **DISCUSSION:** The presentation shows that elements are in place to provide a solid risk mitigation strategy for human exploration, wherever it goes. However, the strategy is fragile and each element must continue to get the attention it deserves, or the risk to astronauts will increase. Further, elements must be combined using a solid systems engineering approach that considers astronaut operational plans and constraints, or again, risk will increase.

Learning Objectives

1. The audience will learn about the risk of radiation to astronauts.
2. The audience will learn about current efforts to mitigate the risk of radiation exposure to astronauts.

Wednesday, 09/01/2021**Plaza D/E****10:30 AM****[S-49]: PANEL: GLOBAL REACH COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS****Chair: Douglas Files****Co-Chair: Paul DeFlorio**

Panel Overview: Expedient response to a physiologic event or a mishap with mass casualties is of paramount importance to flight surgeons and it is an essential function aiding our ability to maintain global reach. Moreover, proportional and appropriate actions must be taken at a moment's notice. This panel will immerse participants in a hands-on mishap sequence, beginning with an inflight emergency due to a physiologic event. Participants will assess scene safety and respond to casualties to determine if they require aeromedical evacuation. They will then address the environmental considerations for their personnel remaining in the deployed location. At the conclusion, participants will have reinforced preparedness for maintaining global reach.

[249] GLOBAL REACH AEROMEDICAL EVACUATIONBryant Martin¹, Douglas Files¹¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Education - Program / Process Review)*

BACKGROUND: Flight surgeons are responsible for certifying patients with medical needs that exceed capabilities in deployed locations. This interactive scenario will simulate evacuation clearance cases to maintain and improve comprehensive medical readiness skills. **OVERVIEW:** Following a mass casualty event or aircraft mishap a number of patients may require aeromedical evacuation. In this session participants will make complex medical decisions clearing patients for aeromedical evacuation using a tracking system like the US Transportation Command Regulating and Command & Control Evaluation System from the deployed environment. **DISCUSSION:** Medical clearance and patient movement certification are important functions both in the deployed location and in garrison. The training is applicable beyond the Air Force to all aeromedical evacuation including the Tri-service interface with the American inter-theater military casualty evacuation system.

Learning Objectives

1. The participant will prepare patients for aeromedical evacuation and discuss complex medical decision making.
2. The participant will learn about safety factors in patient movement as well as how to perform the U.S. Air Force medical clearance process.

[250] GLOBAL REACH MASS CASUALTY RESPONSERussell Turner¹, Douglas Files¹¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Education - Case Study)*

BACKGROUND: Mishap and mass casualty response are important capabilities for flight surgeons and can often involve inherent hazards. This session will involve a simulated mass casualty event with multiple casualties and injured aircrew following an aircraft mishap. **OVERVIEW:** medical first responders must be equipped with a wide range of skills to include advanced trauma life support, triage and procedural skills. Aerospace medicine physicians often manage mass casualties at a higher level, requiring more specific knowledge of the mishap response plan and their role within the National Incident Management System. To complicate matters, aircraft contain many hazardous materials that make ensuring scene safety particularly important. **DISCUSSION:** Given the relatively low frequency of a mass casualty events and aircraft mishaps, maintaining the necessary skillset to ensure rapid and appropriate response in an emergency situation can be difficult. Insight into the National Incident Management System while working through a simulated mass casualty and aircraft mishap will provide bolstered disaster response capabilities.

Learning Objectives

1. Attendees will participate in the strategic implementation of mishap response in a complex mass casualty situation.
2. Attendees will discuss complex decision making during a mass casualty event

[251] GLOBAL REACH IN-FLIGHT PHYSIOLOGIC EMERGENCY RESPONSEBenjamin Smith¹, Douglas Files¹¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Education - Program / Process Review)*

BACKGROUND: Acute physiologic emergencies such as decompression sickness, spatial disorientation and hypoxia can have catastrophic consequences when occurring during flight. These causes are often preventable, so preparation is imperative. **OVERVIEW:** Physiologic events require medical evaluation to determine any contributing factors such as flight equipment, environmental conditions, and how these could be prevented. Some physiologic events require a medical workup for diagnosis of an underlying condition that may cause a predisposition to future events. Attendees will work through a scenario involving a physiologic event. **DISCUSSION:** Physiologic events resulting in injury are not common in aircrew, making maintaining currency as an aerospace medicine physician challenging. Attendees will perform a case-based analysis of a mishap sequence that results in an injury to demonstrate the potentially serious consequences of these events. Following the training, the attendees will have improved comprehensive medical readiness skills.

Learning Objectives

1. Attendees will be able to respond to an in-flight physiologic event in which an aircrew member has been injured.
2. Attendees will discuss flight equipment issues, environmental conditions and physiologic aspects of in-flight emergency events.

[252] GLOBAL REACH PREVENTION AND TRAVEL MEDICINE UPDATECady Blasser¹, Douglas Files¹¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Education - Program / Process Review)*

BACKGROUND: Often our operational airfields are in locations that may pose unique environmental hazards due to endemic and vector

borne diseases. Aerospace medicine professionals must be prepared to provide support for worldwide deployments. This presentation will help aerospace medicine professional maintain currency with participation in travel medicine briefings. **OVERVIEW:** Medical expertise in travel health is an essential capability for flight surgeons and medical travel guidelines are always changing. This program will allow aeromedical professionals to participate in travel medicine briefings for deployment to Niger.

DISCUSSION: This program offers flight surgeons the opportunity to use the latest travel medicine guidelines to plan and present a briefing on the unique risks associated with a deployment to Niger. Special attention will be paid to malaria prophylaxis as well as Ebola activity in the region.

Learning Objectives

1. Participants will prepare and present relevant medical guidance for an upcoming deployment to Niger
2. Participants will discuss the health risks for military troops deploying to a tropical environment

Wednesday, 09/01/2021**Plaza F****10:30 AM****[S-50]: PANEL: NO KIDDING, THERE I WAS: LESSONS FROM THE FIELD, AEROMEDICAL RESEARCH, AND PILOT-PHYSICIANS****Chair: Christopher Bates****Co-Chair: Joe Zhang**

Panel Overview: INTRODUCTION: 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 advancing aerospace medicine through research. **CASE PRESENTATION:** This panel will present case studies from both military and civilian organizations that demonstrate how Pilot-Physicians help advance aerospace medicine through research. **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.

[253] CHANNELIZED ATTENTION AS DEMONSTRATED BY C-17 APPROACH INTO KABUL, AFGHANISTANChristopher Backus¹¹USAF, Doha, Qatar*(Education - Case Study)*

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.

[254] CHARACTERISTICS OF THE MICROBIOLOGY BIOME IN RPA COCKPITS

Joe Zhang¹

¹USAF, Langley AFB, VA, USA

(Original Research)

INTRODUCTION: Remotely Piloted Aircraft operators spend hundreds of hours in the cockpit performing operations across the globe. Pilots and Sensor Operators, prior to COVID-19, did not have an established cleaning regimen between crew swaps while the aircraft was in flight. This is a study that took place prior to COVID-19 and is a review of the bacterial biome that formed on control surfaces in a typical ground control station during continuous combat operations. **BACKGROUND:** Remotely Piloted Aircraft have been in near continuous use with several crews responsible for a single sortie that may last over 20 hours. Crews find themselves in tight, enclosed, and often secured environments for many hours and outbreaks of illness are not unheard of. While there are some cleaning procedures performed by aircraft cockpit maintenance following aircraft landing, not every cockpit control surface was cleaned regularly and there were no standardized cleaning procedures performed between crews. This study is the first of its kind to identify typical organisms that are found on the cockpit control surfaces. **CASE PRESENTATION:** Multiple RPA cockpit controls from a combat cockpit that has been in near continuous use for over ten years were sampled with sterile microbiology swabs and cultured for 24 hours in blood agar. Microscopic identification of bacterial species were performed with standard laboratory identification procedures. Generalized human skin flora species were identified with unequal colony counts on the various control surfaces. One sample of Methicillin Resistant Staph Aureus (MRSA) was also identified on one control surface.

DISCUSSION: This was the first of its kind study in the microbiology biome of an operational RPA cockpit. While conducted as a snapshot in time, it is a good indication that further studies including fungal and viral studies are still recommended for ensuring a reduction in disease transmission between aircrews. The cleaning procedures have been changed since this study with the advent of COVID-19 but this gives an informative insight into the non-pandemic biome as well as indicate likely post pandemic cleaning habits which are expected to return in the future. This study also helps to highlight the need to recommend standard cleaning instructions as well as supplies needed to help reduce future disease transmission rates in this high demand career field.

Learning Objectives

1. Improve generalized understanding of the operational RPA cockpit environment and aircrew habits.
2. Appreciate the integration of medical disease prevention into RPA operations and maintenance.

[255] RAPID CABIN DECOMPRESSION AND IPBAM DATA DURING F/A-18C HORNET FLIGHT: A CASE REPORT

Tuomo Leino¹

¹National Defence University Finland, Helsinki, Finland

(Education - Case Study)

INTRODUCTION: Rapid cabin decompression is one possible explanation of physiological episodes (PEs). In Finland, after hypoxia-like symptoms three F/A-18C Hornet pilots have been successfully treated with US Navy Table 6 hyperbaric oxygen therapy because of decompress sickness (DCS) type 2. **BACKGROUND:** Cabin altitude is 6000 meters (air pressure 6,843 psi) when F/A-18C Hornet is flying at 50 000 feet altitude. Environmental Control System (ECS) is responsible of maintaining adequate cabin pressure. Cabin pressure regulator system is very complex technical system using pressurized bleed air from jet engine. **CASE PRESENTATION:** F/A-18C Hornet started decent at 48 000 ft with 15 degrees nose down attitude, speed brake out and power setting 80 % in both engines. At 42 000 ft Hornet started turn and continued decent. At 40 000 ft power setting was increased to 94 % in both engines. According to Insta Pilot Breath Air Monitor (IPBAM), cabin altitude rapidly decreased from 5241 meters in 3 seconds to 4542 meters. After that IPBAM data showed rapid cabin decompression in 4 seconds to 6707 meters. MASTER CAUTION visual and audio warning were activated due to CABIN light and also IPBAM vibration alarm was sensed in flight mask. Without delay pilot activated 100 % emergency oxygen and continued emergency decent towards 10 000 feet. After 19 seconds, ECS established normal 5 psi pressure difference to aircraft altitude. Wingman escorted the fighter as chase plane in radar trail formation during RTB. No symptoms were reported by pilot and postflight aeromedical check was normal. **DISCUSSION:** Case report demonstrates cabin altitude changes second-to-second during rapid decompression in F/A-18C Hornet. At high altitude, power increase from 80 % to 94 % has increased bleed air pressure to ECS and Cabin Air Pressure Regulator have been unable control it leading to cabin pressure difference over 5,5 psi compared to aircraft altitude. At this point, Cabin Air Pressure Safety Valve has opened causing rapid decompression. It took 19 seconds for Cabin Pressure Regulator to normalize cabin pressure difference. Above 40 000 ft test pilots recommend to minimize rapid movements of throttle (PCL) and adjust cabin temperature to full cold. Technical maintenance of Cabin Flow Valve, Avionics Flow Valve and Cabin Air Pressure Safety Valve have been changed from On-Condition philosophy to flight time based (E maintenance). US Navy has also recommended removal of Exit Air Valve.

Learning Objectives

1. The participants will be able to learn about aircraft systems which produce cabin pressurization.
2. The audience will understand that physiological episodes (PE) still are phenomena in F/A-18 Hornet fleet and there is no single factor leading to PEs.
3. The audience will learn how fighter formation is co-operating during CABIN emergency.

[256] CONTRIBUTIONS OF PILOT PHYSICIANS TO ATTACK HELICOPTER OPERATIONAL REQUIREMENTS

Ian Curry¹, Steven Gaydos²

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

(Education - Program / Process Review)

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-64 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 Objectives

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.
2. The process of rapid technology fielding will be examined in an operational environment.
3. The topic of human systems integration will be evaluated in terms of the cost benefit analysis conundrum of risk to life from unfamiliar equipment as opposed to the efficacy of hostile action in the absence of said equipment.

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

James Webb¹

¹Scientific Aerospace Research Consulting (SARC), LLC, Bandera, TX, USA

(Education - Case Study)

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 336th TFS, later upgrading to Aircraft Commander positions before our Vietnam tours. About a month after I finished my tour at the 389th 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_z 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.

Wednesday, 09/01/2021
Governor's Square 12

10:30 AM

[S-51]: SLIDE: MEDICAL SCREENING & HEALTH STATUS

Chair: Denise Baisden

Co-Chair: Sky Wolf

[258] PRE-FLIGHT MEDICAL SCREENING IN THE COMMERCIAL SPACEFLIGHT PARTICIPANT

Lauren Church¹, Maia Gummer², Eleonor Frost³, Nina Purvis⁴

¹King's College London, London, United Kingdom; ²University College London, King's College London, London, United Kingdom; ³University College London, University of Aberdeen, Aberdeen, United Kingdom; ⁴Bart's and the London School of Medicine, London, United Kingdom

(Original Research)

INTRODUCTION: With the advent of commercial spaceflight, the safety of commercial spaceflight participants (CSPs) 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 proposes a possible pre-flight 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 better understand the physiological changes in the SSE, and then 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 to fly 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 unthought of considerations. **RESULTS:** Literature review and questionnaire results are collated and presented. There are conditions which might be prohibitive, such as recent surgery (14 days), ventricular arrhythmia, or severe inflammatory bowel disease. There are conditions, where appropriately managed, which might 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 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.
3. The delegate will develop an understanding of tailoring a medical history to conditions relevant for suborbital spaceflight.

[259] THE CASE FOR REDUCED AEROMEDICAL EXAMINATION STANDARDS FOR SOME AIR SPORTS

David Bareford¹, Marja Osinga¹, Jurgén Knueppel¹

¹FAI CIMP, Lausanne, Switzerland

(Original Research)

INTRODUCTION: The current standards for medical examinations have been selected to be proportionate to the level of flight safety required for each activity. In most countries a formal aeromedical examination is required to participate in very low risk air sports and recreational flying. We propose that there is enough evidence to prove that flight safety would not be compromised by the introduction of new, less extensive medical assessments for some aviation sports. Further, experience in countries with minimal, e.g., drivers'-license - equivalent medical exams for some air sports and some forms of recreational flying proves that risks to passengers and public are acceptable. **METHODS:** A risk assessment has been carried out against these various medical

standards and a theoretical risk benefit analysis undertaken. Accident statistics for sport aviation have been obtained from various countries and various air sports and compared to their medical standards to support the theoretical calculation. **RESULTS:** ICAO decided that a 1% level is the acceptable risk for a Class 2 private pilot's medical. Based on a theoretical European sport pilot population of 100,000 an ICAO Class 2 would have a lifetime cost of €6,500,000. There would be 0.38 passengers killed a year with no significant ground casualties. For a medical standard equivalent to a 2% risk the cost would reduce to €860,000. An additional passenger would be killed every 4 years. For a medical standard equivalent to a 20% risk (self-certification) the cost would reduce to zero. An additional passenger would be killed every 2 years. ICAO Class 2 represents an expenditure of €2,360,000 per life saved over self-certification. Twenty percent of pilots would be grounded. Accident statistics obtained indicate that this risk benefit model is correct. **DISCUSSION:** National and regional aeromedical authorities should adopt newer medical standards based on a 5% predicted risk of sudden incapacity in the next year (Class 4) and a 20% risk (Class 5) for some lower risk air sports. This will reduce overall costs of flying and increase participation without significantly increasing the risk of fatalities or harm to aerial athletes, recreational pilots, spectators or third parties due to medical events.

Learning Objectives

1. The participant will learn the history of aeromedical examinations for sport and recreational flying in different nations.
2. The participant will be asked to judge whether an analysis of future risk to aviators and the public is correct, and whether legal authorities should be asked to adopt such minimal but effective requirements for aeromedical examinations.

[260] 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 Takazoe¹, Hideho Gomi¹

¹Japan 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 Objectives

1. The participant will be able to understand the Japanese aviation medical examination system.
2. 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.

