mission; given their potential severity, these risks must be ameliorated prior to flight.

Learning Objectives

1. The audience will gain an appreciation for the effects of spaceflight on ocular conditions and the potential consequences when considering spaceflight medical clearance.
2. The audience will gain an appreciation for the potentially complicated medical clearance needs private spaceflight participants have when compared to professional astronauts.

[475] WHEN BIGGER IS NOT ALWAYS BETTER

Bashir El-Khoury
UTMB, Galveston, TX, USA

(Education - Case Study)

INTRODUCTION: This case report describes a 47-year-old female U.S. Air Force flight nurse who was found to have autosomal-dominant polycystic kidney disease during record review for her annual routine physical health assessment. **BACKGROUND:** Autosomal-dominant polycystic kidney disease (ADPKD) is a relatively common type of kidney disease, typically occurring in between 1 in 400 to 1000 live births. Diagnosis is usually made based on imaging in the presence of known family history; however, genetic testing can be done but is not necessary for diagnosis. Autosomal-dominant polycystic kidney disease is often asymptomatic at presentation, but it can also present with hypertension, hematuria, proteinuria, and renal insufficiency. Extrarenal manifestations of ADPKD include cerebral aneurysm, hepatic cysts, pancreatic cysts, and cardiac disease. **CASE PRESENTATION:** This flight nurse was seen for her routine flight physical without new complaints, but admitted to having a renal sonogram done over 15 years prior to her visit with cysts in both kidneys. She endorsed a family history of ADPKD in her mother, but had never been diagnosed with the disease or been seen by a nephrologist in the past. Record review identified a renal sonogram from 2002 that demonstrated numerous cysts in both kidneys, so the patient was referred to myself in nephrology clinic and MRI Kidney was ordered which demonstrated hepatomegaly, innumerable liver cysts and numerous bilateral renal cysts consistent with ADPKD. Flying duties were suspended and aeromedical waiver was submitted and approved. **DISCUSSION:** This case report describes a relatively common, but often underrecognized condition that affects both men and women in the aviation community. Although typically asymptomatic early in its course, autosomal-dominant kidney disease is the leading hereditary cause of end stage renal disease in the United States. Early recognition and specialty referral can reduce the rate of renal decline, potentially delaying the onset of end stage renal disease. Clinicians should be aware of how to diagnose polycystic kidney disease and refer for specialty consultation as, in most cases, aviators can be considered for aeromedical waiver and returned to flying duties. Complications including hemorrhagic cysts, infected cysts, or renal calculi can occur leading to mission degradation; however, risk to mission accomplishment is reasonably low for both aviation duties and for spaceflight.

Learning Objectives

1. Understand the presentation, diagnosis, treatment and complications of autosomal-dominant polycystic kidney disease in the aviator or spaceflight participant.
2. Understand the aeromedical considerations for waiver for autosomal-dominant polycystic kidney disease and potential implications of the condition on spaceflight.

[476] DECOMPRESSION SICKNESS VERSUS HYPERVENTILATION IN HYPOBARIC PHYSIOLOGICAL HYPOXIA TRAINING

Kristi Ray[1]; Karen Ong[1]; Kris Lehnhardt[2]; L. Deutsch[2]
[1]*UTMB, Galveston, TX, USA;* [2]*NASA, Houston, TX, USA*

(Education - Case Study)

INTRODUCTION: This case describes the possible development of decompression sickness (DCS) in a subject undergoing hypobaric physiological hypoxia training at the Sonny Carter Training Facility , NASA Johnson Space Center in Houston, TX, USA. **BACKGROUND:** Symptoms of patients with hypobaric DCS include joint pain, neurologic symptoms, pulmonary symptoms, and skin symptoms. These symptoms can mimic other conditions such as anxiety-induced hyperventilation and therefore, can be difficult to distinguish from DCS. **CASE:** A 30-year-old male aerospace engineer presented for initial hypobaric physiological hypoxia training. The patient began experiencing bilateral upper extremity neuropathy and paresthesias traveling to 25,000 feet while on 100% oxygen (before the hypoxia exposure). On presentation of symptoms the training was terminated. He remained on 100% oxygen during the descent and symptoms resolved once back at ground level. He was evaluated by the onsite flight surgeon and diagnosed with possible DCS. Patient was treated with a U.S. Navy Treatment Table 5 in the onsite hyperbaric chamber. The patient remained asymptomatic during treatment with an unremarkable clinical exam both during treatment and post-treatment. **DISCUSSION:** In those who undergo pressure changes and altitude exposures, DCS is a differential diagnosis for neurological symptoms. During NASA's hypobaric physiological hypoxia training, subjects undergo a 45 minute pre-breathe with 100% oxygen to decrease the risk of developing DCS by denitrogenating the body. In spite of the pre-breathe protocol, there is a 1 in 10,000 overall risk of developing DCS during this training activity. In this case, the patient's mask was examined to ensure there were no leaks. Additional diagnoses to consider include anxiety, hyperventilation, hypercarbia, breathing gas contamination, and arterial gas embolism. These can mimic neurological DCS, and most resolve once at ground level when the mask is removed. However, there is no clear way to distinguish between these different conditions, so clinicians cannot definitively diagnose. It is recommended to treat patients with either ground level oxygen or hyperbaric oxygen, based on clinical suspicion and severity of symptoms. As this patient continued to be asymptomatic at the 12-hour follow-up, he was returned to full duty, not including alternobaric exposures as he was unable to complete the required physiological training.

Learning Objectives

1. The participant will learn about the presentation of hypobaric decompression sickness.
2. The audience will learn about different differential diagnosis' of those who undergo pressure and altitude exposures.

TUESDAY, MAY 24, 2022

Tuesday, 05/24/2022 ***8:00 AM***

8TH REINARTZ LECTURE
"Overcoming Barriers On The Pressure Spectrum: From The Past To The Future"
A Joint UHMS And AsMA Panel

Moderator: Joseph P. Dervay
Panelists: Richard Moon
Mike Gernhardt
Jay Dean

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany C,D,E

[S-18]: PANEL: BEYOND THE 1% RULE: AEROMEDICAL RISK ASSESSMENT IN THE 21ST CENTURY

Chair: Amy Hicks
Co-Chair: Ryan Mayes

PANEL OVERVIEW: *The U.S. Air Force (USAF) School of Aerospace Medicine (USAFSAM) Aeromedical Consultation Service (ACS) is responsible for evaluating complex medical waiver requests for aviators. Traditionally, the ACS has utilized the 1% rule for medical evaluations, where the maximum acceptable risk for an incapacitating medical event is given as 1% per year. In the past few years, the ACS has received multiple queries from operational communities in the USAF on medical standards, suggesting that aeromedical risk is neither clearly communicated by medics nor well-understood by operators. In order to provide a more transparent and granular assessment of risk, USAFSAM developed the developed the ACS Medical Risk Analysis and Assessment Matrix (AMRAAM). The AMRAAM assess 5 levels of likelihood and 4 levels of severity, with categories based on existing USAF standards for assessing and accepting risk. This approach also brings the ACS into compliance with USAF risk assessment policy and guidance. This panel will detail the development of the AMRAAM and will next discuss three case studies to walk through applied use for cardiology, ophthalmology, and psychiatry cases. This will be followed by a discussion of applications for operational risk analyses beyond aeromedical considerations. Finally, prior to implementing use of the AMRAAM, the ACS conducted a validation study to ensure the AMRAAM performs as expected; the final presentation will detail results of that study. Future directions and applications of the AMRAAM will also be discussed.*

[81] DEVELOPMENT OF THE USAFSAM AEROMEDICAL CONSULTATION SERVICE MEDICAL RISK ANALYSIS AND ASSESSMENT MATRIX

Christopher Keirns, Luke Menner, Amy Hicks, Ryan Mayes, Maximilian Lee, Robert Baltzer
USAFSAM, Wright-Patterson AFB, OH, USA

Education - Program/Process Review

BACKGROUND: Historically, the United States Air Force School of Aerospace Medicine (USAFSAM) Aeromedical Consult Service (ACS) utilized a risk assessment process informed by the 1% rule. Over time, the ACS moved beyond a strict interpretation of the 1% rule due to lack of applicability across aircrew duty positions and missions. However, this rule was not replaced with a formal construct. In order to provide a more systematic and relatable assessment of risk, USAFSAM developed the ACS Medical Risk Analysis and Assessment Matrix (AMRAAM). The AMRAAM is designed to provide a transparent, granular assessment of aeromedical risk by connecting it to well-established weapons system risks. This approach aligns with USAF risk assessment policy and guidance. **DESCRIPTION:** The USAFSAM AMRAAM evaluates likelihood and severity of a given medical condition separately, using five levels of likelihood ranging from rare to frequent and four levels of severity ranging from negligible to catastrophic. The AMRAAM values for likelihood and severity are directly linked to the USAF Airworthiness Bulletin (AWB), which establishes criteria for risk assessment and acceptance of weapons system risk, including components that interact with aircrew. The likelihood values in the AWB (given in operational hours) are converted into probability of a single occurrence per year to translate to medical literature, and the severity criteria mirror the AWB as closely as possible. The resulting 4x5 matrix provides 20 cells, to which aeromedical risk is mapped at a granular level. Each cell is associated with a risk level (high, serious, medium, low); these risk levels also mirror the AWB. **DISCUSSION:** The AMRAAM is expected to dramatically improve the communication of aeromedical risk by (a) linking aeromedical risk to existing system risk benchmarks and (b) conveying risk in a format used by the rest of the USAF. Initial feedback on the AMRAAM has been positive; the AMRAAM is expected to modernize aeromedical risk assessment for the USAF.

Learning Objectives

1. The USAFSAM AMRAAM is derived from already-existing USAF risk analysis and acceptance levels.
2. The USAFSAM AMRAAM evaluates likelihood and severity separately.

[82] CARDIOLOGY CASE STUDY UTILIZING THE USAFSAM AEROMEDICAL CONSULT SERVICE MEDICAL RISK ASSESSMENT AND ANALYSIS MATRIX

Eddie Davenport, Luke Menner
US Air Force, Wright-Patterson AFB, OH, USA

Education - Case Study

BACKGROUND: The U.S. Air Force School of Aviation Medicine (USAFSAM) developed a conceptual framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service (ACS) Medical Risk Assessment and Analysis Matrix (AMRAAM). Prior to implementation, the ACS conducted a study to evaluate results using the AMRAAM to results using the legacy ACS risk assessment process; this study included a re-analysis of multiple cases from each specialty represented within the ACS using the AMRAAM. This presentation will outline the use of the AMRAAM for an exemplar cardiology case study. **CASE DESCRIPTION:** A 43-year-old male KC-135 (FC II) pilot developed substernal chest pain several hours after a 1.5-mile run. At the emergency room his electrocardiogram revealed normal sinus rhythm with ST elevations in leads V2 through V4 and an elevated troponin-I. Emergent cardiac catheterization identified a 90% stenosis in the mid-left anterior descending coronary (LAD) artery. A drug-eluting cardiac stent was deployed to the LAD without complication with discharge the following day. Appropriate medical therapy was initiated, and he completed cardiac rehabilitation along with an occupational evaluation after the initial event. Subsequent, non-invasive cardiac testing was normal and repeat coronary angiography confirmed a patent LAD stent. Of note, he did have moderate residual coronary artery disease with a total overall aggregate stenosis of 110%. His cardiovascular risk factors were medically optimized, and he was allowed to return to restricted flight duties. **DISCUSSION:** Utilizing the AMRAAM to evaluate this case, it is clear that the probability of a recurrent major cardiovascular event drives risk (estimated to be 1-2% annually). Severity of outcome if the event occurs in the aviation environment is potentially catastrophic. This places him in a serious risk category, leading to a restricted waiver recommendation. The use of the AMRAAM facilitates the communication of this risk to medical and operational stakeholders as well as decision makers.