[261] TOWARDS A FASTER RETURN OF THE AIRCREW TO THE FLIGHT DECK AFTER ABDOMINAL SURGERY: OPTING FOR LAPAROSCOPIC OVER CONVENTIONAL SURGERY

AMEET KUMAR¹

¹5 Air Force Hospital, Jorhat, India

(Education - Program / Process Review)

BACKGROUND: Aircrew form a vital resource to the organization, be it the armed forces or the civil airline. At times, they may develop abdominal conditions that necessitate surgery, either, conventional or laparoscopic. There are various quantifiable parameters where a particular surgery is evaluated. An important parameter is ability to return to work. In measuring outcomes in terms of return to work, laparoscopic surgery has consistently scored above conventional surgery.

OVERVIEW: In some abdominal surgeries, laparoscopic surgery is considered as the gold standard. However, in most it has still not attained the gold standard status and this is where we rest our decision making on guidelines. Many a times, there is no clear advantage of one over the other. In this paper, we look at some guidelines for some common abdominal surgery, cholecystectomy, appendectomy, ventral and inguinal hernia repairs and the existing recommendations for disposal and fitness to fly in respect of aircrew who undergo abdominal surgeries. We also review the literature for short-term outcomes of laparoscopic versus conventional surgery. We go on to discuss the merits of opting for laparoscopic surgery over conventional surgery even in surgeries where their guidelines do not find a distinct advantage. **DISCUSSION:** Time taken to return to the flight deck following a surgery is vital, both to the aircrew as well as the organization. Every endeavor should be made to reduce time to recuperate after surgery. Recent literature has provided a compelling weight of evidence that laparoscopic approach to common abdominal surgeries has better short-term outcomes including return to work. This is aptly reflected in the policies that govern the return of the aircrew to flying after laparoscopic surgery viz a viz conventional surgery. With the wider adoption of this technique by our young and skilled surgeons, we can expect a paradigm shift from open to laparoscopic surgery for the aircrew in an effort to return them to the flight deck faster.

Learning Objectives

1. The audience will learn about the role of laparoscopic surgery in abdominal conditions in the aircrew with particular reference to return to work.
2. The audience will learn about how laparoscopic surgery helps an aircrew to return to flying much earlier when compared to conventional surgery.

[262] HISTORICAL OVERVIEW OF AEROMEDICAL NEUROLOGY STANDARDS

Roger Hesselbrock¹

¹USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Almost all neurologic conditions were historically incompatible with flying activities. Medical advances and accumulated data have allowed safe medical certification for some conditions.

TOPIC: Aeromedical certification determinations for neurologic conditions have been challenging due to lack of well-established evidence-based risk data that are applicable to the aviator population. Historically, most neurologic conditions were deemed incompatible with flight activities. While a conservative approach to medical certification is still warranted, medical certification is now possible for an increasing number of neurologic conditions. **APPLICATION:** Neurologic conditions are commonly encountered in aviators. The necessarily conservative aeromedical disposition practices initially

precluded medical certification for almost all neurologic conditions. Aviators with neurologic conditions have continually advocated for return to flying activities. Evolution in medical knowledge and aircraft technology have now permitted safe medical certification in many cases that previously would have been permanently disqualified. Past and current challenges include minimal evidential data for some conditions, and lack of cohort-relevant evidential data for others. This presentation will review the evolution of aeromedical standards for neurologic conditions. Current standards and future trends will be presented and discussed. **RESOURCES:** 1. Davis JR, et al. (Eds). Fundamentals of Aerospace Medicine, 4th Edition; Lippincott Williams & Wilkins, 2008. 2. Gradwell D, Rainford D (Eds). Ernsting's Aviation and Space Medicine, 5th Edition, CRC Press, 2006.

Learning Objectives

1. The participant will be able to discuss the historical evolution of aeromedical standards for neurologic conditions.
2. The participant will be able to note current aeromedical standards for selected neurologic conditions.

[263] THE STUDY ON HEARING STATUS OF AIRCRAFT MAINTENANCE PERSONNEL

Yange Zhang¹, Lin Liu¹, Qin Yao¹, Fei Yu¹, Shan Chen¹

¹Air Force Medical Center, PLA, Beijing, China

(Original Research)

INTRODUCTION: Aircraft maintenance personnel are often exposed to high levels of noise, and are at high risk of noise induced hearing loss. This 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±6.70 yr, work years: 8.38±6.68 yr. The subjects were divided into 3 groups according to age. Group A (n=81), age < 30 yr. Group B (n=38) 30-39 yr, Group C (n=5) ≥ 40 yr. Questionnaires and pure tone audiometry were used. **RESULTS:** 1. Comparing mean hearing thresholds (HT) between left (LE) and right ear (RE), HT of RE was 14.19dBHL and HT of LE was 11.41dBHL at 8kHz, HT of RE was higher than that of LE. T value is 2.215, the difference is statistically significant. Comparing among three groups, HTs of group A are 16.02±8.12dBHL, 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±7.41dBHL, 10.66±10.81dBHL, 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±6.43dBHL, 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, F value 3.638, 3.287, 6.460, 8.954, 5.957, 9.524, 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 the exposure time to noise, 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 programs should be set for maintenance personnel.

Learning Objectives

1. The participant will be able to understand that aircraft noise can lead hearing loss of aircraft maintenance personnel.
2. The longer exposure time of noise was, the heavier hearing loss became. Asymmetric hearing loss of bilateral ears existed in aircraft maintenance personnel.
3. Noise induced hearing loss is not symmetrical. Tinnitus is not associated with hearing loss. Hearing Protection program should be set for maintenance personnel.

Wednesday, 09/01/2021

Governor's Square 14

2:00 PM

[S-52]: PANEL: ADVANCES IN AEROSPACE MEDICINE IN IBEROAMERICA

Chair: Angela Gomez

Co-Chair: Lina Sanchez

Panel Overview: In 2021, the panel sponsored by the Iberoamerican Association of Aerospace Medicine (IAAM) celebrates its 23rd year of sharing scientific advances in Iberoamerica. Conducted in the Spanish language, it will be chaired by the IAAM members, Dr. Angela Gomez, of Colombia, and co-chaired by Dr. Lina Sanchez, of Colombia; the panel will commence with a lecture about abnormalities of binocular vision in pilots in training as a risk to the safety of air operations presented by Dr. Jose Merino, of Mexico. Next, Dr. Rocio Garzon, of Colombia, will talk about an original research about fatigue among the aeronautical maintenance personnel of the Colombian Air Force. Then Dr. Diego Garcia, of Colombia, will talk about HFACS for Iberoamerican countries: achieving equivalence with the original version in English. The panel will continue with a presentation by Dr. Rocio Garzon, of Colombia, about spatial disorientation training at Colombian Air Force. Dr. Jean Carlos Duenes, of Venezuela, will complement the session by discussing heart failure caused by cardiac hemochromatosis in a pilot student. As always, the panel offers an opportunity to learn from our colleagues and encourages an internationally united environment towards enhancing world aviation safety.

[264] ABNORMALITIES OF BINOCULAR VISION IN PILOTS IN TRAINING AS A RISK TO THE SAFETY OF AIR OPERATIONS

Jose Merino¹

¹Aeronautical Visual Therapy for Aviation Pilots Mexico, Mexico City, Mexico

(Original Research)

INTRODUCTION: There are different clinical situations that can prevent the development of a binocular vision, such as the different perception of the image in the retina of the right eye with respect to the left eye when the subject has a condition known as anisometropia. The aviator pilot is not exempt from presenting such anomalies and many students in training in different aviation schools may present such alterations which may put their air operations in risk, particularly in the approach and landing phases. **OBJECTIVE:** Once the cause of the anomaly in the binocular vision is determined, it is possible to establish an adequate treatment through oculomotor and perceptual exercises. This approach us assisted with flight simulation systems to correct in a program which can range from weeks to months depending on the visual problem to increase the safety of the student's air operation. **METHODS:** Twenty cases of aviation students were included in the study, who were rejected by aviation medicine services due to alterations in binocular vision with intermittent monocular suppressions and / or alternating at different distances and decompensated forias triggered during exercises in a flight simulator. An ophthalmological medical examination was performed on each of the aviation students, which included refraction using dynamic retinoscopy and autorefraction, visual capacity and a review of eye movements and accommodative flexibility. **RESULTS:** The average time from the diagnosis of the anomaly in binocular vision of the aviation student in our practice and its reincorporation to their flight activities was six months where eighteen of the 20 cases cases managed to obtain favorable results. **CONCLUSION:** The aeronautical visual therapy program has demonstrated excellent results that are completely measurable and reproducible, where all visual skills are developed in a favorable way supporting our work in brain neuroplasticity.

Learning Objectives

1. The audience will learn about some abnormalities of binocular vision in pilots in training.
2. The audience will learn about the importance of aeronautical therapy in increasing the safety of air operations in aviation students.

[265] ANALYSIS OF CONTRIBUTING FACTORS TO APPEARANCE OF FATIGUE AMONG THE AERONAUTICAL MAINTENANCE PERSONNEL OF THE COLOMBIAN AIR FORCE - COLAF

Rocio Garzón Ayala¹, Nohora Rodríguez Guerrero¹

¹Escuela de Postgrados Fuerza Aérea Colombiana, Bogotá, Colombia

(Original Research)

INTRODUCTION: In today's production environment, which requires the performance of productive work 24/7, it requires aeronautical maintenance personnel to adapt through particularly demanding shift services; This type of work is essential to give continuity to aeronautical work with efficiency and quality reflected in the punctuality of maintenance and the reduction of the accident rate. **METHODS:** Given the multidimensional nature of fatigue, it is necessary to analyze different factors that contribute to its appearance. Measurements were made on 28 individuals from a COLAF Technical Group: individual features, cardiac variability, sleep evaluation survey, neuropsychological tests (for assess attention, flexibility of thinking and visual spatial ability). Likewise, measurements of environmental of sound, light and temperature were carried out in compliance with the standards stipulated for Colombian standards for occupational health. **RESULTS:** According to the data obtained, the variables that show correlation are body mass index, time of service, and how long it takes to get at workplace. Other studies in the aeronautical environment have identified the importance of providing formal education and training in sleep hygiene, alert management, strategies to overcome shift work as well as in this study. Other measurements are systematized techniques based on mathematical models and shift scheduling. **DISCUSSION:** According to the literature and the data obtained, generating a standard for service and rest times has advantages, although it does not correspond to the program for managing fatigue risk, if it constitutes a definitive step towards managing this risk within the institution. It is essential to maintain active research on the factors that influence the appearance of fatigue in this poorly evaluated population group.

Learning Objectives

1. The participant will be able to describe the impact of different factors for the appearance of fatigue in maintenance personnel.
2. The participant will be able to report the main factors to contribute on fatigue on maintenance personnel.

[266] HFACS FOR IBEROAMERICAN COUNTRIES: ACHIEVING EQUIVALENCE WITH THE ORIGINAL VERSION IN ENGLISH

Diego García¹, Johana Giraldo², Carlos Salicrup³

¹Embry Riddle University, Daytona Beach, FL, USA; ²Colombian Civil Aviation Authority, Bogotá, Colombia; ³Aeromexico, Mexico, Mexico

(Education - Program / Process Review)

BACKGROUND: The Human Factors Analysis and Classification System (HFACS) framework and taxonomy is a widely accepted instrument for the analysis of the human role, preconditions, supervisory and organizational influences causing accidents and incidents. HFACS is extensively used in assessing mishaps in safety-critical industries, and have been proven to be comprehensive, reliable, and relatively easy to apply. Indeed, copious scientific evidence demonstrating HFACS suitability for safety assessment in complex systems makes it one of the most applied accident investigation tools worldwide, Iberoamerican countries included. Numerous military and civilian organizations in Spanish-speaking countries use HFACS versions loosely translated into Spanish, causing some elements of the taxonomy to be lost in translation or distorted from their original meaning. Previous research found that unstructured modification of the validated tool impacted its reliability greatly, encouraging a rigorous adaptation process for HFACS Spanish versions. **OVERVIEW:** Cross-cultural adaptation of analytic instruments requires a structured process to validate existing tools in other languages/cultural settings. A translation-retro translation approach was used to achieve a consensual Spanish version achieving conceptual equivalence with the original HFACS version in English. Using an online survey, native Spanish-speaking HFACS experts were asked to translate the main tiers, categories, and subcategories of the taxonomy into Spanish. A 3-step reassessment was used to solve discrepancies and to narrow down the final translated taxonomy to a general consensus among

the panel of experts. Finally, the resulting Spanish version was translated back into English by native English-speaking experts, in order to evaluate conceptual equivalence between the resulted and the original version of HFACS. **DISCUSSION:** HFACS Spanish version will be presented as the initial step for cross-cultural adaptation of the taxonomy into the Spanish language. This Spanish version was built after a general consensus of HFACS experts and establishes the base for validating the instrument in different safety-critical operational settings in Spanish-speaking countries. Also, this constitutes the first effort for achieving cultural and conceptual equivalence among different HFACS versions, while maintaining its widely recognized attributes and advantages for accident investigation and safety management processes.

Learning Objectives

1. Discuss the requirements for cross-cultural adaptation of the HFACS taxonomy into Spanish.
2. To show advances in first effort for achieving cultural and conceptual equivalence among different HFACS versions.

[267] SPATIAL DISORIENTATION TRAINING AT COLOMBIAN AIR FORCE

Rocio del Pilar Garzon-Ayala¹

¹Colombian Air Force, Bogotá, Colombia

(Education - Program / Process Review)

BACKGROUND: Spatial disorientation (SD) continues to be one of the most important contributors to aircraft incidents and accidents in the world today. This phenomenon can be experienced by pilots whether they fly military or civil aircraft, regardless flight experience (represented by flight hours). During their career, pilots are exposed to presenting episodes of SD. For this reason, one of the main tasks to prevent the fatal consequences of SD is the education and training of aircrews.

OVERVIEW: The Colombian Air Force currently performs the SD training program supported by high-tech equipment, which integrates different axes movements, visual information on high definition, as well as the tasks to perform a normal flight mission. The aim of the training program is to show the manifestations of the physiological limitations of the human being. This training demonstrates the strategies to recognize, prevent, or overcome an SD episode. **DISCUSSION:** Colombian Air Force pilots must take this training every 4 years according to military regulations. The training consists of a theoretical session and a practical session of illusions. This training method was built after 6 months of work, including review of the SD literature and information provided by pilots most experienced in each type of aircraft (fixed and rotatory wing) and operation. The first training is exactly the same for pilots of all type of aircraft; it includes the most frequent and most dangerous illusions. After this phase, the participants are trained on different illusions pertinent to the operations they perform. Under this training scheme, 329 students have been trained from April 2015 to September 2019. This training has been very well accepted by pilots. This training has allowed mixed groups of trainees with low and high experience. This approach has provided an opportunity for improved collaboration. Also enriched feedback to personnel with less expertise on regular flight missions.

Learning Objectives

1. Presenting the Colombian Air Force flight physiological training program in Spatial Disorientation. It was created with the purpose to supplement the formation of the aircrew, improving effectiveness and efficiency on aeronautical activity in different operational contexts.
2. To show a training program that can be used as a model for other physiological training programs.

[268] HEART FAILURE CAUSED BY CARDIAC HEMOCHROMATOSIS IN A PILOT STUDENT

Jean Carlos Duenes¹

¹Cardiology Venezuelan Civil Aviation Institute, Bogotá, Colombia

(Education - Case Study)

INTRODUCTION: This case report describes a case of a pilot student who was studying to determine the presence of heart failure potentially caused by increase in iron deposits **BACKGROUND:** Hemochromatosis is a

recessive hereditary disorder that causes an increase of intestinal iron absorption. It is a disease characterized by an excessive iron deposit in a variety of tissues, including the heart. It occurs as a result of ferritin accumulation in the left ventricle bringing as consequences systolic dysfunction, heart rhythm disorders, clinical manifestations include atrials, ventricular tachycardia, atrioventricular block and symptoms of congestive heart failure, this last one is the first cause of death in these patients. Also, the diagnosis can be confirmed taking endomyocardial biopsy where iron deposit is seen in the sarcoplasm. **CASE PRESENTATION:** A 21-year-old male who was interested in obtaining an aeromedical certificate presented with risk factors for coronary heart disease, his symptoms were dyspnea, paroxysmal nocturnal dyspnea, palpitations, generalized asthenia (weakness concomitant with erectile dysfunction) and a family history of sudden death. Results of the medical examination revealed the presence of apex beat displacement outside the fifth intercostal space with axillary midline hyperdynamic character. As a result of Holter monitoring, severe impairment of function was evident in the left ventricle, with ventricular tachycardia. After multiple other studies, the conclusion was reached that hemochromatosis was present. The student was treated with a cardio defibrillator, inhibitor angiotensin receptors, and beta-blocker therapy. **DISCUSSION:** Patients with dilated or restrictive cardiomyopathy must be examined for this condition. The patient, who was seeking to eventually obtain a commercial pilot's license was not granted a waiver due to the various aeromedical regulations associated with such privilege. Applicants would be considered not fit because of possible complications besides doing pulmonary edema, and sudden death there is also a high probability that paroxysms occur atrial fibrillation with the indication of anticoagulant therapy.

Learning Objectives

1. To determine the presence of heart failure in a pilot student potentially caused by increase in iron deposits.
2. To review Hemochromatosis and its effects as cause of cardiac disease.

Wednesday, 09/01/2021
Governor's Square 15

2:00 PM

[S-53]: SLIDE: ACCELERATION: EDUCATION & IN-FLIGHT MONITORING

Chair: Ian Mollan

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

Chung-Yu Lai¹, Min-Yu Tu², Hsin Chu³

¹National Defense Medical Center, Taipei City, Taiwan (Greater China);

²Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung city, Taiwan (Greater China);

³Civil Aviation Medical Center, Taipei City, Taiwan (Greater China)

(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 the 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 (PhysioFlow®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 the 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 Objectives

1. To understand the mechanism of AGSM to improve G tolerance.
2. To find the objective cardiac parameters applied to assess the AGSM efficiency.

[270] WHAT IS +9Gz? - CENTRIFUGE VS AIRCRAFT: IMPLICATIONS FOR RESEARCH AND TRAINING

Joseph Britton¹, Nicholas Green¹

¹RAF Centre of Aviation Medicine, Henlow, United Kingdom

(Education - Tutorial / Review)

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.

[271] CGEM: A CEREBRAL BLOOD FLOW BASED COMPUTER MODEL OF GZ-INDUCED EFFECTSKyle Copeland¹, James Whinnery²¹Civil Aerospace Medical Institute, Oklahoma City, OK, USA; ²Retired, Oklahoma City, OK, USA*(Original Research)*

INTRODUCTION: Acceleration (G) effects are an important consideration in civil and military aviation, since G-induced loss of consciousness (G-LOC), impaired consciousness, and visual effects can all result in aviation accidents. **METHODS:** A physics and physiology based model (the Civil Aerospace Medical Institute G-Effects Model [CGEM]) using oxygen flow as a proxy for cell supply flow was developed at CAMI to evaluate risk of G-LOC and related phenomena in aircrew. CGEM includes several parameters, including sex, cardiovascular fitness, and other common modifiers such as G-suits, positive pressure breathing gear, anti-G straining and other muscle-tensing. Validation was performed using experimental data from peer-reviewed literature. **RESULTS:** CGEM predicted physiological effects of Gz exposure accurately, with best results in cases of rapid onset rate. Predicted times to G-LOC and absolute incapacitation periods were consistently within one standard deviation of pooled results obtained during centrifuge experiments using USN and USAF pilots. Predictions of G tolerance based on visual effects onset compared well with published data, as did prediction of symptoms expected during a difficult aerobatic maneuver. **DISCUSSION:** CGEM is a new tool by which surgeons, pilots, and accident investigators can gain insights into changes in risk from factors such as flight plan, fatigue, medications, dehydration, and anti-G equipment used. Results support the conclusion drawn from earlier studies that the current warning attached to Federal Aviation Administration special issuance waivers for cardiac disease seems sufficient.

Learning Objectives

1. The audience will learn about an effective technique for modeling acceleration induced physiological effects.
2. The audience will gain understanding of changes in human circulatory performance under Gz acceleration.

[272] USING HMAPS (HOLISTIC MODULAR AIRCREW PHYSIOLOGIC STATUS) INDICES TO DETERMINE DEGRADED PHYSIOLOGIC STATE IN VOLUNTEERS EXPOSED TO BOTH +GZ & HYPOXIABarry Shender¹, Megan Gallo², Eric Joyce³, Jessica Anderson³, Phillip Whitley⁴, Jeremy Beer⁵¹Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; ²Naval Medical Research Unit – Dayton, Dayton, OH, USA; ³Athena GTX, Johnston, IA, USA; ⁴Criterion Analysis, Inc., Miami, FL, USA; ⁵KBR Space & Mission Solutions Group, Brooks City-Base, TX, USA*(Original Research)*

INTRODUCTION: To support US Navy's efforts to mitigate in-flight "physiological episodes" risk, TACAIR aircrew were monitored with HMAPS during high +Gz and severe hypobaric exposures. **METHODS:** HMAPS, a body-mounted, aircraft-independent system, measures pulse oximetry (SpO₂), pulse rate (PR), ECG, G_{xyz}, barometric pressure, and derives respiration rate. A cognitive impairment index (CI) was developed using a cerebral perfusion G-LOC model and SpO₂ and task performance data during hypoxia exposures. A Summary State (SS) index fuses vital signs to estimate overall status. CI and SS have 5-pt. scales (5=max degradation). A G-fatigue (G-F) index uses PR and G-dose to estimate capacity with a 100% (no fatigue) to 0% scale. NAMRU-D conducted a study at KBR's Brooks City-Base, TX human centrifuge (HC) and altitude chamber (AC) with exposures on different days. Eight consented subjects breathed 95% O₂ while exposed to three simulated aerial combat maneuvers (SACM) with multiple 6G/s transitions (+7.5Gz max). A minimum 2min rest separated runs. Runs were halted when subjects' peripheral vision dropped to 60%. Subjects wore an anti-G suit and performed anti-G straining maneuvers. During AC hypobaric exposure, 6 of the subjects breathed air while exposed to 20 min at

2450m, then 30 min at 5350m at an ascent rate of 1,524 m/min.

Subjects pulled a simulated "green ring" (GR) when they felt they would initiate in-flight emergency procedures, then received 100% O₂.

RESULTS: One subject (Sa) demonstrated higher hypoxia tolerance than the others, withstanding 1140s at 5350m compared to 320±109s for the rest. % time Sa's SS and CI≥4 was 18% and 2% at 5350m, respectively, compared to SS for 53±19% and CI for 7±15% of the plateau for the others. Six subjects pulled the GR when SpO₂ dropped by 23±6% from ground values. To judge if Sa's higher hypoxia tolerance extended to G-exposures, we highlight responses to the strenuous second SACM, which had four ≥+6.5Gz peaks. Sa's G-F fell to 76% compared to 25±4% and took 135s compared to 158±14s to recover to 90% post exposure. Sa's SS≥4 was 87% and CI≥4 for 20% of the SACM as compared to SS≥4=82±12% and CI≥4=35±4% for the rest. **DISCUSSION:** While the small number of datasets limits generalization, the fact that Sa exhibited the greatest hypoxia tolerance and lower persistence of high SS and CI values and also had the lowest G-F demonstrates the indices' potential to be sensitive to tolerance differences to both stressors.

Learning Objectives

1. To understand how the HMAPS system detects increasing physiological and cognitive stress relevant to fast jet high +Gz and hypobaric exposures.
2. To determine if tolerance to hypoxic hypoxia stress can provide insight into acceleration tolerance.

[273] COMPARISON OF TRANSCUTANEOUS AND END-TIDAL CO₂ MEASUREMENTS IN AEROSPACE ENVIRONMENTSBarbara Shykoff¹, Lesley Lee¹, Dan Warkander¹, F. Eric Robinson¹, Megan Gallo¹, Cheryl Griswold¹¹Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA*(Original Research)*

INTRODUCTION: Transcutaneous measurement of carbon dioxide partial pressure (tcPCO₂) has been suggested to monitor changes in arterial CO₂ in tactical jet aircrew. In some hospital settings, tcPCO₂ is a good measure of arterial PCO₂ (P_aCO₂). In this IRB-approved study, Naval Aerospace Medical Research Laboratory, funded by Naval Medical Research Center, investigated its applicability under conditions reflective of the environment in the jet. End-tidal PCO₂ (P_{ET}CO₂) was also measured. The correspondence of the two CO₂ measurements was analyzed, and the physiological bases of both methods were considered. **METHODS:** End-tidal PCO₂ (P_{ET}CO₂) and tcPCO₂ were measured simultaneously in healthy volunteers during breathing of 100% O₂ ("hyperoxia") or 11.5% O₂ ("hypoxia") in our laboratory, elevation approximately 900 ft. Participants gave written confirmation of informed consent. Data were gathered during spontaneous breathing at rest, while CO₂ balance was disturbed by imposed hyperventilation and induced CO₂ retention, during skin heating and cooling at rest, and with whole body exercise. Transcutaneous and end tidal oxygen partial pressures, and skin temperature near but not under the heated tcPCO₂ probe were also recorded. Seated rest with 21% O₂ (normoxia) and 35% O₂ and cycling exercise with 40% O₂ supplied were also examined. Analysis was by correlation, Bland-Altman plots, and multiple linear regression. **RESULTS:** Only during normoxic or nearly-normoxic resting measurements were tcPCO₂ and P_{ET}CO₂ equivalent; we did not test during normoxic exercise. Regression analysis indicated that transcutaneous oxygen partial pressure is an important explanatory variable for tcPCO₂ and that local skin temperature also has an effect. Both hyperoxia and hypoxia disrupt the relationship between tcPCO₂ and P_aCO₂. Hyperoxia during rest and hypoxia during exercise also cause P_{ET}CO₂ to deviate from P_aCO₂. **CONCLUSIONS:** In the tactical jet aircraft environment, tcPCO₂ is not useful as even a trend indicator for arterial PCO₂. P_{ET}CO₂ is also not a good indicator of CO₂ status in pilots who breathe nearly 100% O₂.

Learning Objectives

1. Understand the conditions under which tcPCO₂ and PETCO₂ can represent arterial PCO₂.
2. Become familiar with methods to determine correspondence, therefore equivalence, of two measurement techniques.

[274] OCCURRENCE OF HEART ARRHYTHMIAS DURING MILD NORMOBARIC HYPOXIA INDUCTION AND LABORATORY TASK/ FLIGHT SIMULATION PERFORMANCE

Chad Stephens¹, Juan Beltran², Kellie Kennedy¹, Nicholas Napoli²
¹NASA Langley Research Center, Hampton, VA, USA; ²University of FL, Gainesville, FL, USA

(Original Research)

INTRODUCTION: Aviator medical certification involves assessment of medical standards by an Aviation Medical Examiner (AME). To qualify for a first-class medical certificate, cardiovascular health of a pilot is assessed via electrocardiogram (ECG) allowing the AME to detect abnormalities/pathology (e.g., heart arrhythmias). Certification standards are in place to ensure aviators are medically fit for duty and serve as a risk mitigation in the event of adverse conditions (e.g., hypoxia due to aircraft cabin decompression). The occurrence of physiological events (PEs), of which hypoxia is one potential contributing factor, in U.S. military aviators underscores the need for medical certification. Understanding effects of workload inducing tasks during physiological stressors on cardiac function informs aviator medical assessment. **METHODS:** Professional pilots served as test subjects (n=57) in a study involving simulated altitudes of sea level (21.0% O₂) and 15,000 feet (11.2% O₂) induced by an Environics, Inc. ROBD. Each subject experienced non-hypoxic and hypoxic exposures while performing three tasks (computerized neuropsychology tests-CFT/CS, computerized multi-tasking battery-MATB, and fixed-based flight simulation-SIM) each 10-minutes in duration. Physiological data (ECG, PPG, and SPO₂) were recorded and temporally synchronized to permit data analysis. The ECG and PPG signals were visually inspected to identify PVCs in accordance with identification methods accepted in the medical research literature to obtain PVC counts. **RESULTS:** Odds ratios were calculated to examine the association between stimulus task and the occurrence of PVCs during hypoxia induction. The odds of PVCs during SIM was estimated to be 6.81 times the odds of PVCs during CFT/CS. The odds of PVCs during SIM was estimated to be 3.18 times the odds of PVCs during MATB. The odds of PVCs during MATB was estimated to be 2.42 times the odds of PVCs during CFT/CS. The 95% CIs are between 0.98 and 22.22, 0.83 and 12.16, and 0.46 and 12.79 respectively. **DISCUSSION:** The occurrence of PVCs during hypoxia induction had a stronger association with the SIM task than with the MATB or CFT/CS. The results indicate that workload induced by stimulus tasks influences the occurrence of PVCs. Considerations for the compounding effects of workload and physiological stressors underscores the necessity of screening for abnormalities/pathology during aviator medical certification as a mitigation against PEs.

Learning Objectives

1. Understand fundamentals of human factors related to hypoxia exposure in aviation contexts.
2. Discover how mild hypoxia exposure can impact operator performance in aviation contexts.

Wednesday, 09/01/2021
 Plaza A/B

2:00 PM

[S-54]: PANEL: OPERATIONAL CONSIDERATIONS FOR DEATH IN SPACE

Chair: Robert Patlach

Co-Chair: Philip Stepaniak

Panel Overview: BACKGROUND: This panel will discuss the operational considerations of a death in space. **OVERVIEW:** The tempo of flying in space is increasing, especially with the ongoing development of new proposed NASA space programs working in participation with its international partners and commercial vendors involved in human space travel. Mishaps have occurred during launches and landings and to date no catastrophic mishaps or death in space has occurred; nonetheless, the possibility certainly exists. The motion picture industry has somewhat trivialized this event on the big screen, however in reality there are many challenges, impacts and workarounds should a death occur. The goal of this panel is to highlight and outline the multiple operational considerations in responding to a death in space. **DISCUSSION:** This panel will

present the background, historical aspects, and potential mortality risks while on-orbit; a concept of operations timeline including pronouncement, forensic sampling, preparation of remains, and options for storage. Interim events discussed will include behavioral health, crew and family issues with cultural concerns. Other considerations discussed will be future low earth orbit, lunar, Mars and deep space programs.

[275] OPERATIONAL CONSIDERATIONS FOR DEATH IN SPACE: HISTORICAL BACKGROUND, ASPECTS, AND RISKS OF SPACEFLIGHT

Natacha Chough¹, Philip Stepaniak², Kathleen McMonigal², Michael Barratt², Kjell Lindgren², Edward Mazuchowski³, Ann Tsung¹, Travis Houser⁸, Steven Uhl⁹, Robert Patlach⁴, Michael Misiora²

¹University of Texas Medical Branch, Galveston, TX, USA; ²NASA-Johnson Space Center, Houston, TX, USA; ³Joint Base, San Antonio, TX, USA; ⁴KBR, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Human spaceflight presents a challenging and unique environment that comes with inherent risks, some of which can be fatal. Resources for handling in-flight fatalities are limited, leading to reduced capabilities for proper post-mortem forensics and respectful disposal of human remains. The following review of relevant human spaceflight contingency plans, spaceflight close calls, and challenges of working in microgravity serves to highlight both improvements needed to historic in-flight loss-of-crew contingency procedures, and the operational challenges of working in this remote clinical setting in preparation for exploration class missions. **OVERVIEW:** Previous US human spaceflight contingency plans, in-flight close calls, and medical challenges of working in microgravity will be discussed. A review of internal NASA documentation for Apollo and Skylab Medical Operations Projects was conducted. Search terms included "fatal," "death," "contingency," "procedure," and "loss of crew." Additionally, the ISS Health Maintenance System team was surveyed to solicit the most prominent physical and environmental challenges encountered during medical operations of the Space Shuttle and ISS Programs, in order to highlight existing gaps to address when planning future missions. **DISCUSSION:** The risks of human spaceflight underscore the potential for fatal events in an austere environment, which in turn present a unique set of challenges for health care providers and their surrogates working with limited resources when addressing the in-flight death of a crewmember. The evidence presented demonstrates the scope of considerations required, while simultaneously identifying continued operational gaps and updates to medical forensic needs for future spaceflight expeditions. These recommendations may also have cross-applicability for certain military and international environments.

Learning Objectives

1. The audience will become familiar with historic risks of human spaceflight.
2. The audience will become familiar with challenges of performing medical procedures in microgravity.
3. The audience will become familiar with current procedures in place for death on-orbit.