Learning Objectives

1. Understand the application of the AMRAAM to an aerospace cardiology medical risk assessment.
2. Understand the importance of using aircrew specific data in the application of the AMRAAM for aerospace medical risk assessment.

[83] OPHTHALMOLOGY CASE STUDY UTILIZING THE USAFSAM AEROMEDICAL CONSULT SERVICE MEDICAL RISK ASSESSMENT AND ANALYSIS MATRIX

Jonathan Ellis
USAFSAM, Wright-Patterson AFB, OH, USA

Education - Case Study

BACKGROUND: The U.S. Air Force School of Aviation Medicine (USAFSAM) developed a conceptual framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service (ACS) Medical Risk Assessment and Analysis Matrix (AMRAAM). Prior to implementation, the ACS conducted a study to evaluate results using the AMRAAM to results using the legacy method (essentially the 1% rule); this study included a re-analysis of multiple studies from each specialty represented within the ACS using the AMRAAM. This presentation will outline the use of the AMRAAM for an exemplar cardiology case study. **CASE DESCRIPTION:** 45 yo male former HH/UH-1 pilot who was disqualified from flying duties secondary to permanent visual field defects, substandard visual acuity, and substandard stereopsis resulting from bilateral retinal detachments. In addition to the history of retinal detachment, he also developed a cataract after retinal surgery, which was removed and an IOL implanted. His command was interested in reconsidering the case for possible RPA Pilot duties. This case

was selected to use the new AMRAAM to demonstrate the risk analysis and help validate the new tool for use in aeromedical decision making. **DISCUSSION:** When utilizing the AMRAAM to evaluate this case, it is clear that the driver of risk is the permanent visual field defect, substandard visual acuity, and loss of depth perception. Post-treatment and observation, in consideration of manned flight, the likelihood was greater than 99% and the severity was critical, placing him in a high risk category, leading to a permanent disqualification. In consideration of RPA pilot duties, the likelihood remained greater than 99%, but the severity of the impact was reduced to marginal, leading to an RPA pilot waiver recommendation. The use of the AMRAAM facilitates the communication of this risk to medical and operational stakeholders and decision makers.

Learning Objectives

1. The audience will learn about the use of the Aeromedical Consult Service Medical Risk Assessment and Analysis Matrix (AMRAAM) for ophthalmologic diagnoses.
2. The participant will become familiar with the aeromedical risk of retinal detachments and resultant visual field defects for both manned and RPA pilot duties.
3. The audience will learn through illustration with the AMRAAM how shifting from manned flight to RPA pilot duties will change the risk profile to allow a member to continue to serve while maintaining flight safety.

[84] CASE STUDIES UTILIZING THE USAFSAM AEROMEDICAL CONSULT SERVICE MEDICAL RISK ASSESSMENT AND ANALYSIS MATRIX

Kevin Heacock
USAFSAM, Wright-Patterson AFB, OH, USA

Education - Case Study

BACKGROUND: The U.S. Air Force School of Aerospace Medicine (USAFSAM) developed a conceptual framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service (ACS) Medical Risk Assessment and Analysis Matrix (AMRAAM). Prior to implementation, the ACS conducted a study to evaluate results using the AMRAAM to results using the legacy method (essentially the 1% rule); this study included a re-analysis of multiple studies from each specialty represented within the ACS using the AMRAAM. This presentation will outline the use of the AMRAAM for an exemplar mental health case study. **CASE DESCRIPTION:** A male C130 Pilot (FC II) with a history of Major Depressive Disorder (MDD), single episode, mild presented to Mental Health (MH) reporting to his Licensed Clinical Social Worker (LCSW) symptoms consistent with depression, including anhedonia, poor motivation, malaise, and episodes of sadness. Prior to this he was receiving supportive therapy with the LCSW for a phase of life issue, but the diagnosis was changed to major depression. Antidepressant therapy was initiated, and after six months of stability, he was considered for flying waiver for MDD, single episode in full remission. **DISCUSSION:** When utilizing the AMRAAM to evaluate this case, it is clear that the driver of risk during the episode of MDD was both the likelihood of reccurrence and severity of potential outcomes. Post-treatment and observation, the likelihood was adjusted to occasional and the severity adjusted to critical, placing him in a serious risk category, leading to a recommendation for waiver. The use of the AMRAAM facilitates the communication of this risk to medical and operational stakeholders and decision makers.

Learning Objectives

1. Learning Objective: Understand how the AMRAAM is used to assess aeromedical risk for a mental health case study.
2. Learning Objective: Understand the difference in aeromedical risk for single episode vs. recurrent episodes of Major Depressive Disorder.

[85] USAFSAM'S AMRAAM APPLICATION FOR TOTAL FORCE ACCESSIONS

Rodger Vanderbeek, Eduardo Rizo
Air Force Recruiting Service, San Antonio, TX, USA

Education - Program/Process Review

BACKGROUND: The Accession Medical Waiver Division (AMWD) conducts occupational suitability assessments and makes decisions for entrance and initial special duty accessions for USAF and USSF. Communicating those decisions to a variety of line organizations and operators and commanders is challenging especially if couched in largely medical or clinical risk assessment language. The United States Air Force School of Aerospace Medicine (USAFSAM) Aeromedical Consult Service (ACS) shared their new ACS Medical Risk Analysis and Assessment Matrix (AMRAAM) with the AMWD, presenting an alternative risk communication methodology for consideration. **OVERVIEW:** The AMWD in FY22 instituted the concepts from the USAFSAM AMRAAM risk communication model to communicate the results/decisions from our occupational suitability analyses across officer and enlisted accessions for the Air and Space Total Force. Elements incorporated included an estimate of the likelihood (probability/frequency) of adverse events from medical conditions, and the operational mission impact severity from the occurrence of such events. Decisions characterized in this way were communicated to line leadership, in terms more akin to the way the line estimates probability of adverse events and the impact of those events on operations. **DISCUSSION:** The AMWD will describe the feedback from line customers to this new risk assessment communication method for the FY22 period preceding AsMA. Comparison of line perception of risk assessment before and after this change in risk communication approach will be characterized and shared with the AsMA attendees. Specific elements of feedback will be presented. Any lessons learned will also be shared, as well as any potential modifications or improvements to the approach.

Learning Objectives

1. The audience will learn about the AMWD's use of the AMRAAM risk matrix in USAF and USSF accession waiver decisions.
2. The audience will learn about the feedback received from line commanders and other line customers, from the use of a communication method that is more like operational risk assessments (probability of events, and severity of impact on mission if event occurs).

[86] VALIDATION OF THE USAFSAM AEROMEDICAL CONSULT SERVICE MEDICAL RISK ASSESSMENT AND ANALYSIS MATRIX

Amy Hicks, Ryan Mayes, Christopher Keirns, Joseph Wagner, Luke Menner, Maximilian Lee, Robert Baltzer
USAFSAM, Wright-Patterson AFB, OH, USA

Education - Program/Process Review

INTRODUCTION: The U.S. Air Force School of Aviation Medicine (USAFSAM) developed a framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service Medical Risk Assessment and Analysis Matrix (AMRAAM). Prior to implementation, the ACS conducted a study evaluating the AMRAAM compared to the legacy method. **METHODS:** The AMRAAM was evaluated by obtaining subject matter expert feedback, and a formal validation of aeromedical waiver recommendations using the AMRAAM compared to legacy risk assessment methods. Subject matter expert feedback was qualitative and resulted in several adjustments to the AMRAAM (primarily wording of severity or likelihood options). The validation study was conducted by sampling 100 ACS waiver cases from 2019 (prior to AMRAAM development). Each case was re-evaluated, mapped to the AMRAAM, and a recommendation based on the AMRAAM was provided (medically qualified, unrestricted waiver, restricted waiver, disqualified). This recommendation was compared to the recommendation from the legacy method. This allowed the comparison of AMRAAM recommendations vs. legacy recommendations using the Signed-Rank test. **RESULTS:** The Signed-Rank test indicated that the recommendation provided from the AMRAAM was not significantly different than the recommendation from the legacy method ($p>0.05$), meaning that the AMRAAM did not substantially alter the overall assessment based on aeromedical risk. Of note, the Signed-Rank coefficient was positive; this indicates that when the AMRAAM and legacy methods produced a different recommendation, the AMRAAM

recommendation was more liberal (i.e. unrestricted waiver vs. restricted waiver). **DISCUSSION:** The results of the validation study suggest that the AMRAAM does not produce substantially different recommendations than the legacy approach. Coupled with the increased transparency in communicating aeromedical risk using the AMRAAM, and the fact that the AMRAAM is consistent with USAF guidance regarding risk analysis, this suggests the AMRAAM is an appropriate tool for use by the USAFSAM ACS. Implications for future use will be discussed.

Learning Objectives

1. Learning Objective: Understand the results of a validation study for a novel aeromedical risk assessment matrix.
2. Learning Objective: Understand potential future applications of a novel aeromedical risk assessment matrix.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany A

[S-19]: PANEL: IMPORTANCE OF AEROMEDICAL EXPERTISE IN NAVAL AVIATION ACQUISITION

Chair: Chris Foster

PANEL OVERVIEW:*The Naval Air Warfare Center Aircraft Division (NAWCAD) Human Systems Engineering (HSE) Department has established an Aeromedical Monitoring and Analysis Branch composed of uniformed Medical and Medical Service Corps officers tasked to serve as a center of excellence for Naval Aviation Acquisition and a resource to acquisition programs in order to ensure that warfighter aeromedical priorities are appropriately considered at each stage in the acquisition life cycle. This branch includes representatives of the following communities: Flight Surgery, Aerospace Experimental Psychology, Aerospace Optometry, Research Physiology, Audiology, and Aerospace & Operational Physiology. This session will provide an overview of the impetus for standing up the aeromedical branch, discuss the importance of each community in supporting this mission, illustrate the synergy realized by having a team of military experts working together to address warfighter challenges, and provide examples of how this model is already helping the warfighter.*

[87] LEVERAGING FLIGHT SURGEON EXPERIENCE INTO HUMAN SYSTEMS ENGINEERING

Matthew Doubrava
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA

Education - Program/Process Review

After the physiologic events (PE's) that US Navy aircraft equipped with OBOGS experienced in the 2010's, multiple agencies in the Department of Defense and NASA worked together to identify and mitigate root causes. To define, study and prevent PE's, Naval Air Systems Command (NAVAIR) relied on a disparate group of uniformed scientists across multiple commands in addition to the civilian experts already on their staff. This experience highlighted the benefit of having uniformed aeromedical experts on the NAVAIR staff. As a result, in 2021 the Naval Air Warfare Center Aircraft Division (NAWCAD) of NAVAIR at Naval Air Station Patuxent River in Maryland stood up the Aeromedical Monitoring and Analysis Branch of the Human Systems Engineering Department to address the new need. Included in the pool of expertise brought to the new organization is a Navy Flight Surgeon with board certification in aerospace medicine. The flight surgeon role brings three distinct perspectives to the human systems engineering effort. The first is clinical experience. With experience in patient care and in issuing medical clearance for flight, the flight surgeon has first-hand knowledge of the challenges the flight environment has on aircrew. Secondly, the typical navy flight surgeon has significant operational experience, as most are assigned to operational and, often, deploying flying commands. Experiences can range from the care of aircrew in austere environments to first-hand operation of the aircraft to familiarize themselves with challenges of the flight environment. Finally, a flight surgeon that is board certified in aerospace medicine is a champion of preventive medicine, has the requisite training to protect public health, and understands the mechanisms to keeping a population healthy. The cornerstone of this approach is the elimination of hazards to prevent injury to aircrew. Being in the Navy's acquisition center affords the flight surgeon the opportunity to contribute to the engineering effort with the intent to eliminate hazards to aircrew throughout the acquisition life cycle. This presentation will discuss examples and approaches of the flight surgeon contributing to the human systems engineering mission.