[276] TIMELINE OVERVIEW: PROCEDURAL APPROACH TO MANAGING INFLIGHT FATALITY

Michael Barratt¹, Kjell Lindgren¹, Phillip Stepaniak¹, Kathleen McMonigal¹, Gary Beven¹, Edward Mazuchowski², Travis Hauser¹, Steven Uhl¹, Michael Misiora¹, Lorraine Benavides-Gibson¹, Robert Patlach¹

¹NASA Johnson Space Center, Houston, TX, USA; ²US Air Force, San Antonio, USA

(Education - Program / Process Review)

BACKGROUND: A fatality onboard a spacecraft or space station, similar to that in analogous hazardous venues such as polar or other remote field stations, represents a tragic and highly disruptive event. Lack of preparedness for such an event can render a situation worse as stakeholders

formulate real-time responses and actions. The resulting disruption can be mitigated by executing a coherent plan with procedural steps available to both crewmembers and ground support personnel. **OVERVIEW:** A plan has been developed for the International Space Station (ISS) that prepares both onboard crewmembers and ground personnel to respond to an onboard fatality that does not prompt station evacuation. ISS capabilities support ample real-time audio and video channels which can be privatized, as well as sufficient volume that allows private spaces to perform post mortem actions. The plan developed for ISS involves onboard procedures and specialized hardware available to crewmembers, procedures and communication protocols for flight control team members, and actions for other stake holders that ensure a ready and timely response. Just as in ground fatalities, certain actions are time and sequence sensitive. Onboard ISS procedures will guide crewmembers through the steps of pronouncement of death, forensic sampling, final preparation of remains, and short-term storage. These steps are performed in the first 12 hours. Eventual long-term disposition may include onboard storage and/or return to Earth. All steps and procedures must be precise, validated, and well documented during execution yet performed in a dignified manner.

DISCUSSION: The new ISS plan for management of an onboard fatality ensures a mature and orderly response to a tragic event. It is understood that circumstances surrounding an onboard fatality, such as station damage or contamination, may significantly complicate such a scenario. A ready-made sequence of procedures forms the core of such a response to minimize real-time deliberation. As for other emergency response plans, this implies training of crew and flight control team and exercising elements of these procedures. Other space platforms will require similar plans customized to vehicle specific risk scenarios and resources.

Learning Objectives

1. The audience will become familiar with the sequence of events and support elements required to respond to death on-orbit for the International Space Station.
2. The audience will understand the core components of responding to a fatality during spaceflight and how this must be customized to each spacecraft's environment and operating conditions.

[277] OPERATIONAL CONSIDERATIONS FOR DEATH IN SPACE: FORENSIC PATHOLOGY INVESTIGATIONS

Edward Mazuchowski¹, Philip Stepaniak², Kathleen MdMonigal², Joan Bytheway³, Kjell Lindgren², Ann Tsung⁴, Travis Houser⁵, Steven Uhl⁵, Rachel Richardson⁵, Lorraine Benavides Gibson⁵, Michael Misiora⁵

¹Defense Health Agency, Joint Trauma System/Armed Forces Medical Examiner Systm, JBSA Fort Sam Houston, TX, USA; ²NASA-Johnson Space Center, Houston, TX, USA; ³Sam Houston State, Huntsville, TX, USA; ⁴University of Texas Medical Branch, Galveston, TX, USA; ⁵KBR, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: When a death is sudden, unexpected, and/or violent, a forensic pathology investigation is conducted. Space presents a challenging environment for the completion of this investigation. This presentation will discuss how the standard forensic pathology protocol must be modified in order to conduct an accurate, timely, and thorough investigation in space. **OVERVIEW:** Forensic pathology investigations were conducted on the individuals that died during previous spaceflight mishaps. These investigations followed standard forensic pathology protocols that are used during aviation mishaps. Forensic pathologists were able to examine the individual's remains soon after death and determine the cause of death in each instance. The cause of death is the injury or disease that creates a physiologic derangement that leads to death. In previous mishaps, the cause of death was an injury. In current and future spaceflight operations, an individual may die from an injury or a disease. Additionally, the forensic pathologist will most likely not be able to examine the remains soon after death, if it at all. Thus, procedures for documentation of the remains and collection of samples in the weightless space environment have been developed. **DISCUSSION:** Comprehensive forensic pathology investigations are necessary to determine the cause of death and to provide information to prevent future fatalities. Spaceflight operations leadership and flight surgeons must be familiar with the unique procedures necessary to conduct a forensic pathology investigation in the space environment.

Learning Objectives

1. The audience will become familiar with the procedures necessary to complete a comprehensive forensic pathology investigation for a death in space.
2. The participant will be able to describe the challenges that space presents when an individual dies.

[278] OPERATIONAL CONSIDERATIONS FOR DEATH IN SPACE: BEHAVIORAL HEALTH AND PERFORMANCE ASPECTS

Gary Beven¹, Albert Holland¹, James Picano¹, Rachel Passmore², Ronald Moomaw², Jacqueline Reese³

¹NASA Johnson Space Center, Houston, TX, USA; ²UTMB/NASA Johnson Space Center, Houston, TX, USA; ³KBR/NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Human spaceflight presents a hazardous environment that contains inherent risks, some of which can be fatal. To date, there has not been an inflight mission fatality with surviving crew members. Such an event would necessitate the crew act as first responders, declare death, complete forensic sampling, consider options for remains disposition, honor the fallen colleague, grieve at a distance alongside family and friends, and safely continue the mission. If it were to occur, a death during a mission and the actions that the surviving crew take afterward will present significant behavioral health and performance challenges. **OVERVIEW:** The death of a crewmember during a space mission will present unique challenges. These include the necessity of responding to the tragedy in a manner that allows for preservation of forensic samples and addresses pragmatic operational issues including remains disposition and crew duty replacement. These actions will require the suppression of grief in order to function dispassionately; however, natural human mourning and grief will occur and must be addressed in order to carry on mission duties safely. Such an event will also affect the entire spaceflight community including crew, mission control, family, friends, governmental and private spaceflight organizations, and countries of crew origin. This will require an effective and organized response that addresses behavioral health and performance elements as well as operational exigencies. **DISCUSSION:** The NASA Johnson Space Center's Behavioral Health and Performance Operations Group alongside the JSC Employee Assistance Program would respond immediately to a death in space event. Aspects of response would include: consultation with crew surgeons, flight directors and management; private psychological conferences with the mission commander and crew medical officer as well as all other crew members; consultation with NASA Astronaut Office family support providers; engagement with family members; initiation of center-wide Employee Assistance Program crisis response; consultation with International Partners; enabling virtual crew participation in funeral and memorial services; and facilitating grief during the remainder of the mission as well as post-mission. This presentation will provide a notional template of such a response for consideration by other space agencies and programs to utilize as well as discuss relevant lessons learned from the Columbia mishap.

Learning Objectives

1. The audience will become familiar with the predicted behavioral health and performance aspects of crew death in space, including the common stages of grief expected in a spaceflight crew.
2. The audience will become familiar with the predicted behavioral health and performance aspects of crew death in space, including recommendations for a response to such an event.

[279] DEATH IN SPACE PROTOCOL CONSIDERATIONS: ISS, GATEWAY, ORION, LUNAR, MARS AND BEYOND

Ann Tsung¹

¹UTMB, Galveston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Despite the low probability of crewmember death in space, a body bag is on the International Space Stations (ISS) for contingency purposes. The body can be stored and returned in a visiting crew or cargo spacecraft depending on the circumstances. Gateway,

Orion, Lunar, and Mars programs are the missions of the future. Specific contingency protocols should be established as the risk of death will rise with increasing number of missions. **OVERVIEW:** Aspects to be examined include mission length, mission profile, number of crewmembers, vehicle specifications, volume, mass, and time constraints. Also included are medicolegal jurisdiction, forensic sampling capabilities, body bag specifications, options for body disposition, cultural and religious customs, and behavioral health of the living crew. Spacecraft mass and volume constraints will determine if a forensic sampling kit and body bag will be present. For long-duration missions, the durability of the body bag is unknown. Current law does not define medicolegal jurisdiction if death occurs in space, or the party responsible for the death certificate. Body disposition options include re-entry cremation in an expendable vehicle, return in a crewed or reusable vehicle, jettison into space, tethered external vehicle placement, burial on the planetary surface, and perhaps in distant future, human composting in a colony ship greenhouse.

DISCUSSION: The time to construct a protocol for each mission and vehicle has come as the programs are ramping up. Having a systemized process will optimize the behavioral health of the living crew and ground personnel during a very traumatic situation. Procedural validation of the protocols will be vital. An integrated approach to protocol creation should be taken with the engineers, crew surgeons, crewmembers, behavioral health practitioners, and legal representatives. Ultimately, the preparedness will ensure the best chance of a successful mission and lay the groundwork for future commercial space participants.

Learning Objectives

1. Describe various aspects that play a role in developing a death in space protocol.
2. To understand various body disposition possibilities in space by taking multiple factors into consideration.

Wednesday, 09/01/2021
Plaza D/E

2:00 PM

[S-55]: PANEL: OPTIMIZING AIRCREW SCREENING AND SELECTION THROUGH NON-INVASIVE METHODS OF CARDIAC SCREENING - GREAT DEBATES IN AEROSPACE CARDIOLOGY

Chair: Eddie Davenport

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 nuclear 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 three areas of cardiovascular screening; ECG, Echocardiogram; and stress testing. 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 a time for rebuttal. After all presentations, the co-chairs will announce a winner! 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.

[280] AIRCREW SCREENING WITH ECG

Rienk Rienks¹, Norbert Guettler², Eddie Davenport³, Thomas Syburra⁴, Olivier Manen⁵, Ed Nicol⁶, Jo D'Arcy⁶, Denis Bron⁷
¹Central Military Hospital, Utrecht, Netherlands; ²German Air Force, Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; ³USAF School of Aerospace Medicine, Aeromedical Consult Service, Dayton, OH, USA; ⁴Luzerner Kantonsspital, Heart Center, Lucerne, Switzerland; ⁵French Military Health Service, Clamart, France; ⁶Clinical Aviation Medicine Service RAF, Henlow, United Kingdom; ⁷Fliegerärztliches Institut FAI, Dübendorf, Switzerland

(Education - Program / Process Review)

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 non-invasive, simple, rapid, reproducible, cheap and reliable way to look for cardiac diseases that carry the risk of life-threatening arrhythmias. These include channelopathies (long QT and Brugada syndromes), cardiomyopathies (hypertrophic and dilated cardiomyopathy, arrhythmogenic (right) ventricular cardiomyopathy, A(R) VC) and conduction abnormalities (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 silent myocardial infarction. ECGs may also contribute to risk stratification (left ventricular hypertrophy, presence of frequent and/or 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 these arrhythmias, and thus a screening 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 Objectives

1. the participants will learn about the diagnostic value of the electrocardiogram in the diagnosis of cardiovascular disease, especially for the diagnosis of diseases that carry the risk of life-threatening arrhythmias
2. the participants will learn about the applicability and the pitfalls of the use of an electrocardiogram in screening aircrew for cardiovascular disease

[281] ROUTINE ECG SCREENING FOR AIRCREW - CON

NORBERT GUETTLER¹, Rienk Rienks², Edward Nicol³, Thomas Syburra⁴, Denis Bron⁵, Olivier Manen⁶, Eddie Davenport⁷, Joanna d'Arcy³

¹Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck, Germany;

²University Medical Center and Central Military Hospital, Utrecht,

Netherlands; ³RAF Centre of Aviation Medicine, Henlow, United Kingdom;

⁴Luzerner Kantonsspital, Luzern, Switzerland; ⁵Aeromedical Centre,

Dübendorf, Zuerich, Switzerland; ⁶Aviation Medicine Department, Percy

Military Hospital, Clamart, France; ⁷U.S. Air Force School of Aerospace Medicine, Dayton, OH, USA

(Education - Program / Process Review)

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 concentrates on the detection of signs for 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. 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 35th birthday, on an annual basis after reaching the 40th 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, and 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 and then at the first examination after age 50, and every 2 years thereafter. **DISCUSSION:** There have been reports of considerable interobserver variability between physicians 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 of the screening by suggested follow-up investigations. Labeling individuals with an uncertain diagnosis 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. Only a small minority of individuals had findings that should be considered for further investigation; changes in the same individual over time were rare. Standardized ECG criteria are needed.

Learning Objectives

1. Be aware that there is a debate as to what age and how often a resting ECG should be carried out for screening without a specific clinical indication.
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.

[282] THE USE OF ECHOCARDIOGRAPHIC SCREENING FOR OPTIMISING RISK STRATIFICATION IN AIRCREW – WORTH IT EVERY TIME!

Joanna d'Arcy¹, Thomas Syburra², Eddie Davenport³, Edward Nicol¹, Norbert Guettler⁴, Olivier Manen⁵, Rienk Rienks⁶, Denis Bron⁷

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(Education - Program / Process Review)

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. Delegates will be able 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.

[283] ECHOCARDIOGRAPHIC SCREENING FOR AIRCREW - HOW DARE YOU

Thomas Syburra¹, Eddie Davenport², Norbert Guettler³, Gary Gray⁴, Denis Bron⁵, Olivier Manen⁶, Rienk Rienks⁷, Jo d'Arcy⁸
¹Swiss Air Force, Lucerne & Dübendorf, Switzerland; ²US Air Force, Centerville, OH, USA; ³German Air Force, Fuerstenfeldbruck, Germany; ⁴Canadian Air Force, Toronto, Canada; ⁵Swiss Air Force, Dübendorf, Switzerland; ⁶French Air Force, Paris, France; ⁷Royal Netherlands Air Force, Amsterdam, Netherlands; ⁸Royal Air Force, Oxford, United Kingdom

(Education - Program / Process Review)

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 Objectives

1. The audience will get a deeper insight in the characteristics of screening tests according to the 2019 WHO definition.
2. The audience will be able to understand why echocardiographic screening for aircrew is a waste of resources.

[284] EXERCISE STRESS TEST AND CALCIUM SCORING IS ALL THAT IS NEEDED FOR CV RISK ASSESSMENT IN AIRCREW

Joanna d'Arcy¹, Edward Nicol¹, Eddie Davenport², Thomas Syburra³, Norbert Guettler³, Olivier Manen⁵, Rienk Rienks⁶, Denis Bron⁷

¹Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom; ²USAF School of Aerospace Medicine, Dayton, OH, USA; ³Luzerner Kantonsspital, Lucerne, Switzerland; ⁴Zentrum für Luft- und Raumfahrtmedizin der Luftwaffe, Fürstentfeldbruck, Germany; ⁵Percy Military Hospital, Clamart, France; ⁶Central Military Hospital, Utrecht, Netherlands; ⁷Aeromedical Institute of the Swiss Air Force, Dübendorf, Switzerland

(Education - Program / Process Review)

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 are low, mainly due to the exclusion of those with abnormal family history, resting ECG, mild symptoms or abnormal exercise ECG. Evidence would suggest that the current strategy of cardiovascular risk assessment is adequate to maintain flight safety. **OVERVIEW:** Exercise stress testing (ExECG) 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 ExECG 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 ExECG 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 (ExECG) 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 ExECG for cardiovascular risk assessment.

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

Eddie Davenport¹, Joanna d'Arcy², Rienk Rienks³, Norbert Guettler⁴, Oliver Manen⁵, Thomas Syburra⁶, Dennis Bron⁷, Edward Nicol²

¹USAF School of Aerospace Medicine, Aeromedical Consult Service, Wright-Patterson AFB, OH, USA; ²Royal Air Force, Henlow, United Kingdom; ³Netherlands, Utrecht, Netherlands; ⁴German Air Force, Fuerstenfeldbruck, Germany; ⁵French Air Force, Clamart, Ile-de-France, France; ⁶Switzerland Air Force, Luzern, Switzerland; ⁷Switzerland Air Force, Dubendorf, Zurich, Switzerland

(Education - Program / Process Review)

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 symptoms of severe CVD is sudden cardiac death and thus coronary artery disease is a leading cause of disqualification or denial of licensure in both civilian and military pilots. Optimal screening for CVD 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 CAD 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.

Wednesday, 09/01/2021

2:00 PM

Plaza F

[S-56]: PANEL: SAFETY CENTERS YEAR-IN-REVIEW

Chair: Tyler Brooks

Panel Overview: This panel presents a review of recent aerospace safety data. Representatives from military and civil aerospace organizations will present summaries and analyses of recently collected safety data. Topics may include: cause factors including mechanical and human factors, identifiable safety trends, and updates on mitigation strategies for current risks. With certain types of accidents becoming rare events, the panel discussion is a unique opportunity to review the collective experiences of multiple safety programs and consider a variety of risk mitigation solutions.