Learning Objectives

1. The audience will learn about the novel approach of integrating clinical flight medicine into and engineering organization for the purpose to eliminating potential hazards to aircrew.
2. The audience will learn about the three unique characteristics that a US Navy flight surgeon can bring to the Human Systems Integration community.

[88] AEROSPACE EXPERIMENTAL PSYCHOLOGY IN NAVAL AVIATION

Adam Braly
Rice University, Houston, TX, USA

Education - Tutorial/Review

Naval aviators and aircrew operate complex aircraft and operational systems in environments that are physically and mentally demanding on the warfighter, which necessitates human performance and human systems engineering expertise to ensure that operators can safely execute their mission. The Human Systems Engineering (HSE) department within the Naval Air Warfare Center Aircraft Division (NAWCAD) provides the resources and facilities to optimize the human performance and survivability of the human operator. Aerospace Experimental Psychologists (AEP) are embedded within the HSE department. AEPs are experts in aviation safety, selection, training, and human factors, which are all key aspects of Human Systems Integration. Similar to other uniformed scientists AEPs have significant experience in the aviation environment and in working with fleet aviators. AEPs leverage this expertise and experience in collaboration with other scientists and engineers to enhance the human performance, safety, and survivability of the warfighter. AEP activities include both direct program support and research & development activities in areas ranging from human factors to emerging technologies (e.g., extended reality) to manned/unmanned teaming to use of AI and machine in aviation. This presentation will focus on the unique capabilities that the AEP brings to the HSE department at NAWCAD and the discussion will focus on the importance of the human operator in Naval aviation and existing research efforts that are in place to enhance human performance in Naval aviation.

Learning Objectives

1. The audience will learn about Naval Aviation Acquisition and the role of aeromedical community in supporting the acquisition mission.
2. The audience will develop an understanding of the unique capabilities of the Flight Surgery, Aerospace Experimental Psychology, Aerospace Optometry, Research Physiology, Audiology, and Aerospace & Operational Physiology communities and how these capabilities have positively contributed to warfighter safety and survivability through a discussion of recent projects.

[89] FOCUS ON THE HUMAN: NAVY AEROSPACE OPTOMETRY CONTRIBUTIONS TO NAVAL AVIATION HUMAN SYSTEMS ENGINEERING

Micah Kinney
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA

Education - Tutorial/Review

INTRODUCTION: Of all the sensory systems, the visual system provides the most information to the aircrew for orientation, awareness, targeting, and mission completion. In the event of a degraded visual environment either from natural terrain, refractive error, night, weather, or directed energy, aircrew can lose situational awareness or a resultant mishap could occur. Understanding the critical role that vision plays in

human-machine interaction, the Naval Air Warfare Center Aircraft Division (NAWCAD) stood up the first fleet billet for Navy Aerospace Optometry (AsO) in 2020. **TOPIC:** During the recent string of physiologic episodes (PEs) in military aviation, Navy AsO's provided scientific support to further understanding of how the visual system can be utilized to detect early changes in physiology from low oxygen environments. In addition to addressing PEs, AsO's work on eye protection solutions from directed energy or impact forces which are critical to ensure our most precious sense is protected. During the acquisition life cycle, consideration for visual performance should be given to ensure this crucial sense is optimized. Providing support to that end, uniformed Navy AsO's work alongside civilian engineers, physicists, psychologists, and vision scientists to bring a unique clinical and aeromedical experience. **APPLICATION:** As a part of the Aeromedical Monitoring and Analysis Branch within NAWCAD, Navy Aerospace Optometry works across the spectrum of the acquisition life cycle to provide the top visual performance to the aviation warfighter. This brief will discuss unique examples of how the Navy AsO contributes to address: how corrective eyewear interacts with helmets, visors and masks; advance helmet mounted displays and avionics; improve eyewear and active noise reduction ear-cup compatibility; and enhance night vision systems to ensure that the best visual performance is achieved.

Learning Objectives

1. The audience will gain an understanding of what a Navy Aerospace Optometrist is and how they contribute to human systems engineering.
2. The audience will gain a better appreciation for the visual system and its role in sensory perception.

[90] "YOU WANT ME TO FLY WEARING THAT?" RESEARCH PHYSIOLOGY IN THE NAVAL AVIATION ENTERPRISE

Travis Doggett
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA

Education - Tutorial/Review

Each and every day, US Navy aviators and aircrew push the capabilities of the body to the edge and sometimes beyond. Across aviation communities, warfighters not only operate state-of-the-art equipment but also utilize leading-edge techniques, supplements, and training to provide a critical advantage over their adversary. The Naval Air Warfare Center Aircraft Division (NAWCAD) Human Systems Engineering (HSE) Department operates to develop this advantage as the authority responsible for full spectrum life cycle research, engineering expertise, and human system integration of material solutions for critical requirements of the Naval Aviation Enterprise (NAE). Research Physiology is a small subspecialty within the Medical Service Corps (MSC) comprised of Ph.D.-trained officers who are experts in cardiopulmonary, musculoskeletal, & neurophysiological function and their response to the numerous stressors and pathologies. This along with their experience working directly with the warfighter can be leveraged to address NAE challenges and priorities within the aircraft cabin including posture, neck/back pain, in-mask sensors, physiologic monitoring, anthropometrics, altitude, and pressure. Research Physiologists partnered with other communities to conduct essential human subjects research (HSR) in the first-ever manned study investigating pressure-related physiologic events (PE) in the F/A-18 community, which helped to confirm that the PE's observed were not attributable to decompression sickness. This helped to focus acquisition efforts on other potential root causes in order to better protect the operators. Integrating communities such as the Research Physiology community into the NAWCAD HSE department has enabled HSE to align and synchronize aeromedical expertise to better support the acquisition life cycle. Utilizing their expertise, they provide human physiological insight to NAWCAD HSE projects addressing critical requirements to ensure aviator/aircrew protection as they operate in an inhospitable aviation environment while simultaneously enhancing warfighter performance, lethality, and survivability. Integrating this expertise early in the acquisition process safeguards against the development of future physiological problems among aircrew. Alongside the other Aeromedical Communities, Research Physiologists endeavor to place the human first in human systems integration and keep US Navy aviators & aircrew on the leading edge of operational performance.

Learning Objectives

1. The audience will be introduced to the role of Naval Air Warfare Center Aircraft Division (NAWCAD) and its role in advancing human performance and integration through the Naval Aviation Acquisition Enterprise by providing life cycle research and engineering expertise.
2. The audience will be introduced to the Research Physiology community of the Medical Service Corps (MSC) and its Ph.D.-trained officers. The seminar will highlight the expertise Research Physiology offers and leveraged by NAWCAD and applied to projects addressing problems, capabilities, and requirements within the aircraft cabin.
3. The audience will learn that the Research Physiology community provides NAWCAD with extensive experience in physiologic function and their responses to stressors and pathologies enables NAWCAD HSE to sequence and synchronize aeromedical expertise and exercise medical input to the acquisition life process.

[91] OPERATIONAL AUDIOLOGY AND ITS NECESSITY IN NAVAL AVIATION PERFORMANCE

Kyle Shepard
Naval Air Station Patuxent River in Maryland, Patuxent River, MD, USA

Education - Tutorial/Review

Effective hearing and balance is imperative to mission success in all military operations. Situational awareness and communication capability are the most important mechanisms for military members to operate safely and competently as a team in dynamic environments. Temporary or permanent disruption to these abilities account for a large portion of physiologic events (PE's) throughout the Naval Aviation Enterprise. Disruptions can be caused by hazardous noise, vibration, pressure changes, significant motion and other factors. Unfortunately, these stressors are very common throughout Naval Aviation. Fortunately, they can often be mitigated when properly understood and appropriate controls are applied. Audiologists are subject matter experts of the assessment and management of hearing and balance systems. Therefore, this specialty became a primary component of the new Aeromedical Monitoring and Analysis Branch of the Human Systems Engineering Department when it was created in 2021 at Naval Air Warfare Center Aircraft Division (NAWCAD) of NAVAR at Naval Air Station Patuxent River in Maryland. Operational Audiologists in the Navy offer clinical expertise in both hearing and balance, field knowledge of sustaining or enhancing these systems in unique environments and physiologic knowledge to be synergized with the wealth of engineering expertise already present at NAWCAD. This presentation is intended to expand upon unique qualities of the Operational Audiologist in supporting Naval Aviation performance. Discussion will focus the importance of hearing and balance in Naval Aviation, the primary hazards contributing to damage of these systems, current mitigation strategies employed to mitigate these hazards, and finally existing/future research efforts aimed at enhancing hearing aid balance of the military member when operating in hazardous environments.

Learning Objectives

1. The participant will further understand the prevalent hazards contributing to compromised hearing and balance in Naval Aviation.
2. The participant will learn about current and future mitigation strategies to sustain or enhance hearing and balance when exposed to the most prevalent hazards.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscay

[S-20]: PANEL: LESSONS FROM THE THIRD WORLD WAR: LEARNING FROM THE GLOBAL PANDEMIC…FOR TODAY…AND FOR TOMORROW

Chair: Paul K Carlton, Jr

PANEL OVERVIEW: INTRODUCTION: *America, her allies, and competitors are now two years into the global SARS CoV2 pandemic. All have struggled to contain the virus, and it has presented decision makers difficult decisions about protecting "lives versus livelihoods." The pandemic, initially framed as primarily a medical problem, has emerged as a political one as well. The interplay between public health controls and clinical medicine have collided with realities of among many pressures, economics, loss of income, personal freedom, and collective responsibility, which have been all amplified by misinformation.*
OVERVIEW: *Regardless of the source of the pandemic, this global pandemic has impacted nearly every activity and person in every corner of the globe. Conflict, whether diplomatic, economic, or military continues overlapping the pandemic in ways that the world's citizens saw during the last major pandemic, the Influenza outbreak of 1918. We are witnessing what the future of all-domain conflict could look like. This pandemic had been expected, but as a nation, we were ultimately not prepared for the measures needed to address the pandemic or the societal disruption that resulted. The presentations will discuss pandemic responses drawing on past and present events. It will describe the most current mechanisms of spread for SARS CoV-2, and how a focus on fresh air may provide keys to disrupting both the current pandemic and enhance preparedness for the next respiratory pathogens. It will review available technologies that may become adjuncts as we harden against future respiratory pathogens. Finally, it provides a unified model of protection of societies and their critical infrastructure sectors that may be applied in present and the future, arguing for significant national and international attention to the issue of protecting the air that we breath. It advocates for an aggressive wartime mindset of action today, applying the best available science, while actively studying our results.*

[92] IT'S BEEN A LONG TWO YEARS: WE'VE LEARNED A LOT, BUT WE ARE MISSING AN IMPORTANT OPPORTUNTY!

Michael Coghlan
USAF, Columbus AFB, MS, USA

Education - Program/Process Review

BACKGROUND: This presentation will review the status of our response to the SARS-CoV-2 pandemic using a "Protect, Detect, Treat" model. The author advocates for a more proactive approach to hazard mitigation protecting against both the current pandemic and future bio-threats. **OVERVIEW:** Over the course of the pandemic, medical advances have made significant improvements in our ability to treat patients infected with SARS-CoV-2 as reflected by significantly lowering of morbidity and mortality. We have had far less success in developing a real-time ability to detect the to support our traditional public health recommendations. Further, our ability to protect individuals or populations has been mixed. With better availability of personal protective equipment and a highly effective vaccine, we are now able to protect individuals, especially those who are high risk because of either exposure or underlying conditions. On the other hand, we are only now just exploring how a strategy that decreases the viral load in shared air, especially indoor shared air, could impede the propagation of SARS-CoV-2 or future bio-threats. **DISCUSSION:** The "Hierarchy of Controls" from the National Institute for Occupational Safety and Health emphasizes engineering controls, substitution, or elimination of hazards as far more effective than relying on individual behavior such as proper use of personal protective equipment or other administrative actions. This model can be applied to both the current pandemic and future bio-threats.

Learning Objectives

1. Understand the NIOSH Hierarchy of Controls as it relates to airborne pathogen control.
2. Understand the limitations of our current reactive model of combatting airborne pathogens and bio-threats.

[93] WHAT'S O0LD IS NEW AGAIN: LESSONS FROM HISTORY AND THE CURRENT SCIENCE APPLIED TO THE SARS COV2 PANDEMIC

Michael Coghlan
USAF, Columbus AFB, MS, USA

Education - Program/Process Review

BACKGROUND: The most current science suggests SARS CoV-2 is predominantly spread person to person through the air either through droplet nuclei or aerosols. This supports the concepts of protecting the air that we breath to minimize transmission of not only SARS CoV-2, but also other respiratory pathogens. **OVERVIEW:** This presentation will provide a timeline of the current SARS-CoV-2 pandemic and then will discuss a broad overview of prior pandemics, focusing on those that are transmitted primarily through the airborne routes. We will emphasize lessons learned and often forgotten. Special attention will be paid to the knowledge from the 1918 Influenza Pandemic as applied to the 21st century. Early in the pandemic, America focused predominantly on surface transmission with much less emphasis on the role that airborne transmission of virus plays in the propagation of a pandemic. In retrospect, this decision appears to be an incomplete strategy at best, and poorly informed at worst. While great advances have been made with rapid development of a vaccine for personal protection, and treatment has significantly improved mortality from infection, initiatives have lagged in understanding how to best protect the air that we must breathe and operate in. **DISCUSSION:** Protecting air that we operate in is a dual-use (military/civilian) priority, including within the transportation (aviation) sector. Expanding that protection from individual personal protective equipment, whether in the military or civilian environments, will be an important consideration to provide resiliency against future bio-threats, and the lessons of the past and present.

Learning Objectives

1. The participant should understand lessons of the past and how those can influence how we mitigate the risk of SARS-CoV-2 today and harden against future bio-threats tomorrow.
2. The participant should understand the current theories of how SARS-CoV-2 is transmitted.
3. The participant should understand how a delay in understanding that SARS-CoV-2 was transmitted predominantly through the air hampered an adequate response to the current pandemic, and the implications of this delay going forward.

[94] TECHNOLOGY REVIEW: BEST AVAILABLE SCIENCE TODAY VERSUS PERFECT SCIENCE TOMORROW

Mark Ervin
DoE, USAF, San Antonio, TX, USA

Education - Program/Process Review

BACKGROUND: Ventilation science, traditionally the domain of building engineers, architects, and HVAC specialists, appears to be a critical tool in protecting people and populations from airborne pathogen transmission. Therefore, it is important for medical professionals to understand basic ventilation science and how established technologies can augment our ability to provide safe indoor air to our patients. **OVERVIEW:** Increasing fresh air ventilation of enclosed spaces has shown great promise in protecting against airborne pathogens. However, limitations in current building and HVAC design, as well as both financial and environmental considerations limit our ability to increase ventilations to a level that on its own decreases the risk of enclosed indoor air to an acceptable level. One must look to repurposing established technologies to decrease our reliance exclusively on increased air exchanges to ensure safe indoor spaces.
DISCUSSION: Several established and/or emerging technologies show promise in decreasing pathogen loads in enclosed indoor air and can be considered for dual use (military/civilian) applications. These broadly can be categorized into passive pathogen trapping/deactivating technologies (those where the pathogen must be carried in the air to the technology) and active pathogen scavenging (where the technology emits a charged substance that either inactivates, sequesters, or kills the pathogen). Each technology has strengths and weaknesses but broadly all show promise in protecting against COVID and other pathogens. The presentation will review published, unpublished, and independent studies and discuss strength of evidence supporting the use of each technology individually and in sequence.

Learning Objectives
1. Understand the concepts of ventilation and air exchanges per hour and how they may decrease the risk of airborne pathogen transmission.
2. Understand the limitations of increasing air exchanges per hour and how established technologies may augment our ability to increase air exchanges.
3. Understand "Active Pathogen Scavenging" and "Passive Pathogen Scavenging" technologies, the proposed mechanisms of action, limitations, and strength of evidence supporting their use in COVID and future Bio-Threats.

[95] REPORT FROM THE AIR UNIVERSITY: RESULTS OF THE COVID "SURVIVE TO OPERATE" WORKING GROUP

Paul Nelson
Mission-Next Foundation, Oxford, MS, USA

Education - Program/Process Review

BACKGROUND: During a five-month period, from March through July 2020, the Air Force Surgeon General's Task Force at the Air University, in partnership with the Air University Visiting Scholars Program, other Air Force, Department of Defense, civilian academics, practitioners, and operators developed a body of unclassified research focused on novel or creative solutions to help win the "War on COVID." This presentation will summarize this body of work with the benefit of hindsight. **OVERVIEW:** The Air University represents a unique asset with the ability to think critically about strategic, operational, and tactical challenges as a national think tank. Through the Air University Visiting Scholars program and other programs, diverse subject matter experts were leveraged real-time to provide solutions to challenging military problems. Since waging a total war against COVID means the society must "survives to operate" through the pandemic, and with each of our society's designated critical infrastructure sectors considered "dual-use" (military/civilian), our warfighting strategy must account for protecting both military combatants and civilian personnel. **DISCUSSION:** The American civilian population, the military, and each of our critical infrastructure sectors demonstrated significant vulnerabilities to the COVID pandemic, illustrating real concern for a future bio-attack that could be either stand-alone or a part of hybrid warfare. Therefore, the group advocates for a methodical and systematic hardening the national critical infrastructure sectors to deter and defend from future bio-attacks.

Learning Objectives
1. Understand how the NIOSH Hierarchy of Controls can be applied systematically to harden the 16 national critical infrastructure sectors.
2. Understand the concepts of developing and deploying a "Multi-Layered Air Defense" model to protect the people who operate the critical infrastructure sectors.

[96] IF WE ARE EVEN PARTLY RIGHT, WHY WERE WE SO WRONG… WHAT SHOULD WE DO NOW?

Paul K Carlton Jr.[1], Paul Nelson[2]
[1]*Independent Shared Air Strategic Research Board, Oxford, MS, USA;*
[2]*Mission-Next Foundation, Oxford, MS, USA*

Education - Program/Process Review

BACKGROUND: The United States was slow to recognize the importance of indoor air in protecting both the American civilian population and the military at the beginning of the pandemic. Some good news is an emphasis on and investment in enhanced therapeutics and a rapidly developed and deployed vaccine. However, even as of this panel submission, we have not seen a similar investment or focus on ensuring clean indoor air. Based upon the research at Air University and later the Independent Shared Air Strategic Research Group, these are systematic issues that must be addressed to protect our shared air against future bio-threats, regardless of etiology. **OVERVIEW**: When the Air University and the Independent Shared Air Strategic Research Board analyzed the challenges of effective pandemic response, several themes emerged. As a root cause, the nation failed strategically to characterize the nature of the War on COVID, what winning might look like, and how to measure winning (or losing). Without an effective strategy we would, as a country, under-perform even though we are among the richest and most powerful nations with some of the strongest institutions and public health capabilities in the world. Additionally, all our national critical infrastructure shares several vulnerabilities, which include funding streams optimized for profit and not resiliency as well as cyber and human domain vulnerabilities. Because the problems are cross functional, the solutions must also be approached cross-functionally. However, our professional disciplines are not organized, funded, or incentivized to break their respective stovepipes of excellence. **DISCUSSION**: This provides a unique opportunity for the disciplines of Aerospace and Preventive Medicine to lead. They are uniquely positioned to help these national efforts. Our disciplines are accustomed to focusing on operations where risk is mitigated, not eliminated. Further, they frequently cross disciplines, not only with other medical professionals, but also engage cross functionally with other professionals to include but not limited to public health, community engagement, strategic communications, environmental and engineering disciplines.

Learning Objectives
1. Understand systemic reasons why the United States underperformed in our COVID response.
2. Understand the role that Aerospace and Preventive Medical specialties can play in helping to lead a national response towards more resilient national infrastructures in a whole of society approach.
3. Understand what options we have collectively and individually should do to advocate for a more pandemic-proof society in the future.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany F

[S-21]: SLIDES: AERO AND SPACE RELATED TRAINING

Chair: Marc Shepanek
Co-Chair: Brian Musselman

[97] CREW AND CREW-GROUND INTERPERSONAL ISSUES DURING AN EXPEDITION TO MARS

Nick Kanas
University of CA, San Francisco, San Francisco, CA, USA

Education - Tutorial/Review

INTRODUCTION: Mars is a long way from us, ranging from 55 million kilometres at its closest opposition to 401 million kilometres when it is farthest away on the other side of the Sun. As a result, two-way communication between astronauts on Mars and people on the Earth can be delayed by as much as 44 minutes, and current planning for a Mars expedition (outbound, planetary exploration. return) anticipates a mission lasting 2-3 years. These issues will impact greatly on the crewmembers and their relationship with people back home. Behavioral health and team research studies conducted on-orbit on the Mir and International Space Stations and during Mars-relevant space simulation studies on Earth were reviewed in order to identify unique interpersonal stressors that could affect the success of a Mars expedition. **TOPIC:** Stressors identified include: the limited number of social contacts over a long period of time, the impact of national and organizational culture on team performance, increased crew autonomy and its influence on the role of mission control, communication delays with family and friends back home, and the potential interpersonal impact of severe isolation due to the Disappearing Earth phenomenon. These stressors may produce personality conflicts, drops in crewmember morale, loss of team cohesion, crew tension that may be displaced to people on Earth, and confusion in leadership roles. **APPLICATION:** It is important that these interpersonal issues be understood so that proper countermeasures can be established to lessen their effects and enhance the possibility of mission success. Possible countermeasures will be discussed, such as periodic "bull sessions" to

ameliorate crew tension, steps to enhance communication efficiency in order to deal with time delays, and the use of virtual reality or an on-board telescope to counter views of a nearly invisible Earth. **RESOURCES:** [1] Kanas N. (2015) *Humans in Space: The Psychological Hurdles*. Switzerland, Springer International Publishing. [2] Kanas, N. (2020) Spirituality, humanism, and the Overview Effect during manned space missions, *Acta Astronaut* 166, 525-528.

Learning Objectives

1. Based upon on-orbit research and Mars simulation studies on Earth, the audience will learn about unique interpersonal stressors that may impact on crewmembers and mission control personnel during a Mars expedition.
2. The audience will learn about possible countermeasures that can be implemented to mitigate the effects of interpersonal stressors during a Mars expedition.