[286] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEARS IN REVIEW 2019-2020

Ajiri Ikede¹

¹Directorate of Flight Safety, Ottawa, Ontario, Canada

(Education - Program / Process Review)

MOTIVATION: The Commander of the Royal Canadian Air Force (RCAF) is appointed as the Airworthiness Authority for all aviation in the Canadian Armed Forces (CAF). The Director of Flight Safety (DFS) is appointed as the Airworthiness Investigative Authority for all flight safety occurrences with the goal of preventing accidental loss of aircraft and personnel. Contributory or causal human factors are identified using the Canadian Forces Human Factors Analysis and Classification System (CF-HFACS). Statistics and analysis from 2019 are discussed. **OVERVIEW:** Accidents and incidents from 2019-2020 were reviewed to identify human factors which may have caused or contributed to these occurrences. More specifically, the legalization of marijuana in Canada in 2018 has not adversely affected flight safety in the RCAF. **SIGNIFICANCE:** Fatigue, culture and substances hazardous to aviation continue to be relevant hazards in the RCAF. DFS has helped to propel several risk mitigation initiatives specifically aimed these factors, including the implementation of the RCAF Fatigue Risk Management System.

Learning Objectives

1. Understand the overall trends in RCAF flight occurrences from 2019-2020.
2. Understand the effectiveness of having a clear CAF policy on marijuana.

[287] TRANSPORT CANADA: YEAR-IN-REVIEW

Tyler Brooks¹

¹Transport Canada, Ottawa, Ontario, Canada

(Education - Program / Process Review)

BACKGROUND: Transport Canada is the federal regulator responsible for policies and programs which promote safe, secure, efficient, and environmentally responsible transportation in Canada. This presentation will familiarize participants with the mission of the Civil Aviation Medicine (CAM) Branch of Transport Canada and highlight recent topics of interest. **OVERVIEW:** The mission of the CAM Branch of Transport Canada is to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and safety in the field of aviation, and to prevent aircraft accidents due to medically related human factors. The CAM Branch will present an overview of notable civil aviation medically related issues recently

encountered. **DISCUSSION:** Aviation medicine practices and policy respond not only to changes in medicine, but also to changes in society and politics. The CAM Branch of Transport Canada shares its experience responding to a variety of issues since the last report.

Learning Objectives

1. The participant will be able to understand the mission of the Civil Aviation Medicine Branch of Transport Canada.
2. The audience will learn about Transport Canada's approach to managing specific risks related to aerospace medicine.

[288] U.S. ARMY AVIATION SAFETY: FY 2020 YEAR IN REVIEW

Eric Olins¹, Robert Dickinson¹

¹U.S. Army Combat Readiness Center, Fort Rucker, AL, USA

(Education - Program / Process Review)

BACKGROUND: The FY2020 data was obtained from the USA Combat Readiness Center's database, Army Safety Management Information System (ASMIS), for Class A thru C manned aviation mishaps and reviewed for human factors as determined by the accident investigation boards.

OVERVIEW: In the manned aircraft category, Army aviation experienced 46 Class A - C manned aircraft flight mishaps in FY20. This was a decrease of 8% from the 50 Class A-C flight mishaps reported in FY19. The U.S. Army experienced five Class A manned aviation flight mishaps during FY20, 50% below the 10 flight mishaps reported for FY19. The accident rate for Class A flight mishaps (per 100,000 flying hours) was 0.65 in FY20, a 43% decrease from the 1.15 Class A rate recorded in FY19. FY20 was the lowest Class A manned aviation Class A flight mishap rate on record. There were seven aviation mishap fatalities in FY20 compared to three in FY19. Three (50%) of the five Class A flight mishaps occurred at night, two involved controlled flight into terrain (CFIT), one under day conditions and one at night under low illumination. Human error remains the primary cause in manned aircraft mishaps. In FY20, 29 (85%) of the 46 Class A-C flight mishaps were attributed to human error. Most performance-based errors (active failures or actions) in the mishaps included a breakdown in the visual scan resulting in a terrain strike and a ground taxiing blade strike, inadequate real time risk assessment associated with an aggressive flight maneuver, and procedures not followed correctly during an in-flight emergency and an emergency procedure training maneuver. Latent failures or conditions included environmental conditions affecting vision (dust landings, low illumination) overconfidence, complacency, pressing and task oversaturation. Teamwork failures included critical information not communicated and failure to effectively communicate. **DISCUSSION:** Human error was the primary cause in all five of the Class A flight mishaps. The FY20 Class A flight mishap rate of 0.65 was 32% below the five-year rate of 0.95 mishaps per 100,000 flight hours. Hours flown in FY20 were 11% less than hours flown in FY19. Accident investigation boards provide recommended changes to policies, procedures and equipment to prevent future mishaps, improve aviation safety and decrease the annual mishap rate.

Learning Objectives

1. Review the overall trend in U.S. Army manned aviation flight mishaps and the most common identified causal factors.
2. Understand how human factors influenced the U.S. Army's manned aviation flight mishaps.

[289] IMPACT OF THE COVID-19 PANDEMIC ON U.S. CIVIL AVIATION IN 2020

Stacey Zinke-McKee¹

¹University of Oklahoma, Norman, OK, USA

(Original Research)

INTRODUCTION: Trends in accident rates and performance data were analyzed for all types of civil aviation operations with emphasis on 2019 and 2020 data. **METHODS:** U.S. civil aviation accident data was analyzed to determine trends from 1990 to 2020; and the impact of the COVID-19 pandemic during 2020, whereas, safety performance measures were analyzed for various time periods, depending on available data. **RESULTS:** Fatal accident rates for all types of operations, except commuter airlines, significantly decreased for the period 1990 to 2020 ($p < 0.05$). During the same period, air carrier ($p < 0.001$), air taxi ($p < 0.05$), and general aviation

($p < 0.01$) non-fatal accident rates decreased more rapidly than their respective fatal accident rates. The general aviation fatal accident rates (1.03, 0.91, and 0.84 per 100,000 hours) were below the target rates (1.04, 1.02, and 1.01 per 100,000 hours) for 2015 through 2017. Actual safety performance measure rates were all below their respective target rates for 2017. **CONCLUSION:** An analysis of accident rates between 1990 and 2020 and trends in safety performance measures for all types of operations indicated steady improvements in civil aviation safety, with a significant impact from the COVID-19 pandemic during 2020.

Learning Objectives

1. The participant will be able to identify and describe the trends in fatalities in US Civil Aviation Safety from 1990 through 2020.
2. The participant will be able to identify and describe the impact of the COVID-19 pandemic on fatalities in US Civil Aviation Safety during 2020.

[290] NASA 2020 YEAR IN REVIEW

Tracy Dillinger¹

¹NASA, Washington, DC, USA

(Education - Program / Process Review)

INTRODUCTION: This presentation provides information regarding NASA reportable mishaps, close calls, and hi-visibility events during the year 2020. In addition to occurrence data, human factors and mishap prevention information is also provided. The focus will be on current data, analysis, and trends based on 2020 data. **METHODS:** NASA collects Class A, B, C, and D mishap information as well as close calls and hi-visibility events in an investigation database called NMIS – NASA Mishap Investigation System. NMIS data, along with human factors (HF) data from the NASA Safety Center (NSC) database is annually analyzed and reported. This includes analysis and trending by year, aircraft, and other various factors. Data from 2020 will be used to show current events and trending, including NASAHFACS analysis of human factors data. **RESULTS:** NASA continues to experience low occurrences of reportable events including low aviation mishap rates. Efforts to maintain vigilance and instill a strong prevention-focused safety culture are an important part of NASA Safety program. **DISCUSSION:** Analysis of NMIS data and safety prevention efforts indicates steady improvements in all safety -- including aviation. Efforts to delve further in human factors seek to maintain advancements, continually improve future mishap reduction efforts, and see further decline in preventable mishaps.

Learning Objectives

1. The audience will learn about the mishap reporting system used by NASA and recent trends in aviation.
2. The audience will learn about human factors in NASA events as reported in the NMIS system.

[291] NAVAL AVIATION SAFETY: 2019-2020 YEAR IN REVIEW

Robert Krause¹, Paul Demieri¹, Dan Immecker¹, Robert Miranda¹

¹Naval Safety Center, Norfolk, VA, USA

(Education - Program / Process Review)

The Naval Safety Center analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors. **OVERVIEW / METHODS:** All Class A flight mishaps involving US Navy and Marine Corps aircraft during fiscal year 2019-2020 (FY19-20) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 19-20 there were multiple Class A Flight mishaps in the U.S. Navy and US Marine Corps. A review of Class A flight mishaps over the past 10 years demonstrated that human factors were the predominant causal factors. A review of current Physiological Episodes in Naval Aviation will also be presented.

Learning Objectives

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

[292] SAFETY CENTERS: YEAR-IN-REVIEW

Geoffrey Ewing¹, Michael Luby¹, Nancy DeLaney¹, Michael Armstrong¹

¹USAF, Albuquerque, NM, USA

(Original Research)

INTRODUCTION: The Air Force Safety Human Factors Division supports commanders and safety professionals Air Force wide by applying human factors (HF) expertise to identify, anticipate, analyze, manage and prevent human factors risk in Air Force operations and safety culture. **METHODS:** The Human Factors Division analyzed All Class A mishaps, manned/unmanned aviation mishaps, fatalities, CFIT/GLOC events, and the predominate HFACS codes found in the 2020 mishaps. **RESULTS:** Overall USAF mishap trends were mixed in 2020. HFACS code rates stayed relatively consistent. **DISCUSSION:** HF continues to contribute significantly to aviation mishaps. Gaps in analysis, communication, and application of HF recommendations are the horizon to further impact mishap rates through HF mishap findings.

Learning Objectives

1. Review the overall trends in US Air Force flight mishaps.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for USAF US Air Force mishaps.
3. Understand limitations and recommendations to improve translation of HF mishap recommendations to behavior change that reduces mishap frequency and severity.

Wednesday, 09/01/2021

2:00 PM

Governor's Square 12

**[S-57]: PANEL: USAF'S NEW TOTAL FORCE
ACCESSION MEDICAL WAIVER DIVISION:
INTEGRATED, EVIDENCE-BASED, RESEARCH
FOCUSED**

Chair: Maria Angles

Co-Chair: Richard Speakman

Panel Overview: Up until 2019, the US Air Force (AF) brought in new recruits through many different accession sources and with different medical waiver authorities. This led to variation in waiver decisions that became highlighted as "inconsistent." The Vice Chief of Staff of the AF (VCSAF) mandated establishment of an Accession Medical Waiver Cell through which all new accessions to all components of the AF (Active Duty, Reserves, Air National Guard, USAF Academy) would pass. His direction to the Air Education and Training Command (AETC) Commander was for this "cell" to align under AF Recruiting Service and "to facilitate process improvement, standardization and programs efficiencies." This panel will explore and elucidate the newest Department of Defense (DOD) & USAF regulatory guidance on entrance and duty specific medical conditions (AFMAN48-123), and the current mission, structure and status of the new "cell". Then, members from the new "Medical Waiver Division" will discuss the overall accessions process and the purpose of military entrance medical standards. Actual data from the recent years of decisions will be presented with waiver rates and other metrics related to deployability of the force. The team will also present current AF processes for initial flying and special operational duty clearance examinations with further detail on USAF Flying Class I Pilot outcome data. Similar diagnostic analysis for waived conditions and rates will be presented. The panel will conclude with the Division's future initiatives in driving towards more precision decisions.

[293] NOBODY READS ANY MORE! THE NEW USAF MEDICAL STANDARDS BIBLE

Richard Speakman¹

¹USAF Air Force Medical Readiness Agency, DHHQ, VA, USA

(Education - Program / Process Review)

BACKGROUND: Medical standards have been a cornerstone of aerospace medicine since 1918. The US Department of Defense (DoD)

updated its accession medical standard publication and added a second volume addressing retention standards. Additionally, US Air Force (USAF) updated its instruction on medical standards, Air Force Manual 48-123.

OVERVIEW: AFMAN 48-123 outlines the authority, creation, and application of medical standards for accession, retention and flying/special duty exams for the USAF. The accession and retention medical standards start with DoDI 6130.03. The USAF medical standards working group recommends various medical standards to the flight and operational medicine cooperate board. Ultimately, the USAF Chief of Aerospace Medicine Policy and Operations approves changes to the Medical Standards Directory (MSD). AFMAN 48-123 delegates certification authority to a variety of levels depending on the complexity of the medical standard and the risk to flight safety.

DISCUSSION: Understanding the creation and framework of medical standards allows aeromedical professionals to employ evidence-based medicine in the maintenance of medical standards. The US military services now have similar accession and retention standards. Standardization of the application of medical standards minimizes disparity, increases interoperability and reduces detrimental operational impacts due to medical conditions.

Learning Objectives

1. The audience will be aware of the source DoD and USAF documents that provide the authority to apply medical standards.
2. The audience will become familiar with the USAF working groups that maintain the Medical Standards Directory.

[294] ACCESSIONS MEDICAL WAIVER DECISIONS - TOTAL FORCE INTEGRATION, TIMELY AND PRECISE

Maria Angles¹

¹USAF, San Antonio, TX, USA

(Education - Program / Process Review)

BACKGROUND: Medical standards and the execution of occupational suitability assessments are a focus for force development. Data driven, knowledge-based risk assessments that directly impact the warfighter and standardized execution of these standards among a diverse military environment drove the development of Total Force Accession Medical Waiver Division (AMWD). The Air Force (AF) is the first service to integrate the defined mission sets for the different components into one division for standardized, timely, evidenced based occupational suitability assessment decisions. **OVERVIEW:** Developing data driven risk analysis and waiver criteria to capture the risk to the mission and to the individual is key to finding "the right" risk aperture for Total Force development. The AMWD performs occupational suitability assessments through four program branches focused on Enlisted, Officer, and Cadet accessions, as well as a Flight and Operational Special Duty branch for specific AF Specialty Codes. The Operations branch integrates data sets for analysis to shape waiver protocols and ultimately create a feedback loop to shape medical standards for the changing landscape of AF combat operations. AFMAN 48-123 delegates certification authority to ensure consistency across the accession sources and flight and special duty waivers. Precision workflows and IT systems that capture needed data and development of these systems to be more agile and integrated will allow tracking trends, data analysis and future outcome-based research to further inform medical standards development. **DISCUSSION:** Precise, rapid occupational suitability assessments across the Total Force provides equitable decisions and data sets allowing analysis of occupational certifications. Medical standards and waiver decisions are one facet of Force Development that directly affects combat capabilities. Understanding the impact of medical standards and standardization of occupational suitability assessments across multiple mission sets allow aeromedical professionals to impact future medical standards, risk aperture determinations and the development of future integration of operational outcome-based research.

Learning Objectives

1. The audience will learn about the newly developed USAF Medical Waiver Division integration and processes.
2. Familiarization with precise, rapid occupational suitability assessments across the Total Air Force and the impact on Force Development.

[295] SO YOU WANNA JOIN THE AIR FORCEHernando Ortega¹¹US Air Force, Joint Base Randolph San Antonio, TX, USA*(Education - Program / Process Review)*

BACKGROUND: US military accession medical standards are defined in Department of Defense Instruction 6130.03 and applied initially by Medical Entrance Processing Command (MEPCOM) and the Department of Defense Medical Evaluation Review Board (DODMERB). Specific goals of the standards are to ensure individuals entering military service are 1) free of contagious diseases, 2) free of conditions that may require excessive lost duty time or early separation, 3) able to complete training, 4) adaptable to all military environments, and 5) able to do military duties without worsening the medical condition. The newly established Accession Medical Waiver Division (AMWD) is the authority for all medical waiver determinations to those standards. There is potential risk to both the USAF and to the individual when a waiver is granted. The current accessions waiver process is described with associated risks. Overall accession numbers will be discussed.

OVERVIEW: AMWD has used a database to track all waiver decisions and diagnoses for accessions and initial special duty determinations. The operations branch tracks waiver rates and key outcomes that may indicate the efficacy of the medical standards and the waiver process as a risk reduction tool for the services. They performed a retrospective descriptive analysis and will present the most frequent diagnoses that requested waiver determination for accession categories with waiver rates. Additional data re: Review in Lieu of (RILO) and Medical Evaluation Board (MEB) diagnoses have been compiled and will be presented for background risk assessment knowledge. **DISCUSSION:** The analysis of waiver requests and rates are subject to the bias of the medical standards themselves. Those conditions not listed as disqualifying will not be found. It is clear that vision, musculoskeletal, psychological and pulmonary conditions are significant for military service. Additionally, occupational suitability risk assessment takes into account the presented conditions that result in limitations of duty and separation from the service.