[98] A SUPPORT MODEL FOR ADVANCED FLIGHT TRAINING SYSTEM USING EYE-TRACKING AND FLIGHT SIMULATORS

Mariusz Pietrzyk
[1]*The Military Institute of Aviation Medicine, Warsaw, Poland*

Original Research

OBJECTIVE: To develop a model to support the pilot training system using the eye movement monitoring method and flight simulator under G-Force. **METHOD:** A group of about 15 pilots of master class instructors with extensive aviation experience and about 15 cadets of the Polish Air Force Academy at the beginning stages of aerial training conducted a series of tasks in the flight simulation under G-Force. These focus on Air to Ground and Basic Fighter Maneuvers, including flight operations with VFR visibility, IFR procedures - in simulated conditions of lack of visibility, and IFR procedures - in the absence of ground visibility. Experiments were conducted using an overload centrifuge for the MIG-29 flight simulator. The vision system of the simulator provides a wide field of view (120x70°) and high-resolution images required to visualize the terrain and aerial situation in all lighting and weather conditions. The cockpit equipment is highly responsive to the actual aircraft provides over 90% compliance, allowing for a high-fidelity reconstruction of situations occurring during real flights. Eye-tracking was facilitated with The GLASSES portable google sensor manufactured by Sensomotoric Instruments GmBH (SMI, Tetlow, Germany). We evaluated the following metrics: total and proportional time of perception, length and frequency of fixations and their clusters, the amplitude and direction of saccades. **RESULTS:** The eye-tracking metrics were significantly different between the two groups of pilots. The outcomes enabled the modelling of the ideal pilot operative characteristics used to aid the assessment of performing tasks. CONCLUSION: We proposed an eye-tracking technique for advanced pilot training. It is to provide an instructor with a view of the pilot's eye movements along with the results of this analysis. Such an approach would equip the instructor with tools to quantify performance and potentially reduce mental overload.

Learning Objectives

1. Visual Perception and attention distribution analysis while performing flight tasks.
2. The impact of flight experience on visual fixation allocation and saccades direction.
3. Proposed model for aided pilot training.

[99] IS IT BETTER TO WATCH OR LISTEN? A RANDOMIZED TRIAL OF VIDEO-MODELLING VS TELEMENTORING FOR INTERVENTIONS PERFORMED BY SEARCH AND RESCUE MEDICS

Jessica McKee[1], Corey Tomlinson[2], Nigel Donley[3], Juan Wachs[4], Andrew Kirkpatrick[1]
[1]*University of Calgary, Calgary, Alberta, Canada;* [2]*Canadian Forces, Ottawa, Ontario, Canada;* [3]*R19 Wing and 422 Squadron Search Air Rescue, Comox, British Columbia, Canada;* [4]*Purdue University, West Lafayette, IN, USA*

Original Research

INTRODUCTION: Impacting survival from catastrophic trauma in both the military and civilian environments will require life-saving interventions (LSIs) to be delivered in the prehospital phase of care where provider skills and experience are limited. Informatic technologies may provide a force-enabler capability in potentially allowing less experienced providers to perform LSIs. Two candidate technologies are remote telementoring(RTM) or video modelling(VM). Although using VM is ubiquitous in everyday life, little has been done investigating the utility of VM to improve performance during LSIs. We compared Search and Rescue (SAR) Techs performance of LSIs when randomized to either RTM, VM or neither. **METHODS:** SAR Techs were asked to perform three tasks: iTClamp, CAT and SAM tourniquet application For CAT Tourniquet application they were randomized to one of three groups i) Video-Modelling (VM) ii) Telementoring (TM) iii) control. For the SAM and iTClamp application they were randomly allocated to one of two groups i) TM or II) VM. **RESULTS:** 24 SAR Techs participated. There were 8 SAR Techs in each of the three CAT tourniquet groups. Comparing mentored to control there was no significant difference in time to stop bleeding(p=0.798), total trial time(p=0.328) or blood loss(p=0.878). However, the mentored group was able to obtain significantly more tourniquet pressure than control(p=0.005). The Control group was significantly faster than Video modelling in controlling the bleed (p=0.000) and total trial time(p=0.000), although tourniquet pressure(p=0.279) and blood loss(p=0.721) were not different. There was no control group for SAM tourniquet application(12 VM; 12 RTM). The mentored group was significantly faster(p=0.000) in both the time to stop bleeding and total trial time. However, there was no difference in tourniquet pressure(p=0.198) or blood loss(p=0.799). In those mentored, time to stop bleeding was significantly faster with the CAT(p=0.010) than the SAM, with a significantly higher tourniquet pressure(p=0.001). Twelve RTM and 12 VM applied the iTClamp. Telementoring was significantly faster (p=0.000) than video modelling. **DISCUSSION:** In this study setting, there were apparent objective and subjective benefits between real-time tele-mentoring versus video modelling. Thus, both techniques may have merits and further controlled studies should continue.

Learning Objectives

1. To Discuss the epidemiology of trauma death in relation to the gaps in care required to address these deaths.
2. To describe the potential techniques of real-time Telementoring and just-in-time video modelling as solutions to enhance far-forward life-saving-interventions.
3. To explore differences in performance metrics between real-time Telementoring and just-in-time video-modelling.

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

Claire Goldie[1], Clay Woody[2], Kevin O'Brien[1], Chris Aura[1], Cristina Delgado-Howard[1]
[1]*USAARL, Fort Rucker, AL, USA;* [2]*ORCEN, West Point, NY, USA;*

Original Research

BACKGROUND: Aviator Training Next (ATN) was recently introduced into the U.S. Army's Initial Entry Rotary Wing training curriculum and sought to compare the effectiveness of part-virtual reality (VR) flight training against traditional training methods. Students were semi-randomly allocated to either a control (non-VR) or experimental (VR) group. In support, USAARL developed and analyzed data from 3 flight student questionnaires, designed to gather demographic information about the students in each group, determine any correlations between demographic characteristics and flight performance, and compare physiological responses to VR and live flying between the 2 groups. **METHODS:** Raw questionnaire data were processed and encoded using Python code developed at the USAARL. The data were then split into VR and non-VR groups for comparative analysis. Various statistical tests were applied to the data, depending on data type and

normality. The outputs were then used to generate descriptive demographic and physiological response statistics for each group, check for group differences and, using Spearman's correlation, test for any associations between the demographic or physiological variables and flight performance. **RESULTS:** A total of 361 non-VR and 300 VR students were included in the analysis. Demographically the 2 groups were generally split equitably and none of the demographic or physiological variables showed any significant correlation with performance. Sickness reporting rates were low in both groups but the VR group reported earlier onset and greater severity for eye strain and nausea. They also declared more prolonged symptoms (> 1 hour) after VR flight. Both groups appeared to show adaptation with a longitudinal reduction in reporting rates. Female students reported more (non-significant) symptoms during training but there was no difference in performance outcomes by gender. **DISCUSSION:** Individual demographic variables did not impact the observed performance scores for either group, suggesting that those who meet the selection criteria for flight school are likely to succeed, irrespective of individual characteristics. This highly selected population also shows low physiological response rates to aviation-related motion stimuli. However, VR appears to generate more symptoms in some, and these may be more severe and last longer. Nonetheless, students appear to adapt well over time to VR, with little difference in training outcomes between the 2 groups.

Learning Objectives

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

[101] TWO-PHASE MOTION SICKNESS EXPERIMENTATION MODEL AMONG THE MILITARY MEDICAL STUDENT TRAINING IN TAIWAN

Chung-Yu Lai[1], Hsin Chu[2], Min-Yu Tu[3], Kwo-Tsao Chiang[4]

[1]*Institute of Aerospace and Undersea Medicine, National Defense Medical Center, Taipei City, Taiwan (Greater China;* [2]*Civil Aviation Medical Center, Taipei City, Taiwan (Greater China;* [3]*Aviation Physiology Research Laboratory, Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan (Greater China;* [4]*Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan (Greater China)*

Original Research

INTRODUCTION: Airsickness will degrade pilots' performance and even endanger flight safety. Military medical students are obligated to serve in the military base for two years after graduation and are responsible for taking care of pilots. It is essential for future flight surgeons to be familiar with motion sickness. The purpose was to evaluate a two-phase model for those students to experience airsickness symptoms and test their susceptibility to motion sickness. **METHODS:** A two-phase motion sickness experimentation model was included in the clerkship training program conducted by Aviation Physiology Research Laboratory since 2018. This model includes an initial subjective susceptibility assessment phase, followed by a physical tolerance test phase. Motion Sickness Susceptibility Questionnaire Short-form (MSSQ-Short) was used to evaluate the susceptibility of participating medical students based on their experience to motion stimuli in childhood and adulthood. Coriolis cross-coupling stimulation on an electrical rotary chair was applied to test the physical tolerance of these students. The maximal tolerable spinning rate on the rotary chair is used as an index of physical tolerance. Association between the MSSQ susceptibility score and maximal spinning speed is analyzed using SPSS 24 software. **RESULTS:** 57 medical students (38.6% female gender) with an average age of 23.1 years voluntarily completed this training during the clerkship. This group showed comparable mean childhood and adulthood MSSQ scores. However, an inverse correlation between MSSQ score and tolerance to rotary chair induced motion sickness were observed (spinning speed in MSSQ score ≥ 20 vs. MSSQ score <20 groups: 11.3 vs. 18.7 RPM; P <0.001). **DISCUSSION AND CONCLUSIONS:** The experimentation model in the aerospace medicine program provides military medical students with first-hand experience of motion sickness and allows them to correlate past experiences of motion sickness with symptoms under stimuli. A two-phase motion sickness experimentation model, combining past experience with the symptoms in a simulator, is a good tool and can be used to emphasize the importance of practical aerospace medicine training in clerkship. Meanwhile, this tool promotes students' ability to link their knowledge of clinical specialty to aerospace medicine.

Learning Objectives

1. The participant will be able to learn the relationship of motion sickness between childhood and adulthood stages.
2. The participant will be able to understand the military medical students in Taiwan.

[102] TRINITY VIRTUAL REALITY TRAINING ENVIRONMENT AND ADAPTIVE TRAINING ALGORITHM FOR LONG DURATION HUMAN SPACEFLIGHT

Allison Anderson, Abhishektha Boppana, Esther Putman, Quinlan Lewis, Benjamin Peterson, Torin Clark

University of Colorado Boulder, Boulder, CO, USA

Original Research

INTRODUCTION: Historically, NASA has led the way in virtual reality (VR) technology development to train astronauts for microgravity environments. Long duration exploration missions (LDEM) will require crews to maintain skills on tasks such as entry descent and landing (EDL), habitat maintenance and repair, and planetary surface extravehicular activity (EVA). To be successful, performance on these tasks will need to be maintained after high-fidelity training on Earth pre-mission and refreshed during transit prior to execution on the surface. **METHODS:** We develop a training environment for mission critical LDEM tasks. Our multi-environment virtual training simulator, called **Trinity** includes three environments focused on Mars mission concepts: EDL, habitat maintenance/repair, and EVA using a surface rover. Trinity is presented using a head-mounted-display (HMD, HTC Vive Pro). Task difficulty is adaptively scale with user-specific acquisition of skills. **RESULTS:** We assess skills transfer going from the virtual training environment to a high-fidelity test environment (physical mock-up) in human subject experiments. We also present our novel lock-step adaptive training algorithm adjusts difficulty based on the participant's performance using a common two-up, one-down (2U1D) staircase, where two consecutive correct responses are needed to progress to the next level and a single incorrect response drops participants down a level. Critically, the 2U1D staircase is adapted to ensure all dimensions of performance progress in a synchronized manner, such that participants acquire skills in an integrated fashion. This is a critical component automating training for complex, operationally relevant tasks. **DISCUSSION:** This research investigates the use of immersive, adaptive VR environments to train astronauts specifically designed for LDEMs by 1. Incorporating multiple, mission critical tasks for a mission to Mars; 2. Investigating skills transfer, retention, and generalizability; 3. Designing with low volume, mass, and operational overhead; and 4. Investigating the degree to which the proposed training can also provide secondary benefits of broad brain stimulation.

[This material is based upon work supported by the National Aeronautics and Space Administration under Grant/Contract/Agreement No. 80NSSC21K1140.]

Learning Objectives

1. Understand the utility of VR training for long duration exploration spaceflight missions in a low mass, power, and volume configuration.
2. Understand how adaptive training algorithms enable user specific skills acquisition.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany 3

[S-22]: PANEL: CULTIVATING THE IDEAL CREW MEDICAL/SURGICAL OFFICER FOR EXPLORATION-CLASS SPACE MISSIONS

Sponsored by Space Surgery Association

Chair: Danielle Carroll
Co-Chair: Peter Lee

PANEL OVERVIEW: *Medical and surgical pathology both pose profound risk to crews on missions to austere environments, including deep space. The ideal crew physician for exploration-class spaceflight should possess a diverse, robust skill set that can ensure the proper care of a variety of disease processes on any long-duration missions that preclude real-time communication with terrestrial resources. This panel will discuss the surgical and procedural capabilities that should be possessed by the ideal crew physician, and will provide recommendations for several approaches in cultivating the optimal skill set to ensure crew health and well-being on long-duration missions. Laying the foundation for surgical needs in the spaceflight context, Dr. Brown will begin the panel by providing an overview of the medical and surgical risks in the exploration-class mission setting. The panel will then transition to a discussion of specific skill set requirements, wherein Dr. Lee will discuss the results of a multi-centered survey of surgical subspecialists who weighed in on the level of complexity and training requirements involved in establishing proficiency in a set of surgical procedures that align with NASA's top Human System Risks. Dr. Formanek will then discuss the use of spaceflight analogues to serve as a mechanism for training and maintenance of proficiency for anesthetic care. Dr. Pohlen will provide an analysis of available portable imaging modalities and detail a plan for best utilizing the available imaging tools for guidance of interventional medical procedures in the spaceflight environment. Lastly, Mr. Whitlock will provide a summary of the Space Surgery Association's research mentor database, a novel mechanism for pairing ongoing projects with colleagues and research assistants with complementary skill sets, to facilitate ongoing work in the burgeoning field of Space Surgery.*

[103] SURGICAL CONSIDERATIONS FOR HUMAN SPACE FLIGHT

Lisa Brown
University of Auckland, Auckland, New Zealand

Education - Program/Process Review

BACKGROUND: Managing the health of space flight participants requires a thorough knowledge of all potential medical and surgical risks encountered. With the advent of commercial space flight as well as longer duration missions planned to the Moon and Mars the breadth of conditions is vast. NASA has profiled through the Integrated Medical Model and published an Accepted Medical Condition list identifying the most likely encountered conditions during flight. Many of these conditions when encountered in standard clinical practice within the terrestrial Hospital setting are managed by Surgical services. Further, many of the worst-case scenarios in space flight also require an invasive surgical solution such as limited surgical stabilisation of fractures or surgical drainage of abscesses. A detailed surgical approach and understanding of how to manage these risks is thus important. **OVERVIEW:** The surgical risks that require consideration for space flight can be broadly categorised based on: 1) the duration and extent of space flight out of lower earth orbit and 2) the medical profile of the space flight participants. Trauma and infection have been identified as the two most likely groups of conditions encountered during flight, these encompass many potential surgical risks. Longer duration flights have increased physiological risk due to: radiation exposure, prolonged microgravity and distance from advanced care. Surgical conditions (including appendicitis, cholecystitis, diverticulitis) could develop over a mission with the resultant complication such as abscess formation requiring management with surgical drainage or limited surgery. In planning extended duration missions out of lower earth orbit with terraformed colonies the ability to manage more complex scenarios such as mass casualty incidents and stabilisation of patients using advanced critical care is required. The management of surgical risks during space flight also requires the presence of medical device technology to help manage these conditions. Vehicle capacity and advances in technology including robotics are significant considerations. **DISCUSSION:** Crew medical officers need to be well versed in surgical techniques to be able to manage any surgical conditions encountered on space flight. This requires pre-emptive training on human anatomy, physiology, surgical techniques and the use of technological adjuncts and microgravity specific surgical devices.

Learning Objectives

1. The audience will learn of the surgical risks that require consideration for human space flight.
2. The audience will be able to give consideration to the requirements needed by a crew medical officer to be able to mitigate surgical risks during space flight.

[104] ARE SURGEONS NECESSARY FOR AN EXPLORATION CLASS MISSION?

Peter Lee[1], Danielle Carroll[2], Tovy Kamine[3]
[1]*Brown University, Providence, RI, USA;* [2]*University of Colorado Boulder, Boulder, CO, USA;* [3]*Baystate Medical Center, Springfield, MA*

Education - Program/Process Review

BACKGROUND: While there is no debate as to the need of a physician on a future exploration class mission, the need for a surgeon is much less clear. While it would be ideal to have a fully trained surgeon as part of this future crew, practical limitations may make this difficult. Therefore, there is a need to understand the numerous factors that impact whether such a future crew should necessarily include a surgeon or not. **OVERVIEW:** While many opinions and anecdotes have been offered as to whether a surgeon is needed on a future exploration class mission, objective evidence has been limited and difficult to obtain. Here, we describe the full range of factors that may impact this decision. These factors include, but are not limited to a balance between 1) the need for a surgeon based on anticipated medical and surgical conditions, 2) the trade-offs required in order to include a surgeon as opposed to a non-surgeon physician, and 3) a determination of what are acceptable risks and conditions that would not be able to be treated, should they occur. Objective data are offered based on surveys of academic surgeons of all major surgical specialties who were asked, for a wide range of surgical procedures, how many procedures would be required for a surgeon and non-surgeon physician to perform to become proficient. While non-surgeon physicians can be trained to perform a wide range of discrete surgical procedures (e.g. appendectomy, cholecystectomy), certain procedures require fully trained surgeons to perform adequately (e.g. exploratory laparotomy with repair of any injuries found). Further research and discussions are necessary before this debate can be resolved. **DISCUSSION:** With the anticipated limited number of crew members that would be on a future near-term exploration class mission, the make up and skills of every crew member is of paramount importance. The surgical capability of this future mission will be, at least in large part, dependent on the skills of the physician crew member(s). The final determination as to whether it will be acceptable to not have a surgeon as part of the final crew will be based on a delicate balance between practical limitations and acceptable medical/surgical risks and even potential loss of life on this future mission.

Learning Objectives

1. We aim to review the full range of factors, variables, and conditions that are relevant to the question of whether a surgeon is necessary for a future exploration class mission and to provide the learner a better understanding of the nuances involved in this ongoing debate.
2. This presentation also aims to provide some objective data regarding the practical possibilities and limitations of training non-surgeon physicians to perform the necessary surgical procedures for a future exploratory class mission.

[105] PERIOPERATIVE ANALOGUES FOR SPACEFLIGHT

Arthur Formanek[1], Tovy Kamine[2]
[1]*Brigham and Women's Hospital; Harvard Medical School, Boston, MA, USA;* [2]*Baystate Medical Center, Springfield, MA, USA*

Education - Program/Process Review

BACKGROUND: Perioperative care in spaceflight remains a great unknown, and a trained anesthesiologist may not be readily available. Two notable primate deaths under anesthesia after return from spaceflight highlight the risk of perioperative care in the spaceflight environment. Analogues to spaceflight perioperative care may be found both in resource limited environments which mirror the medical capabilities in spaceflight as well as physiologic analogues which mimic the physiologic effects of microgravity on anesthesia. **OVERVIEW:** For necessary training of anesthetic providers, several analogues including remote environments and developing nations may be examined. Provision of anesthetic care in developing nations or remote fields are appropriate resource analogues. Developing nations often do not have medically trained anesthetic providers, supplies, medications, and monitors deemed as necessary medical equipment, and mortality is dramatically higher in these environments as a consequence. The training paradigm for proficiency in perioperative tasks in these environments may be used as a guide for minimum necessary training for a crew medical officer. From a physiologic standpoint, the alterations in the sympathetic nervous system and parasympathetic nervous system in response to microgravity have profound implications on the safe administration of anesthesia and perioperative care. Certain disease processes such as a functional ileus and Shy-Drager syndrome may be used as physiologic analogues to study the possible effects of patients undergoing surgery during spaceflight or immediately after return to Earth. **DISCUSSION:** For perioperative care to be safely administered peri-spaceflight, knowing the minimum necessary training to provide safe care is needed. Furthermore, great understanding of interaction between the physiologic changes of microgravity and anesthetics is necessary. Studying terrestrial analogues provides a useful body of knowledge to draw from in order to create an anesthetic plan.

Learning Objectives

1. The participate will learn about useful terrestrial analogues for safe delivery of perioperative care.
2. The participant will understand the alterations in the autonomic nervous system from microgravity and the risk posed to safe perioperative care.
3. The participant will learn about methods of delivery perioperative care in remote environments.

[106] PRACTICAL USE OF PORTABLE IMAGING MODALITIES FOR DIAGNOSTIC AND PROCEDURAL GUIDANCE INFLIGHT

Michael Pohlen[1], Danielle Carroll[2]
[1]*Stanford University, Redwood City, CA, USA;* [2]*University of Colorado, Boulder, CO, USA*

Education - Tutorial/Review

INTRODUCTION: Medical imaging plays a vital role in the prevention, diagnosis, and treatment of surgical pathology in the modern terrestrial healthcare environment. As exploration-class missions increase demands for the independent provision of complex care, the ideal crew medical/surgical officer must become comfortable with the performance and interpretation of diagnostic imaging and the use of imaging in procedural guidance. **TOPIC:** Ultrasonography has been a well-tested tool within the medical kit aboard the International Space Station for over two decades with its use studied extensively for the diagnosis of numerous medical conditions. Less examined is its potential for interventional guidance in spaceflight. Ultrasound is central to many minimally invasive procedures which have clear utility for the unique pathologies of the resource-constrained spaceflight environment. Likely applications of ultrasound guidance on exploration-class missions include vascular access, percutaneous nephrostomy and cholecystostomy, abscess drainage, nerve blocks, joint aspirations/injections, foreign body retrieval, and thoracentesis, among others. Successful execution of many of these procedures will require dedicated pre-mission training, though performance can be augmented with AI and ground-based teleradiology support. Advanced ultrasound techniques have potential to extend the utility of the modality, including 3D and 4D imaging to reduce operator dependence, facilitate deep-learning algorithms, and improve surgical planning. Additionally, recent advances in contrast-enhanced ultrasound and ultrasound elastography may provide improved preoperative lesion visualization and characterization. Lastly, should future power, mass, and volume limitations allow, use of non-sonographic modalities may prove valuable, including small portable digital radiography units which may enable limited procedural fluoroscopic guidance. **APPLICATION:** Development and implementation of portable and easy-to-use imaging modalities for a non-radiologist crew medical/surgical officer should be prioritized during mission planning to provide an acceptable standard of care via prompt diagnosis and treatment of a variety of surgical conditions. These modalities should be augmented with interpretive support from terrestrial teleradiology and AI. Such systems will prove valuable not only in long-duration spaceflight, but for procedural work in limited resource and remote settings on Earth.