Learning Objectives

1. Become familiar with the medical waiver review process used by the AF's new Accession Medical Waiver Division.
2. Learn the medical conditions most commonly disqualifying for military service and rates of waivers granted for entry to the USAF.
3. Learn the most common diagnoses that result in medical evaluation board (MEB) reviews or reviews in lieu of (RILO).

[296] WHAT YOU MAY NOT KNOW ABOUT AF SPECIAL DUTY EXAMS AND PILOT QUALIFICATIONPatrick Skiver¹¹American Military University, Charles Town, WV, USA*(Education - Program / Process Review)*

BACKGROUND: Historically 1-2 members of AETC/SGPS were assigned to review, certify, and provide waivers for flying or operational special duty accessions. Although these members were experts in applying medical standards, there was no time for program oversight, Quality Assurance (QA) review, analytics, or standardization. The Base Operational Medical Cell (BOMC) was established to standardize processes for physical examination completion. The new Accession Medical Waiver Division (AMWD) has been given the authority for initial special duty exam certifications, along with manpower to help manage QA and analytics. **OVERVIEW:** On 21 May 2019, the Air Force Chief of Staff mandated establishment of the AMWD in order to facilitate process improvements, standardization and program efficiencies across the Total Force recruiting enterprise. Data on the absolute numbers of pilot examinations and certifications will be presented, along with disqualification rates. Additionally, an analysis of processing time reductions for the new Division compared to earlier processes will be presented. A retrospective descriptive analysis will present the most frequent diagnoses that requested waiver determination for Flying Class I categories with waiver and disqualification rates.

DISCUSSION: This team works in concert with the Aeromedical Consult Service and Military Flight Screening office at USAF School of Aerospace Medicine. Overall, the vast majority of applicants for special duty are

medically acceptable. The AF Medical Service (AFMS) has consistently provided more medically certified applicants for pilot per year than the AF can train. As part of the Accession Medical Waiver Division, the Flight and Operational Special Duty Branch not only dramatically reduced exam certification/waiver timelines, but they are actively addressing long standing questions in standardization of workflows to ensure an equitable accession process across the TF recruiting enterprise.

Learning Objectives

1. The audience will learn about the Accession Medical Waiver Division's process for adjudicating Initial Flying & Special Operational Duty Exams.
2. The audience will learn about IFC I qualification, disqualification, and waiver rates.
3. The audience will learn about the top disqualifying diagnosis for IFC I exams.

[297] PRECISION DECISIONS -- FUTURERodger Vanderbeek¹¹Air Force Recruiting Service, San Antonio, TX, USA*(Education - Program / Process Review)*

BACKGROUND: Occupational suitability assessments and subsequent decisions for entrance and initial special duty accessions depend upon predictive models of disease/injury progression, risk of recurrence, risk of relapse, and risk of exacerbation from occupational exposures. They further depend upon a robust understanding of the operational mission task requirements and environmental challenges and their performance requirements. Gaps in knowledge across this entire spectrum exist. **OVERVIEW:** In order to reduce or close these knowledge gaps, the Accession Medical Waiver Division (AMWD) needs research, studies and analyses to capture operational outcomes of suitability decisions. These outcomes provide the critical evidence-base for deeper enlightenment of the impact of decisions across a potential risk aperture involving a large number of occupations (Air Force Service Codes or AFSCs) that are potentially affected by an even larger domain of medical challenges (congenital, acquired, injury). **DISCUSSION:** Outcomes for analysis will be presented, both operational performance outcomes and clinical outcomes. The network of data systems will also be presented that harbor the array of outcomes needing analysis. Specific current and potential research projects will then be presented that pursue the desired outcome analysis, and subsequently their utilization in occupational suitability analysis tailoring and refinement, as well as informing policy for medical standards. Lastly, how operational aerospace medicine experts might be able to contribute to this endeavor will be discussed.

Learning Objectives

1. The audience will learn about both operational performance outcomes and clinical outcomes of interest in making occupational suitability assessments.
2. The audience will learn about research projects being conducted to apply outcome evidence-based analysis to occupational suitability decisions and to medical standards and policy.

Wednesday, 09/01/2021**2:00 PM****Exhibit Hall****[S-58]: POSTER: PHYSIOLOGY****Chair: Gloria Leon****Co-Chair: Nereyda Sevilla****[298] TRIAL TO ESTABLISH FORMULA TO PREDICT G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC)**Masataka Mine¹, Nobuhiro Ohru¹, Koichiro Kuramoto¹, Masanori Fujita¹, Naruo Kuwada¹¹Japan Air Self-Defense Force Aeromedical Laboratory, Saitama, Japan*(Original Research)*

INTRODUCTION: Gravity-induced loss of consciousness (G-LOC) is a major threat to fighter pilots and may result in fatal accidents. High +Gz

(head-to-foot direction) acceleration force induces cerebral blood loss and results in loss of peripheral vision, loss of central vision (black out), and G-LOC. At the Japan Air Self-Defense Force Aeromedical Laboratory (JASDF AML), we measured trainee's cerebral oxyhemoglobin (oxyHb) value using near infrared spectroscopy (NIRS) (NIRO-150G, Hamamatsu Photonics K.K., Hamamatsu, Shizuoka, Japan) during human centrifuge training. In the past, we tried to establish a formula to predict G-LOC using oxyHb value, height, weight, and body mass index (BMI). The results at that time, G-LOC was significantly associated with BMI and Rate of change of Maximum to Minimum value of oxyHb by Logistic regression analysis. The formula to predict G-LOC was the following: $\text{Log}(P/1-P) = -0.2951 \times (\text{BMI}) - 0.6919 \times (\text{Rate of change}) + 2.9701$. P represents percent probability of G-LOC (decision level: 0.15, sensitivity: 67.6%, specificity: 81.4%, accuracy: 79.5%). This time, we examined the accuracy of this prediction formula. **METHODS:** The subjects were trainees who underwent human centrifuge training of JASDF AML Fighter Training Basic course students from 2017 to 2018, who were able to confirm BMI and NIRS data. The trainees' age was 24.1 ± 1.7 (S.D.) (range, 22–30) years old, and BMI was 22.5 ± 1.8 (19.15–27.76). The training profiles evaluated were following: 4G–15sec, 5G–10sec, 6G–8sec, and 7G–8sec, with anti-G straining maneuver, but without G-suits (60 sec interval and onset rate of 1G per sec). **RESULTS:** Among 59 trainees, 16 (27.1 %) had G-LOC and 43 (72.9 %) did not have G-LOC. Regarding the accuracy of the formula to predict G-LOC, the sensitivity was 59.5 % and the specificity was 76.2 %, which was almost the same as when the prediction formula was created. **DISCUSSION:** We established the formula to predict G-LOC with the sensitivity was 59.5 % and the specificity was 76.2 %. BMI and changing of cerebral oxyHb were main factors to predict G-LOC. We want to contribute to reduce accidents due to G-LOC using our formula to predict G-LOC for actual aviation environments in the future.

Learning Objectives

1. The participant will be able to understand what is G-LOC prediction formula.
2. The participant will be able to understand Change of cerebral oxyHb and BMI are the factors that make up the G-LOC prediction formula.

[299] EFFECT OF HIGH INSPIRED OXYGEN CONCENTRATION ON THE BLOOD PRESSURE RESPONSE TO ANTI-G TROUSER INFLATION UNDER SUSTAINED +GZ ACCELERATION

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(Original Research)

INTRODUCTION: Pilots of high-performance aircraft breathe an enriched oxygen gas mix to maintain a sea-level equivalent oxygenation, or better, at high cabin altitudes. High arterial oxygen tensions can suppress chemoreceptor activity which may influence the cardiovascular response to +Gz but this has yet to be investigated. **METHOD:** As part of a larger study investigating the development of acceleration atelectasis, beat-to-beat non-invasive arterial blood pressure (ABP), heart rate (HR), end-tidal partial pressure of oxygen (PetO₂), peripheral arterial oxygen saturation (SpO₂) and transcutaneous oxygen tension (tcPO₂) were recorded in 14 subjects who undertook two 90 second exposures at +5 Gz on a centrifuge, breathing air (normoxia) or 94% oxygen (hyperoxia). Subjects wore full coverage anti-G trousers (FCAGT) and were instructed to remain relaxed throughout, only tensing their muscles if required to prevent visual loss. **RESULTS:** Hyperoxia prevented a decrease in SpO₂ under +Gz, which was otherwise reduced to ~85% in normoxia, while a reduction in tcPO₂ was observed in both conditions. Heart-level ABP was increased under +Gz, with greater rises seen with longer durations of exposure, but appearing to plateau after ~75 seconds. At +5 Gz with FCAGT inflation, systolic blood pressure was significantly lower ($P < 0.01$) in hyperoxia compared to normoxia, but diastolic pressure remained unaffected. Thus, hyperoxia attenuated the rise in pulse pressure ($P < 0.003$). Hyperoxia had no effect on blood pressure at rest at +1 Gz, though heart rate was slightly lowered ($P < 0.05$). **CONCLUSION:** These data suggest that chemoreceptors play a role in the pressor response to +Gz acceleration. Altered cardiovascular performance in aircraft using high oxygen concentrations as the breathing gas may result in degraded G

protection. Further studies are required to determine whether a similar effect occurs with lower oxygen concentrations representative of oxygen system output at low cabin altitudes.

Learning Objectives

1. The audience will learn about the blood pressure response to anti-G trouser inflation under sustained +Gz acceleration.
2. The audience will learn the effects of high inspired oxygen concentrations on this response and the potential role of the chemoreceptors.

[300] SOYUZ LANDING RISK FACTOR CHARACTERIZATION

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(Original Research)

INTRODUCTION: This study has tracked astronaut injuries during Soyuz landings. Currently it is unknown how landing conditions, space-flight deconditioning, and crew anthropometrics affect injury types and risks. Understanding these relationships will allow better quantification of the risk of injury for future spacecraft designs. **METHODS:** An estimation of the occurrences of injury during Soyuz landings was determined using flight medical records from the NASA LSAH and supplemented with a retrospective and prospective survey questionnaire. Injuries were classified into five discrete classes based on severity and long-term health risks. Mission variables were then analyzed against injuries through Spearman, logistic regression, and injury percentage comparison. Mission variables include age, gender, mission duration, extravehicular activity (EVA) time, vehicle type, location in vehicle, weather condition, landing orientation, ground conditions, wind speed, temperature, air pressure, and humidity. **RESULTS:** Injuries predominate in the shoulders, arms, back, and knees and tend to be of lower severity, but greater than previously predicted. Seat location increased injury chance by 22%, with a predominance of injuries occurring in the right seat. Female astronauts experience injuries 24% more than males and have a 54% chance of being injured overall. Logistic regression and Spearman analysis show no statistically significant results with available variables. When measured co-dependently, ground conditions with wind speeds most correlate with injury rates. **DISCUSSION:** Predominance of right side seat injuries may be explained by orientation of the vehicle at landing, and vehicle travel direction. Female astronauts exhibit differences in strength and musculoskeletal composition from males, which may be exacerbated by the deconditioning effects of space, leading to an overall lower tolerance to impact loading. Increased ground stiffness and wind speed contribute to the kinetic energy of the vehicle at landing, which most correlate with injury. Limitations of this analysis include astronaut surveys are collected retrospectively, Soyuz seat acceleration data are not available, and landing conditions are general estimates of the landing zone. Given the low number of Soyuz landers and even lower number of injured crew, more astronaut landing data are needed to strengthen statistical correlations in order to better quantify the risk of injury for future spacecraft designs.

Learning Objectives

1. How landing conditions, spaceflight deconditioning, and crew anthropometrics affect injury types and risks associated with Soyuz landings.
2. Understand the importance of astronaut risk assessment in current and future spacecraft landings.

[301] AN OPERATIONAL SCALE MODEL SHORT-ARM HUMAN CENTRIFUGE AS A CUBESAT PAYLOAD

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(Education - Tutorial / Review)

INTRODUCTION: Microgravity has been studied as one of the influential factors affecting astronaut health during space travel. With plans of long-term space flights, and the Moon and Mars as the next steps in human deep space exploration, missions could span from a few

days to months. This imposes a wide variation to mission architecture and planning for commercial enterprises and national agencies as the spacecraft need to be equipped to protect astronauts against the effects of prolonged durations in microgravity. In the extreme these could lead to potentially life-threatening physiological responses inflight and during return to Earth or other large gravitational bodies. **TOPIC:** Our team at Simon Fraser University's Aerospace Physiology Laboratory is currently in the process of designing a compact short-arm human centrifuge designed to be installed in a variety of spacecraft, using a minimal space allocation. To more thoroughly test the centrifuge prototype, we have proposed to implement a miniature version of this device as the payload of a CubeSat, a classification of Nano-satellites. **APPLICATION:** The CubeSat would use a single reaction wheel as an analog for the centrifuge. The reaction wheel would be used in combination with a series of magnetorquers to learn about how to cancel the torque effects of the centrifuge in a power efficient manner. Although the centrifuge will primarily produce torques in a single axis any variations in loading or vibrations in the motor will cause minor torques off axis. These will need to be actively monitored and cancelled in order to prevent unwanted rotation of the spacecraft. Using the information from the in-orbit testing, we will incorporate modifications to our subject-run studies on Earth using our ground-based centrifuge. This will enable us to more thoroughly develop and study countermeasures for space applications and will result in a more in-depth understanding of human physiological responses to artificial gravity in a microgravity environment.

Learning Objectives

1. The participants will be able to understand the importance of modelling human physiology innovation prior to prototyping and running human performance research. Participants will also learn about scaled, on-orbit testing of aerospace physiology equipment and its importance in mitigating risk in human performance research.
2. The participants will be able to understand the necessity of a health sustaining method for long term spaceflights and its effect on the human body.

[302] CURRENT PREVALENCE OF NECK PAIN IN UK MILITARY AIRCREW

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(Original Research)

BACKGROUND: Neck pain is known to be a potential consequence of military flying associated with exposure to high G, the use of head mounted equipment and the need to achieve unfavorable postures. There is a need to understand the prevalence of neck pain amongst aircrew and identify associated factors in order to tailor mitigating strategies. The NATO HFM RTG 252 on Aircrew Neck Pain Prevention and Management has recently published recommendations to help quantify and mitigate neck pain. In order to allow comparison across nations of prevalence of neck pain in military aircrew a set of core questions were recommended. The aim of this work was to establish the prevalence of neck pain in the UK military aircrew population using the NATO recommended core questions. **METHOD:** A questionnaire, based on NATO core questions, was developed and distributed to all UK military aircrew via an e-survey in March 2019. Questions on neck pain experienced over the 12-month period prior to the survey together with exercise and activity undertaken outside of flying, platform flown, and head equipment worn were asked. The NATO definition of significant flight related neck pain was used. **RESULTS:** 596 responses were received across all aircraft platform types. Significant flight related neck pain was reported by 51% of fast jet (FJ), 17% of FJ trainer, 41% of rotary wing (RW) and 22% of multi-engine aircraft aircrew. 22%, 21% and 8% of FJ, RW and ME respondents respectively perceived neck pain to have an impact on safety during a 'worst-case' flight. Significant associated factors ($p < 0.05$) included Night Vision Goggle (NVG) use in the past 12 months (FJ and ME) and time spent wearing NVGs (RW). Time sitting at work, excluding in the aircraft, was also a significant factor associated with neck pain for FJ aircrew ($p=0.01$). **CONCLUSIONS:** Neck pain continues to be reported by UK military aircrew. For the first time in the UK, duration spent sitting at work has been identified as an associated factor. This may have the most potential to be easily

implemented in order to add to the suite of interventions to help address aircrew neck pain.

Learning Objectives

1. The audience will understand the incidence of neck pain reported by UK military fast jet, rotary wing and large multi-engine aircrew in 2019
2. The audience will understand factors that have been identified as being associated with aircrew flight related neck pain

[303] CHRONONUTRITION: THE EFFECTS OF MEAL CONTENT AND TIMING ON SLEEP AND CIRCADIAN RHYTHMS

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(Education - Program / Process Review)

BACKGROUND: Aviators, flight surgeons, and support personnel frequently travel across several time zones for training and missions, or experience shifts in their sleep schedules while supporting missions. Although strategies for entrainment of the circadian rhythm with light are well established, less is known about how meals, in both content and timing, can affect the quality and duration of sleep, or the ability of food to entrain the circadian rhythm. There is little guidance for travelers and crewmembers for this aspect of fatigue management.