Learning Objectives

1. Explore current and near future options for portable imaging which may be useful in the spaceflight setting.
2. Understand the role of portable imaging for procedural guidance inflight.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany 4

[S-23]: PANEL: TAKE A DEEP BREATH: NATO RTG 299 PULMONARY SCREENING AND MANAGEMENT IN AIRCREW

Chair: Dara Regn
Co-Chair: Erik Frijters

PANEL OVERVIEW: *The adverse mission impact of respiratory complaints cannot be understated as the recent increases in occurrences of unexplained physiologic events in military aircraft often described as "hypoxia like" have resulted in mission stand downs. This, combined with poor air quality in our current deployed environments and increasing global prevalence of respiratory diseases has highlighted the need for routine baseline pulmonary screening and need for examination of best practices for evaluation and treatment of pulmonary complications in our aviators. In our continued NATO multinational military aviator operations and training, it is therefore important to come to a consensus on the best practices on the pulmonary screening and care of our aviators to maintain optimal pulmonary function and performance, and to maintain and expand our aviator pool. In many medical areas we have found traditional civilian based recommendations do not meet the needs of our aviation population due to pilots' unique physiologic stresses of their operational environment, and deployments. In this panel we will discuss: the unique pulmonary physiologic stresses in the operational environment with consideration also given to increasing prevalence of respiratory diseases such as asthma and now COVID-19 in the general population, current statistics on our aviators pulmonary function over the last 5 years to determine a baseline in this population, examine pilot pulmonary screening algorithms amongst NATO and allied nations and discuss the impact of COVID 19 on these practices and finally examine prevalence of asthma in our NATO and allied nation pilots. Ultimately, the goal of RTG 299 is to minimize risk to our aviators by reducing risk of occurrence of pulmonary physiologic events in flight and optimizing pulmonary function of our operators.*

[107] PULMONARY FUNCTION IN AVIATORS: WHY WE NEED PULMONARY SCREENING AND STANDARDS

Dara Regn[1], Erik Frijters[2], Gary Gray[3], Norbert Guettler[4], Kartsten Lindgaard[5], Alaistair Bushby[6], Tuomo Leino[7]
[1]*USAFSAM, WPAFB, OH, USA;* [2]*Center for Man in Aviation, Royal Netherlands Air Force, Soesterberg, Netherlands;* [3]*CFEME/Medical Services Department of National Defense Canada, Toronto, Canada;* [4]*Air Force Centre of Aerospace Medicine, Cologne, Germany;* [5]*Danish Defense Medical Command, Aviation Medicine Center, Skrydstrup AFB, Denmark;* [6]*Centre of Aviation Medicine, RAF Henlow, United Kingdom;* [7]*Air Force Command, Tikkakoski, Finland*

Original Research

In this section, we will discuss the literature regarding pulmonary physiology in the aeromedical context and NATO pulmonary standards. It has been well established in the medical literature since the 1940s that pulmonary function superior to that of the general population is a physical requirement of military aviators given physiologic stresses of aviation. Unfortunately however, there has been a global increase in prevalence of diseases that reduce pulmonary function such as clinical asthma, premature births and now COVID 19. We have found these statistics are reflected in our aviation applicants therefore making it all the more critical that we effectively utilize pulmonary screening and standards. The current NATO pilot training pipeline requires applicants to undergo medical screening in accordance with each country's initial applicant medical standards. The investment in these applicants is considerable. For example, to train a pilot applicant to fly a next generation warfighter is a considerable time and financial investment as high as $30M (USD). The final determination of what airframe the medically cleared and trained applicant will ultimately fly is left to the line to determine based upon member's performance assessments in undergraduate pilot training (UPT). Therefore, given the significant investment in the candidate, initial applicant screening criterion are traditionally more stringent than those of trained assets, with recommendations limiting applicants to specific airframes due to medical reasons being rare and requiring exception to policy. NATO Air Forces' pulmonary function standards will be discussed in this section as well as current respiratory issues facing our high-performance aviators, to include rates of "unexplained physiologic events or UPEs" often described as "hypoxia like". In conclusion, we will put forth pulmonary standard recommendations based upon the clinical research findings of the NATO RTG 299.

Learning Objectives

1. Understand the changes in pulmonary physiology in general aviation.
2. Understand the unique physiologic changes in high performance aviation.

[108] CURRENT NATO POLICIES ON PULMONARY SCREENING AND ACCEPTABLE PULMONARY CONDITIONS IN MILITARY PILOTS

Erik Frijters[1], Karsten Lindgaard[2]
[1]*Center for Man in Aviation, Royal Netherlands Air Force, Soesterberg, Netherlands;* [2]*Danish Defense Medical Command, Skrydstrup AFB, Denmark*

Original Research

INTRODUCTION: Military pilots are subjected to extreme physical demands, particularly in high performance jet aircraft. The use of on-board oxygen systems, decreased cabin pressures and flying with survival gear place a heavy burden on pilot pulmonary function. In contrast, rotary wing pilots are subject to pulmonary stresses due to underwater egress training requirements and the need to operate in forward positions where the climatic conditions may not be controlled. Acceptable pulmonary function required for flying military aircraft is not well documented. Currently, it is unclear how different NATO countries perform pulmonary screening and what is deemed acceptable. **METHODS:** In order to identify current policy in NATO countries, a questionnaire was sent out to 29 partner nations. Questions were asked about which regulations were used, by which means pulmonary function is assessed and which pulmonary conditions and medication are deemed acceptable for pilot applicants and pilots. **RESULTS:** Eleven completed questionnaires were returned. Ten out of eleven countries do pulmonary function testing (PFT) using spirometry on pilot applicants, six out of eleven do PFT on every medical exam, most commonly assessing FVC, FEV1, FEV1/FVC, PEF. There are notable differences in acceptable pulmonary conditions and allowing medication. **DISCUSSION:** Differences in screening for respiratory conditions and for acceptable medication were identified using a questionnaire. This study supports a more uniform and "best practice" oriented procedure towards pulmonary screening of military pilots.

Learning Objectives

1. Identify differences in pulmonary screening policies in pilot applicants and military pilots.
2. Identify current pulmonary standards and acceptable medication for NATO pilots.

[109] BASELINE PULMONARY FUNCTION IN NATO PILOT APPLICANTS OVER A FIVE YEAR PERIOD

Norbert Guettler[1], Dara Regn[2], Jared Haynes[3], Karsten Lindgaard[4], Gary Gray[5], Tuomo Leino[6], Alaistair Bushby[7], Erik Frijters[8]
[1]*Air Force Centre of Aerospace Medicine, Cologne, Germany;* [2]*711th Human Performance Wing, USAFSAM, Wright-Patterson AFB, OH, USA;* [3]*711th Human Performance Wing, USAFSAM, Wright-Patterson AFB, Dayton, OH, USA;* [4]*Danish Defense Medical Command, Aviation Medicine Center, Skrydstrup AFB, Denmark;* [5]*CFEME/Medical Services Department of National Defense, Toronto, Canada;* [6]*Air Force Command, Tikkakoski, Finland;* [7]*Centre of Aviation Medicine, RAF, Henlow, United Kingdom;* [8]*Center for Man in Aviation, Royal Netherlands Air Force, Soesterberg, Netherlands*

Original Research

INTRODUCTION: In our continued NATO multinational military aviator operations and training, it is important to come to a consensus on the best practices on the pulmonary screening and care of our aviators to maintain optimal pulmonary function and performance, and to maintain and expand our aviator pool. The purpose of this study was to assess baseline pulmonary function of pilot candidates over a five year period in NATO pilot applicants. **METHODS:** The demographics to include anthropometrics and spirometry of medically cleared pilot applicants in NATO were analyzed from 2012 to 2018. Participants included pilot candidates from 6 NATO countries (Canada, Denmark, Germany, Netherlands, United Kingdom, United States). The parameters analyzed include anthropometric data, actual and percent predicted forced vital capacity (FVC), forced expiratory volume (FEV1) and FEV1/FVC ratio. **RESULTS:** Initial review of approximately 4339 candidates' data from 6 countries from 2012 to 2018 indicate that pilot candidates have superior pulmonary function compared to their age, gender, ethnicity and anthropometric matched peers in the general population used in commonly used reference databases such as National Health and Nutrition Databases (NHANES) and Global Lung Function Initiative (GLI) database. (Data analysis ongoing). **DISCUSSION:** Our preliminary study results reveal that at baseline, pilot candidates have superior lung function compared to their matched peers in commonly used reference databases such as NHANES and GLI. Theoretically, this would improve tolerance and performance in flight as it has been established that notably in high performance flight, aircrew flight equipment (AFE) such as ejection seat harnesses cause significant mechanical restriction and obstruction of baseline pulmonary function. In addition, this is in line with the high-performance pilot as an "elite athlete" paradigm. Defining "normal" pulmonary function in our aviation population will help us establish pulmonary function standards and further optimize pilot performance with early identification and intervention when they fall below these standards enhancing mission performance.

Learning Objectives

1. Learn that the assessment of baseline pulmonary function in pilot candidates is essential to determine tolerance to adverse physiologic impact of flight (ie reduced forced vital capacity (FVC), atelectasis etc).
2. Unterstand that the assessment of the impact of aircraft configuration and pilot flight equipment (PFE) on pilot pulmonary physiology will enable us to optimize pilot selection and performance.

[110] ASTHMA IN NATO PILOTS

Gary Gray[1], Alistair Bushby[2], Erik Fritjers[3], Norbert Guettler[4], Tuomo Leino[5], Karsten Lindgaard[6], Dara Regn[7]
[1]*CFEME, Toronto, Toronto, Ontario, Canada;* [2]*Royal Air CAM, RAF Henlow, UK, United Kingdom;* [3]*Center for Manned Aviation, Royal Netherlands AF, Soesterberg, Netherlands;* [4]*Center for Air and Space Medicine German AF, Fuerstenfeldbruck, Germany;* [5]*Air Force Command Finland, Tikkakoski, Finland;* [6]*Royal Danish Center for Aviation Medicine and Aviation Physiology, Air Base Karup, Denmark;* [7]*USAFSAM, Wright-Patterson AFB, Dayton, OH, USA*

Education - Program/Process Review

INTRODUCTION: Asthma is a significant aeromedical concern in both civilian and military aircrew. Acute asthma attacks in aircrew may result in mission compromise, or potentially affect flight safety. Even without an acute attack, an underlying asthmatic diathesis may adversely affect small airway function leading to increased ventilation-perfusion mismatch with hypoxemia potentially reducing G-tolerance and contributing to unexplained physiologic events (UPEs). The onset of asthma in trained pilots may result in loss of expensively trained resources. **METHODS:** A questionnaire was formulated by WG 299 to obtain information on the incidence of a new asthma diagnosis in participating-nation pilots over a 10 year period. Information on selection policy and acceptable treatments was also acquired. **RESULTS:** Initial data has been acquired from 7 participating Air Forces on over 28,000 pilots over a period up to 10 years. Preliminary data indicates an incidence of new asthma diagnosis of 0.7/1000 pilot-years with the majority of pilots being returned to active flying status, sometimes with operational restrictions. Most nations allow pilots to continue flying with medications including inhaled corticosteroids and long-acting bronchodilators. For most nations, candidates with a history of asthma may be accepted after further investigation. **Conclusion:** While asthma remains a significant aeromedical concern, it appears that with appropriate screening of applicants the incidence of asthma in trained pilots is low, with the majority being returned to at least restricted flying duties. Asthma remains a significant aeromedical concern potentially contributing to UPEs

Learning Objectives

1. Learn the incidence and prevalence of asthma amongst NATO pilots and aircrew.
2. Understand the potential for G-tolerance compromise and UPEs through asthma-induced small airway dysfunction.
3. Learn the screening tools used by NATO nations for assessing asthma.