OVERVIEW: The circadian rhythm is well known for its control over wakefulness, hormone secretion, and body temperature. Controlled by the suprachiasmatic nucleus (SCN) of the hypothalamus, light forms the primary input for entrainment of the circadian rhythm, but studies have shown correlation of different diets with sleep quality. A review of the literature was conducted with regards to both content and timing of meals and their effect on several sleep parameters, including sleep duration (SD), sleep latency (SL), sleep efficiency (SE), waking after sleep onset (WASO) and overall sleep quality (SQ). **RESULTS:** Intake of certain foods including high glycemic index meals, rice bran extract, tart cherry juice, and kiwifruit have been shown to positively affect parameters including SQ, SL, SD, WASO, and SE. Cross-sectional analyses of various populations have also shown correlation of higher intake of seafood, greater food variety, and adherence to the Mediterranean diet with improved SQ relative to others in their cohort. Micronutrients also have been shown to affect sleep, with iron, magnesium, and zinc showing positive effects on SD. Other micronutrients have conflicting associations reported in the literature. **DISCUSSION:** In small, controlled trials intake of specific foods or micronutrients and adherence to the Mediterranean diet have been shown to improve multiple qualitative sleep parameters. Without caloric deficit, the timing of meals has not been shown to affect the entrainment of the SCN. Most studies concerning diet and sleep quality are cross sectional or have a small sample size; few have repeated similar interventions, making generalizability for travelers or use in operational settings difficult. More work remains to be done, especially in athletes. Controlled trials with objective sleep data will shed more light on short- and long- term effects of dietary changes on sleep quality.

Learning Objectives

1. Readers will better understand the relationships between diet and sleep, and how these interact to influence task performance.
2. Readers will be able to recognize sleep-promoting foods and micronutrients and the limits of these interventions for affecting the circadian rhythm.
3. Readers will be able to think critically on their own dietary habits and how these might influence the quality of their sleep.

[304] THE IMPACT OF PERSONALITY ON THE EFFECTIVENESS OF MODAFINIL AS AN ALERTNESS AID

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(Original Research)

INTRODUCTION: Evidence suggests that the alertness aid modafinil may benefit some, but not all, based upon individual susceptibility to

fatigue (Caldwell et al., 2020). Other research suggests variation in response to a variety of pharmacological interventions based upon personality (Corsi et al., 2016; Lancaster & Boivin, 2005). This study examined the impact of personality on the effectiveness of modafinil in maintaining cognitive alertness during sleep deprivation. It was hypothesized that personality traits would be associated with varied cognitive performance based on the trait and specific task. **METHODS:** This was a mixed-model, double-blind study of 22 participants ages 22-40 tested on two days with 36 hours of continuous wakefulness, one day after administration of 200mg of modafinil and the other after placebo, counterbalanced. Participants were assessed on the Psychomotor Vigilance Test (PVT; Dinges, 1985), Wisconsin Card Sorting Test (WCST), Stroop Task, Rapid Decision Making task (RDM), and Delayed Match to Sample task (MTS; NTL ATS). Participants completed the NEO-PI-R (Costa & McCrae, 1985b, 1989a, 1992b) prior to testing and were sorted into high/low categories for each of the five personality traits using a median split. The study was approved by the Naval Medical Research Unit Dayton IRB in compliance with regulations governing the protection of human subjects. **RESULTS:** Mixed-model ANOVAs were conducted with personality (high, low) as the grouping factor and drug (modafinil, placebo) and session (baseline-test 4) as the repeated measures. Significant 3-way interactions for the WCST revealed low Agreeableness associated with fewer errors compared to high Agreeableness after modafinil in session 5; and low Agreeableness after placebo of session 4 associated with fewer errors than high Agreeableness. Significant group X drug interactions revealed low Neuroticism associated with faster RT and fewer lapses on the PVT after modafinil than placebo; high Neuroticism associated with slower RT after modafinil than placebo for the Stroop task; and high Openness associated with fewer correct responses after modafinil than placebo. **DISCUSSION:** These results support the theory that personality impacts the effectiveness of modafinil on cognitive performance. This study revealed varying associations of personality on performance after administration of modafinil, suggesting a complex interplay of personality, pharmaceuticals, and cognitive-specific tasks.

Learning Objectives

1. The audience will learn how personality impacts the effectiveness of a DoD-approved alertness aid on cognitive performance during sleep deprivation.
2. The audience will learn which specific personality traits are associated with improved and/or decreased performance on specific cognitive tasks during sleep deprivation and after consumption of an alertness aid.

[305] ALERTNESS MEDICATIONS: A REVIEW OF POLICIES IN MILITARY AND CIVILIAN HIGH RELIABILITY ORGANIZATIONS

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(Original Research)

INTRODUCTION: Both training and spaceflight operations frequently require international travel, 12-hour or longer shifts, and multiple shifts in succession without adequate crew rest. Ground and inflight evidence shows that fatigue increases the risk for performance decrements¹. Given that the spaceflight environment is unique to NASA, human performance, fatigue, and the risk of catastrophic outcomes are not. This work strongly applies to High Reliability Organizations (HROs)². HROs are defined by extremely safe and reliable operations intended to reduce risk of catastrophic outcomes and include the commercial and military aviators, railroads, nuclear power plants, Special Operations Forces (SOF), and others. HROs have well-established standards for the use of alertness medications during operations. This study was to explore if NASA's draft policies are consistent with how other organizations facing similar risks associated with complex decision making under fatigue currently employ. **METHODS:** Policy statements, regulations, and firsthand accounts were collected from open source information and government databases. These policies were compared to NASA's draft policies regarding complex decision-making and alertness medication and assessed for similarities and differences. **RESULTS:** NASA's

unpublished alertness medication policies are most like policies held by military organizations. Civilian aviators, rail workers, and commercial driver policies do not endorse alertness medication in workers but allow for use when prescribed. Nuclear power stations currently do not allow alertness medication. **DISCUSSION:** Civilian and Military HROs utilize alertness medications divergently. Civilian HROs generally focus on work hour restriction and required rest periods as the ideal form of fatigue management. Pharmacologic methods are managed by the individual and their physician. The civilian sector typically does not require "slam shifts" or emergency utilization, which military members experience regularly during active operations. As such, military policies allow for focused and proactive use of alertness medications in aviators and SOF. NASA draft policies appear to be in line with military aviators and SOF. Data collection for crew utilization, specifically to observe any changes in performance or adverse effects, is needed to increase mission effectiveness in the microgravity environment, especially given the prospect of long duration space missions.

Learning Objectives

1. Understand NASA alertness medication policy in respect to other industries.
2. Understand need for further research in alertness medication protocols for NASA.

[306] SLEEP AND FATIGUE ESTIMATE COMPARISON: COMMERCIAL FITNESS WATCH VERSUS RESEARCH-GRADE ACTIGRAPH WATCH

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(Original Research)

INTRODUCTION: Objective fatigue assessments are typically produced using sleep estimates from research-grade actigraph devices that are input into biomathematical fatigue models. However, these devices have limitations in operational settings due to manual data processing requirements, durability, and lack of additional desired features, suggesting commercial fitness devices might be more appropriate. The current study compares sleep estimates and resulting fatigue assessments between the Garmin fenix[®] 5X and Micro Motionlogger[®] in an operational sample. **METHODS:** Thirty-six volunteer Airmen (majority male) at Joint Base Charleston provided 35 usable data sets over a 14-day period. The study was designated Not Human Subjects Research by the Air Force Research Laboratory Institutional Review Board. Volunteers wore both fitness and actigraph watches on separate wrists (randomly assigned) and completed an activity log to denote sleep and watch off-wrist period times. We collected sleep statistics from the fitness watch and scored the actigraph watch data. We then compared the number of sleep/wake minutes and sleep start/end time estimates between the devices for primary sleep periods registered by both devices with linear mixed effects analyses. Lastly we compared resulting fatigue assessments between the devices based on all sleep periods from a biomathematical fatigue model with descriptive statistics. **RESULTS:** Analyses suggested that the fitness watch had significant sleep minute overestimation (55.02 (Estimate) \pm 5.37 (Standard Error)) and wake minute underestimation (-14.02 \pm 1.05), and significant earlier sleep start time (14.58 \pm 1.82) and later sleep end time (-12.38 \pm .87) minute estimation compared to the actigraph watch for primary sleep periods. The fitness watch missed 31 nap periods and some primary sleep periods outside of normal sleep hours. The fitness watch fatigue predictions were on average lower than the actigraph watch. Although these differences were negligible for most participants, for some participants fatigue estimates were much lower or higher due to overestimated sleep periods or missing sleep periods outside of normal sleep hours, respectively. **DISCUSSION:** Developers must continue to increase the accuracy of sleep metrics produced from commercial fitness watches in order to provide an ideal device to capture sleep estimates in the field for effective fatigue assessment.

Learning Objectives

1. Understand limitations of commercial fitness devices in regard to estimating sleep.
2. Understand the implications of commercial fitness device sleep estimate limitations in terms of assessing fatigue in an operational context.

[307] IDENTIFICATION OF FATIGUE RISK MANAGEMENT SYSTEMS RELEVANT TO ARMY ROTARY WING EXTENDED OPERATIONS

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(Original Research)

INTRODUCTION: Army rotary wing extended operation work cycles can last 14-16 hours and take place in harsh environments. Aviators often fly around-the-clock with little opportunity for sleep. Fatigue caused by operational demands and poor sleep is a common feature of aviators' duty days. Fatigue is compounded by the physiological limitations experienced by aviators during the window of circadian low—a period of maximum sleepiness and low performance capability during a 24-hour cycle. As a result, the need for a method of adding performance indicators into flight operations risk predication models was identified as a gap by the Army's rotary wing community. This presentation describes findings from an expert panel that evaluated fatigue risk management systems (FRMS) with potential applicability to Army aviation.

METHODS: A multi-step process was conducted; first, a systematic literature review identified relevant FRMS. Second, these were presented to an expert panel that included aviation operations experts and researchers from military, federal government, and industry. Third, interim recommendations were published in a USAARL Report (See Nwala et al., 2019). The final step of the process identified next steps for the development of tools to meet the fatigue management needs of Army aviators.

RESULTS: Eight viable systems were found from the review. It was also found that no FRMS currently exist for rotary-wing operations. Of the eight FRMS identified, the panel found that two systems showed promise for this population: 2B-Alert (developed by the U.S. Army Medical Research and Development Command) and FAID Quantum developed by a private company. The panel also developed a set of near and long-term recommendations, which will be discussed in this presentation.

DISCUSSION: The evidenced-based presentation of currently available FRMS to an expert panel of Army aviation stakeholders led to the identification of two FRMS with promise for rotary wing extended operations. The impact of the panel discussion extends beyond the identification of potential FRMS. By convening a multidisciplinary panel of experts, the conversation created a much-needed venue for exploring current operational needs related to fatigue and valuable insight on how others fields manage it. The panel also produced a set of recommendations that require future collaboration in order to evaluate current technology and/or develop future FRMS tailored to the Army's rotary wing needs.

Learning Objectives

1. To garner knowledge on the available fatigue and scheduling management tools and how they apply to military aviation operations.
2. To understand the difference of each fatigue management tool and how the use benefits aviators.

[308] CHANGES IN PERFORMANCE AND BIO-MATHEMATICAL MODEL PERFORMANCE PREDICTIONS DURING 45 DAYS OF SLEEP RESTRICTION IN A SPACEFLIGHT ANALOG

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(Original Research)

INTRODUCTION: Lunar crews are likely to be comprised of small groups of individuals living in confined spaces for more than a month at a time, and mission support personnel may not be consistently available to

assist crewmembers. Prior spaceflight missions have established that crewmembers achieve less than the recommended number of hours of sleep per night on Earth; however, it is unclear whether short sleep in space among highly motivated individuals relates to performance changes. Furthermore, it is unclear whether bio-mathematical models that are used to design work schedules on Earth can accurately predict performance in isolated and confined operational environments.

METHODS: We studied crewmembers over 45 days during a simulated space mission that included five hours of sleep opportunity during the week and eight hours of sleep on weekends to characterize changes in performance on the psychomotor vigilance task (PVT) and subjective fatigue ratings. We further evaluated how well bio-mathematical models designed to predict performance changes due to sleep loss compared to objective measures of performance. **RESULTS:** We studied 20 individuals during five missions and found that objective performance, but not subjective fatigue declined from the beginning to the end of the mission. We found that bio-mathematical models were able to predict average changes across the mission but were less sensitive at predicting average performance changes throughout the day. **CONCLUSIONS:** Our findings suggest that sleep should be prioritized in lunar crews to minimize the potential for performance errors. Bio-mathematical models may be useful tools for crews to schedule their sleep and activities during lunar missions.

Learning Objectives

1. The audience will learn about how crewmember performance was affected by sleep restriction during an analog spaceflight mission.
2. The audience will learn about how well bio-mathematical models predicted crewmember performance with sleep restriction during an analog spaceflight mission.

[309] IS IN-FLIGHT HYPOXIA STILL A PROBLEM FOR AVIATORS, AND WHAT CAN WE DO ABOUT IT?

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(Education - Tutorial / Review)

INTRODUCTION: In order to investigate the three questions posed of what effects hypoxia has on aviators, why it continues to be a threat to both civil and military aviation even in the present day, and what can be done to protect against it or mitigate its effects, a thirteen-year retrospective literature review was carried out in the annals of the two journals of the Aerospace Medical Association: "Aviation, Space and Environmental Medicine" (January 2007 to December 2014), and "Aerospace Medicine and Human Performance" (January 2015 to September 2020). **METHODS:** The following search terms were used for a 'first pass' visual scan of the journals: "hypoxia", "hypoxic", "hypoxaemia", "oxygenation", and "anoxia". This was followed by a cross-check with the yearly index published in the December journal of each year. All relevant articles were entered into EndNote as well as into a spreadsheet which identified them as falling into one (or more) of the following categories: "Hypoxia effects", "Still an issue?", "Countermeasures", "Hypoxaemia and 'fitness to fly' studies", "Altitude medicine", "Equipment and technical aspects", and "Microgravity exposure". **RESULTS:** A total of 130 articles was identified. 65 articles related to the effects of hypoxia, with six of these also dealing with hypoxia awareness training. Seven articles illustrated the ever-present hazard of hypoxia and the importance of physiological training. 30 articles addressed a variety of countermeasures. The remainder of the articles have been excluded from the discussion as these were not directly relevant to addressing the three subject questions. This included sixteen articles dealing with hypoxaemia and 'fitness to fly', (save for two of these overlapping with hypoxia effects (regarding pulmonary hypertension)), eleven articles categorised under 'altitude medicine', eight articles dealing with equipment or operational aspects, and two articles considering adjuvant microgravity exposure. There were nine overlapping articles in total. **DISCUSSION:** The research contained in all of these articles serves to advance knowledge about the effects of hypoxia, and the utility of various countermeasures. In addition to the 'tried and true' approach of hypoxia awareness training, there are various emerging technologies and further areas for research. Individual physiological variability, as well as external extenuating factors, will continue to play a role in unexpected occurrences of hypoxic symptoms.

Learning Objectives

1. Participants will learn about the variety of physiological effects that hypoxia has on aviators.
2. Participants will gain an appreciation of why hypoxia continues to remain an issue for aviators.
3. Participants will gain insight into a range of countermeasures against hypoxia, including hypoxia awareness training.

[310] HYPOXIA AWARENESS TRAINING: PILOT' EXPERIENCE OF HYPOXIA PARTICIPATING IN FIVE AVIATION PHYSIOLOGY COURSES OVER A TIME PERIOD OF 16 YEARS

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(Original Research)

INTRODUCTION: The German Air Force Centre of Aerospace Medicine provides Hypoxia Awareness Training for flight personnel in a hypobaric chamber at intervals of four years. Refresher training in aviation medicine is required throughout the careers of the flight personnel. This raises the question whether these personal hypoxia experiences have changed over time. **METHODS:** 70 male military aircrews attended five aviation medicine training courses every four years between 2002 (age 33+/-4 yrs.) and 2019. Each pilot underwent 5 exposures to reduced pressure in a hypobaric chamber to a simulated altitude of 25,000 feet to experience change of pressure and hypoxia (hypoxia recognition training). Heart frequency, oxygen saturation, hypoxia recognition time (HRT) and hypoxia symptoms were recorded. After a modification of the hypobaric chamber a remote controlled oxygen-separation was introduced in 2003. **RESULTS:** There was a significant difference regarding the hypoxia recognition time in the first and the following courses. In the first course the students disconnect themselves from 100% oxygen and the HRT was 72 sec. After the modification in 2003 the students were disconnected unperceived by the instructor from outside the chamber. The HRT under this condition were at least 99 sec (99 sec – 104 sec). The oxygen saturation when feeling the first hypoxia symptom averaged to 87 %. The students reconnect to 100 % oxygen at an average oxygen saturation of 70 %. The most frequent 1st symptom was sensation of heat (44 %) followed by dizziness (18%). Only 8 pilots (11%) had the same first symptom during all five courses. 13 (19%) aircrew didn't experience any hypoxia symptoms at least one time during the aeromedical training courses and 2 aircrew didn't feel any symptoms during three hypoxia demonstrations. **DISCUSSION:** The difference regarding the HRT between the first and the other courses could be an effect of the different disconnection methods from 100 % oxygen. In the first course the disconnection from oxygen was conducted by the students but not in the following courses. So this could be the explanation why they felt the hypoxia symptoms 27 sec earlier. The recognition of hypoxia symptoms is not very reliable and therefore it makes sense to train it during a pilot's career. Medical monitoring is helpful for the safety crew to realize health problems of trainees in time and gives a feedback to the students.

Learning Objectives

1. Understand the benefit of hypoxia training in a hypobaric chamber.
2. Understand the change of hypoxia symptoms during a pilots' career.

[311] EFFECTS OF RAPID HYPOBARIC PRESSURE FLUCTUATIONS ON A RODENT MODEL

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(Original Research)

INTRODUCTION: Episodic, repeated cockpit pressure fluctuations can occur in aircraft due to complications with the system designed to control and maintain cockpit pressurization. It is possible that these decompression/compression cycles could place aircrew at risk for a range of physiological or cognitive performance deficits, but it is unclear if these fluctuations are

severe enough to elicit these effects. **METHODS:** This study investigated the effect of hypobaric pressure fluctuations over 25 minutes in a hypobaric chamber on the formation of vascular gas emboli and biomarkers of decompression injury, behavioral changes, and alterations in neuroanatomy and neurophysiology in male Sprague Dawley rats. This study protocol was reviewed and approved by the Wright Patterson AFB Institutional Animal Care and Use Committee in compliance with all applicable federal regulations governing the protections of animals and research. **RESULTS:** Transient reductions in activity levels and decrements in performance on a motor coordination task were measured in rats during exposure to 0.8 psi/sec fluctuation profiles with an initial altitude of 8,000 feet. Ultrasound imaging during the exposure revealed no vascular gas emboli in the pulmonary artery of rats exposed to fluctuation profiles of up to 1.5 psi/sec starting at initial altitudes of 8,000 feet and 14,000 feet. Increased astrocytic activation in the hippocampus was found in rats three days following exposure to 1.5 psi/sec fluctuations. **DISCUSSION:** Behavioral alterations and neuroanatomical changes have been associated with pressure fluctuation exposure in a rodent model, although the specific cause of both the transient impacts on motor activity and the astrocytic activation in the hippocampus are yet to be determined. Now that exposure levels necessary to induce adverse effects have been identified, future targeted studies to identify causal mechanisms and time courses of these effects can be performed in the rodent model.

Learning Objectives

1. The participant will be able to identify what physiological effects have been observed in a rodent model during and after hypobaric pressure fluctuations similar to those that can occur in certain aircraft.
2. The audience will be able to understand how the results of this initial study can be applied to more focused studies that seek to identify the underlying mechanisms of the effects that were associated with pressure fluctuation exposures.

[312] PANORAMIC VIEWS WITH SECOND-GENERATION TRIFOCAL INTRAOCULAR LENSES

Rebecca Mendelsohn¹, Patrick Hughes¹

¹Charles E. Schmidt College of Medicine, Florida Atlantic University, Boca Raton, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Advances in aviation technology often place rigorous demands on aviators' vision. These demands, amplified further when aviators develop age-related vision changes, necessitate glasses, contact lenses, or surgical intervention to enhance aviators' quality of vision to adhere to FAA requirements. Second-generation trifocal intraocular lenses (IOLs) have been an incredible enhancement to quality of vision, depth perception, and peripheral field of view compared to previous corrective measures. Novel IOLs will likely become the future treatment option of choice for pilots. **TOPIC:** Previously, monovision was touted as a viable solution to age-related visual changes, with one eye corrected for distance vision and the other eye corrected for near vision. This was accomplished with contact lenses, LASIK/PRK, or IOLs. Monovision has significant disadvantages, including compromised vision at near, far and intermediate distances, poor depth perception, and diminished peripheral field of vision. Furthermore, when aviators with monovision correction eventually develop cataracts, decreased vision in the eye being utilized for flying diminishes even further, while the eye being utilized for near vision also has reduced acuity and fatigues more readily. Binocular vision is tremendously helpful to pilots during the final approach and landing. Pilots utilizing monovision tend to have steeper approaches, higher sink rates at touchdown, and are less accurate with touchdown location. Numerous studies continue to report that suboptimal ophthalmic correction in pilots has contributed to a number of aviation accidents and incidents. Novel trifocal lens implants focus light from distance, intermediate, and near simultaneously, addressing all focal lengths in a patient's field of view. With intermediate-distance vision optimized to 60 cm focal point, and near vision optimized to 40 cm focal point, the lens enables 88% of light utilization with approximately 50% dedicated to distance, 25% to intermediate, and 25% to near vision. Patients can have outstanding visual acuity, even in low-light environments. **APPLICATION:** Trifocal IOLs are rapidly becoming the treatment of choice for age-related visual changes in patients with incredible visual demands, such as aviators. The enhanced

visual parameters of these new lenses are critical for pilots when performing tasks such as aerial refueling, formation flying, and landing on a carrier deck.

Learning Objectives

1. The audience will learn about novel, trifocal intraocular lens implants (IOLs) and the benefits they offer over traditional treatment options for age-related visual changes.
2. The audience will learn the pitfalls of monovision correction and its impact on the occupational performance of aviators.

[313] UNDERSTANDING THE FACTORS CONTRIBUTING TO SPATIAL DISORIENTATION IN UK MILITARY AVIATION: ANALYSIS OF INCIDENTS 2014-2018

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¹QinetiQ, 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 disorientation 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 collect up-to-date data by extending the DIS 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 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 Objectives

1. The audience will learn about the factors that contribute to disorientation in UK military aircrew.
2. The audience will understand the survey technique developed to capture aircrew experiences of disorientation.

[314] RABIN CONE CONTRAST COLOR VISION TEST REPEATABILITY INDICES

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(Original Research)

INTRODUCTION: The repeatability of the INNOVA Systems (Burr Ridge, IL) Rabin Cone Contrast test for normal color vision is reported to be

excellent (Chay et al. 2019). However, there is little information available as to the repeatability of the test for a cut-off score of 55 that allows individuals with mild color vision defects qualify as pilots in the U.S. Air Force and Navy. There is also little information available as to the between-session repeatability for the sensitivity of each eye. The purpose of this study is to determine these values. **METHODS:** Monocular chromatic thresholds were measured for the L-cone, M-cones, and S-Cones. Sixty color-normal (CVN) subjects and 68 subjects with a red-green color vision defect (CVD) participated. Color vision was classified using the Rayleigh color match. Ninety-three percent of the CVNs and 86% of the CVDs returned within 10 to 15 days to repeat the test. **RESULTS:** The between-session AC1 coefficient of agreement in terms of normal/abnormal red-green color vision was 0.97 (95% CI of 0.92 to 1.0). The between-session repeatability for the 55 cut-off was lower at 0.88 (95% CI of 0.80 to 0.97). The lower repeatability was primarily due to 45% of the CVD who passed the first session, but failed at the second session. Because the between-eye and session differences were not normally distributed, the limits of agreement (LOA) between eyes and the coefficients of repeatability (COR) between sessions were based on the median differences and the 2.5 percentile and 97.5 percentile scores. The median values for the between-eye differences and the between-session differences were all near zero. The CVN between-eye LOAs were -10 to 15 units for the L cone, +10 units for the M-cone and -5.0 to 10 units for the S-cone. The CVN between-session CORs were similar for the respective cone mechanisms. The deutan LOAs and CORs were -30 to 40 units for the L-cone and -45 to 40 for the M-cone. The protan LOAs and CORs were -25 to 60 for the L-cone and -30 to 20 for the M-cone. The S-cone LOAs and CORs were +10 units for both the protans and deutans. **CONCLUSION:** The CVN LOAs were slightly lower than the previous results. The LOA and COR for the CVDs were at least 3 times larger than the CVN values for the L and M-cone stimuli, but similar to the CVN values for the S-cone. This between-session variability could be sufficient to erode the repeatability of the test when using a cut-off score of 55.

Learning Objectives

1. Understand the overall repeatability of the Cone Contrast Test for the two pass/fail scores.
2. Understand the differences in the between-eye and between-session limits of agreement.

[315] INFLUENCE OF REPEATED EXPOSURES TO VARIATIONS OF G ACCELERATIONS IN THE CEREBRAL AUTOREGULATORY MECHANISMS IN HIGH PERFORMANCE PILOTS

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¹Lisbon Medical School, Lisboa, Portugal

(Education - Tutorial / Review)

The evolution of high-performance aircraft systems has been resulting in a crescent exposure of pilots to physiological stressors. In this set, +Gz accelerations are especially important once they can induce blood flow redistribution in a cephalad-to-foot direction, with consequent impairment of cerebral perfusion, and possibly resulting in loss of consciousness (G-LOC). A rupture between cognition and the ability to act, marked by periods of absolute and relative incapacitation have already been reported in conditions of decreased intracranial pressure (ICP). Transitory ischemia in the retina can be noticed in the pilots as peripheral vision loss, greyout, and blackout. These events arise as a result of ICP variations and may or may not precede a G-LOC episode. New lines of research have been suggesting the existence of adaptive cardiovascular mechanisms that are able to modulate the physiological resistance of pilots to G accelerations. Regular training in +Gz environments have shown a protective role by modulating blood pressure, and the downstream parameters influenced by this variable. In opposition, long periods of lack of training seem to result in the reduction of a +Gz resistance. However, there are no studies focusing on how G accelerations influence ICP and the capacity of autoregulation induced by training. A major problem in data collection comes from the difficulty in performing accurate ICP measures in an aeronautic environment, that has been overcome with the development of non-invasive techniques. Among these, some of the most promising ones are the transcranial doppler end the optic nerve sheath diameter, that are already used in the clinical context. In future projects, we aim to evaluate ICP variations in high-performance pilots using non-invasive

approaches and to explore eventually adapting cerebral mechanisms that may arise from training.

Learning Objectives

1. The participant will be able to understand how repeated exposures to bouts of training may influence adaptations on cerebral mechanisms in high-performance pilots by affecting variations of intracranial pressure.
2. The participant will be able to develop and promote therapeutic strategies in pathologies specific related to the performance of high-performance pilots.

Wednesday, 09/01/2021

4:00 PM

Grand Ballroom

[S-59]: PANEL: THE 12TH ANNUAL RAM BOWL

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Allen Parmet

Co-Chairs: Jan Stepanek, Rebecca Blue

[316] THE 12TH ANNUAL RAM BOWL

Allen Parmet¹, Rebecca Blue², Jan Stepanek², Robert Johnson³, Roy Allen Hoffman⁴

¹University of Southern California, Kansas City, MO, USA; ²Mayo Clinic, Scottsdale, AZ, USA; ³University of Texas Medical Branch, Galveston, TX, USA; ⁴US Navy, Falls Church, VA, USA

(Education - Program / Process Review)

PANEL OVERVIEW: The 12th Annual RAM Bowl features teams from the Air Force, Navy, Army, Mayo Clinic, Wright State, University of Texas and an International team competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Teams compete in a college bowl format that tests aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and Aeromedical transportation. Questions are divided into toss-up questions and bonus questions. Multiple rounds of competition will lead to the selection of this year's victor and awarding of the Louis H. Bauer Trophy, sponsored by the American Society of Aerospace Medicine Specialists.

Learning Objectives

1. The contest will enable participants to prepare for ABPM examinations in Aerospace Medicine.
2. Attendees will receive an intense review of Aerospace and Preventive Medicine.

THURSDAY, SEPTEMBER 2, 2021

Thursday, 09/02/2021

8:15 AM

Grand Ballroom

55TH ANNUAL HARRY G. ARMSTRONG LECTURE

Serena Aunon-Chancellor

The Future of Science in Low Earth Orbit

Thursday, 09/02/2021

9:30 AM

Governor's Square 12

[S-60]: POSTER: SAFETY & ENVIRONMENTAL MEDICINE

Chair: Ernest Prochazka

Co-Chair: Jaime Harvey

[317] ALUMINIUM CONTENT IN 'CREW MEALS'

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¹Dt. Lufthansa AG, Frankfurt am Main, Germany

(Original Research)

INTRODUCTION: The aluminum contents in crew meals have been measured and compared with existing data to estimate and evaluate the uptake of aluminum by crew members. Results were also compared to existing official data on common aluminum contents of typical foods in Germany. **METHODS:** Lufthansa Crew Meals are produced by the Lufthansa Service Company. The Meals are packed hot into sealed aluminum boxes right after been cooked and subsequently cooled at least 39 degrees F, the so called 'Cook&Chill' Process. The food packages are handled entirely in a cold chain until the food trays are reheated in the stove on board the plane. All meals tested were heated to 338°F for 25 minutes after the above mentioned 'Cook&Chill' process. Values reported, represent total aluminum content composed of the natural content in the food plus the potential migration from the aluminum trays. **RESULTS:** Extensive tests at an accredited food safety laboratory reported total aluminum contents of between 2 and 5 mg/kg in most of the meals. The calculated incorporation of aluminum per person per week is about 9 mg, based on a typical 'Crew Meal' of 500 g and a typical 3,5 days per week on board a plane. **DISCUSSION:** In 2013, the European Council recommended a maximum of 5 mg/kg of aluminum in food, based on the principal that this should be reasonably achievable (ALARA-Principle). However, so far no medical reasons have been established for such a limit. The tolerable weekly ingestion (TWI) recommended by the European Food Authority (EFSA) is 1 mg per kg body weight. 'Crew Meals' contribute on average approximately only 13% of the tolerable dose of aluminum ingestion per week as recommended by EFSA (Tolerable maximum 70 mg for a person of 70 kg weight per week). The migration of aluminum, from the trays into the food during the 'Cook&Chill' process, is estimated to be fairly low based on standard food science. During chilled distribution virtually no aluminum migration from the trays into the food is expected. Limiting the re-heating process and avoiding longer warm holding periods is expected to further reduce aluminum migration into the food. However, the extend of aluminum migration into the food can differ by food types. In particular, foods high in natural acids seem to leach out more aluminum during the heating process. Bioavailability of aluminum is very low due to the fact that less than 1 percent of aluminum passing the gut is absorbed into the body.

Learning Objectives

1. The aluminum content of meals produced in Germany is low. It varies with the natural acids in the food.
2. The 'Cook & Chill' process does not cause a significant migration of Aluminum from the tray into the food.
3. Heating of 'Crew Meals' in the stove on board for 30 minutes is save.

[318] SUPPLY WITH VITAMIN D OF PILOTS AND AVIATION PERSONNEL OF THE GERMAN ARMED FORCES. FIRST RESULTS.

Torsten Pippig¹

¹Centre of Aerospace Medicine of German Air Force, Fuerstenfeldbruck, Germany

(Original Research)

INTRODUCTION: The main source for vitamin D3 in humans is the own synthesis in the upper layers of the skin with sunlight (80–90 %). Around 10–20 % of vitamin D3 needs are covered by nutrition. 25-OH-VitD is the storage form of the vitamin D3 in the serum. A level, of at least 30 ng/ml is considered sufficient. **METHODS:** In this study, the vitamin D3 values in serum of 2176 subjects (license required-personnel of the Bundeswehr) are evaluated during the investigation