Tuesday, 05/24/2022 ***10:30 AM***
Tuscany 12

[S-24]: PANEL: BEHAVIORAL HEALTH AND PERFORMANCE OPERATIONS AND RESEARCH IN HUMAN SPACEFLIGHT

Chair: Steve Vander Ark
Co-Chair: Gary Beven

PANEL OVERVIEW: *The Behavioral Health and Performance (BHP) specialists at NASA Johnson Space Center (JSC) share the goal of promoting optimal performance for astronauts during all phases of their career, beginning with the astronaut's selection to the NASA Astronaut Corps through their training for and completion of a spaceflight mission. The BHP Operations team supports areas such as astronaut selection and training, routine behavioral healthcare, and work-rest schedule; whereas, BHP Laboratory personnel conduct research in space and analog platforms to address the risks and other challenges astronauts will face during future deep space missions—research that align with the NASA Human Research Program's Human Factors Behavioral Performance Element goals. This panel will provide details of recent work conducted by the BHP Operations and the BHP Laboratory teams at NASA JSC, and will demonstrate their shared goals and their contributions toward optimizing performance and maintaining the behavioral health and well-being of astronauts during all mission phases. In 2020-2021, NASA conducted an astronaut applicant screening process to select its 23rd group of astronaut candidates. The BHP Operations team evaluated applicants and provided valuable input to the Astronaut Selection Board and the Aerospace Medical Board. The first presentation in this panel will summarize BHP's contribution to this selection process and will provide lessons learned for future astronaut selection cycles. The second presentation will discuss a critical competency that astronauts must possess to succeed—Team Orientation and will discuss how the BHP Operations team screens for this important skill and the challenges of assessing this competency. A third presentation will summarize BHP's current work on managing fatigue in astronauts and mission-critical operators at JSC (e.g., flight directors), and what these fatigue management services may include during future exploration missions. The last two presentations will focus on the research completed by the BHP Lab related to important measures of behavioral health and well-being. One presentation will provide an overview of the "exploration measures" program, describe its implementation across spaceflight analogs and ISS, and its importance for future research and operations. The final presentation will provide a detailed look at the relationship of two exploration measures— mood and affect as it relates to a high-fidelity robotics simulation task.*

[111] BEHAVIORAL COMPONENTS OF NASA'S 2021 ASTRONAUT SELECTION CYCLE

Gary Beven[1], Charles Dukes[2], Albert Holland[1], James Picano[4], Kimberly Seaton[2], Jana Tran[2], Steve Vander Ark[3]
[1]*NASA Johnson Space Center, Houston, TX, USA;* [2]*UTMB, Houston, TX, USA;* [3]*KBR, Houston, TX, USA*

Education - Tutorial/Review

INTRODUCTION: To successfully implement the behavioral aspects required to select and screen for long-duration missions on the International Space Station and for Artemis Program lunar missions, a multi-phase process combining best practice elements from the fields of industrial-organizational psychology, operational psychology, aerospace psychology and aerospace psychiatry, are needed. Furthermore, this process should preferably be implemented by professionals with extensive experience in human spaceflight operations. **TOPIC:** In late 2021, NASA completed the selection process for its 23rd class of astronaut candidates. NASA's multi-phase U.S. astronaut selection process identifies the most qualified astronaut candidates from a very large number of applicants. With the approaching end of the International Space Station program in 2028 and the advent of Artemis Program missions beyond low earth orbit and to the lunar surface, NASA focused on selecting those individuals who were most suited to the unique demands of long-duration spaceflight and the demands of future lunar missions. In total, NASA received 12,080 applications for the 2021 astronaut selection cycle. Of these 12,080 individuals, 120 were invited to NASA Johnson Space Center for round 1 initial screening and interviews, which consisted of an Astronaut Selection Board (ASB) preliminary interview, medical examinations, and psychological testing. Thirty individuals were then invited to return for round 2. This final round consisted of further medical testing, comprehensive behavioral assessments, psychiatric examinations, and a second ASB interview. After round 2, 10 astronaut candidates were ultimately chosen to initiate basic training in Houston. The contents, benefits, and lessons learned from implementing this phased astronaut selection process during the COVID pandemic will be discussed. The lessons learned can benefit the future selection of astronauts, whether for NASA or private spaceflight missions. **APPLICATION:** The need for a structured, multi-phase behavioral selection process that uses best practices from the fields operational psychology and aerospace psychiatry, preferably planned and implemented by personnel with extensive spaceflight operations experience, is required to ensure that this aspect of the astronaut candidate selection and screening process is successful.

Learning Objectives
1. Participants will learn the specific behavioral health and performance contributions to a NASA astronaut applicant screening process.
2. Participants will learn challenges introduced by the pandemic for this selection cycle's screening process.

[112] EVIDENCE-BASED PROCESS FOR ASSESSING TEAMWORK COMPETENCIES FOR HIGH-RISK, OPERATIONAL OCCUPATIONS

Isabel Bilotta[1], Alexa Doerr[1], Suzanne Bell[2], Al Holland[2], Jim Picano[2]
[1]*KBR, Houston, TX, USA;* [2]*NASA, Houston, TX, USA*

Education - Program/Process Review

BACKGROUND: We offer a detailed look at how behavioral competencies necessary for high-risk, operational jobs, including task- and person-oriented aspects of teamwork, leadership, and followership, should be defined and operationalized in context. These competencies are thought to positively predict performance in aerospace professions. Assessments in high stakes selection contexts and the way associated behavioral competencies are evaluated must be carefully considered to ensure that the best applicants are selected. We provide insight into the development and measurement process for these competencies in the context of astronaut selection, elaborating on critical competencies and describing challenges to measurement. **OVERVIEW:** When selecting applicants for high-risk, operational professions, care must be taken to appropriately conceptualize and operationalize the competencies that are most predictive of on-the-job performance. We developed behaviorally anchored rating scales (BARS) based an extensive, systematic review of the literature on teamwork, leadership, and followership. Refinement of the BARS occurred in tandem with the development of novel selection assessment exercises. The exercises simulated leadership and teamwork tasks that applicants would likely engage in on the job. Because they mimic job-relevant tasks, the behavioral assessments offer fidelity and predictive validity. We identified team orientation, which reflects a person's willingness to function as part of a team, as a particularly relevant competency. However, measuring team orientation proves challenging. It is not team- nor task-specific, making it difficult for evaluators to understand how to rate an *individual's* team orientation when they are operating within a group. For the astronaut selection context, this competency was broken down into person- and task-oriented components to reflect these nuances during evaluation. **DISCUSSION:** This work will educate AsMA professionals about a structured process, rooted in best practices from organizational and operational psychology, to define and operationalize behavioral competencies for selecting individuals for high stakes, operational occupations. We will elaborate on challenges to measurement and will demonstrate how the BARS were used to provide comprehensive anchors for raters to rely on when evaluating applicants.

Learning Objectives
1. Professionals will understand an evidence-based process for defining and operationalizing behavioral competencies necessary for selection in high-risk occupations.
2. Professionals will leave with knowledge of varied challenges to measuring and examining specific behavioral competencies (e.g., team orientation) in practice.

[113] AN OVERVIEW OF FATIGUE MANAGEMENT SERVICE AT NASA JOHNSON SPACE CENTER

Pamela Baskin[1], Charles Dukes[2]
[1]*KBR, Houston, TX, USA;* [2]*UTMB, Houston, TX, USA*

Education - Tutorial/Review

INTRODUCTION: In response to the operational need for fatigue-related countermeasures, NASA established a Fatigue Management Services (FMS) team in 2016. The role of the FMS is based on the approved *Guidelines for Management of Circadian Desynchrony in ISS Operations* (SSP 50480-ANX3) for fatigue management of astronauts and mission critical personnel. **TOPIC:** The primary objective of FMS is to bring all the fatigue management activities under the umbrella of the Space Medicine & Clinical Operations Division and Behavioral Health and Performance operational team; to centralize and formalize overall management, coordination and implementation of the fatigue management support; and to ensure the necessary level of focus is given to fatigue management for the various clients at Johnson Space Center: Astronauts, Flight Directors, Flight Controllers, Flight/Crew Surgeons, and other mission essential personnel completing shift work and/or international travel. The FMS standardized practice consists of the following six steps: Sleep Education and Training; Comprehensive Initial Assessment; Pre-Travel or Shift Work Assessment; Recommended Travel and Shift Work Schedules; Post-Travel or Shift Work Assessment; and a Follow-up Assessment. FMS focuses on an individualized fatigue management practice when providing clients with guidance of countermeasures. Available countermeasures are shift schedules, light exposure/avoidance, naps, relaxation training, and non-pharmacological and pharmacological medications to optimize well-being for mission support. During exploration missions outside of Low Earth Orbit, managing work/rest schedules will require increased autonomy. This will entail fatigue management countermeasures that will allow the crew to oversee their own well-being using tools that provide immediate feedback. Activities being considered include objective sleep and cognitive measures that provide real-time feedback, and a scheduling tool to assist in developing optimal performance schedules. Other novel countermeasures that may be useful are alpha stimulation for treatment of insomnia and relaxation practices for reducing anxiety and stress. **APPLICATION:** This presentation will provide an overview of JSC Fatigue Management Services for crewmembers during ISS and future exploration missions to manage fatigue and overall well-being. This presentation will allow for thought provoking discussions on current and future fatigue management countermeasures.

Learning Objectives
1. Participants will learn the importance of a formalized fatigue management program for spaceflight operations.
2. Participants will understand the fatigue management services that are being considered for exploration missions outside of low earth orbit.

[114] HUMAN FACTORS AND BEHAVIORAL PERFORMANCE EXPLORATION MEASURES: ASSESSING ASTRONAUT RISK

Suzanne Bell[1], Sheena Dev[2], Sara Whiting[2], Lauren Landon[2], Jennifer Miller[3], Diana Arias[3], Alaa Khader[3], Lindsey Sirianni[3], Cara Spencer[3], Sydney Begerowski[4], Pete Roma[2]
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Education - Tutorial/Review

INTRODUCTION: The Human Factors and Behavioral Performance Exploration Measures (HFBP-EM) suite is a set of standardized measures to assess behavioral health and performance risk related to future exploration class missions, and to support reduction of the Human Research Program's (HRP) Behavioral Medicine (BMed), Team, Sleep, and Human Systems Integration Architecture risks. This presentation will provide an overview of the HFBP-EM program, describe its implementation across spaceflight analogs and the international space station (ISS), and discuss analytical approaches to characterize risks of human spaceflight. **TOPIC:** HFBP-EM was collected during Human Exploration Research Analogs campaigns 4 and 5, and during the SIRIUS 19 mission in the Russian Ground Based Experiment Complex. A subset of the HFBP-EM suite was collected during spaceflight as part of HRP's Standard Measures in Spaceflight Project. Data was collected from a total of 55 multinational astronaut and astronaut-like crewmembers

(mean age: 39.5, SD = 7.6; 31% female; 91% with advanced degrees). Three broad categories of HFBP-EM data and their relevance to HRP risks will be discussed: 1) surveys that assess team functioning (Teams risk) as well as mood and affect (Bmed risk), 2) performance-based tasks of cognitive functioning and operationally relevant performance (Bmed risk), and 3) physiological biomarkers of sleep (sleep risk) and heart rate (Bmed risk). **APPLICATION:** Astronaut teams selected for future space exploration missions will face a number of challenges that pose significant yet still unknown risks to the behavioral health and performance of astronauts. The HFBP-EM suite provides a comprehensive assessment of behavioral health and performance in space analog and spaceflight settings. Evidence will characterize risk and inform mitigation strategies to maintain the high level of operational performance required of successful long duration space exploration missions.

Learning Objectives

1. To obtain knowledge on the coverage and content of the Human Factors Behavioral Performance Exploration Measures suite.
2. To understand the research and operational settings to which the Human Factors Behavioral Performance Exploration Measures suite could be applied.

[115] THE IMPACT OF MOOD AND AFFECT ON OPERATIONALLY RELEVANT PERFORMANCE AMONG ASTRONAUT-LIKE INDIVIDUALS IN SPACE ANALOG SETTINGS

Sheena Dev[1], Sara Whiting[1], Jennifer Miller[2], Millenia Young[3], Pete Roma[1], Suzanne Bell[3]
[1]*KBR, Houston, TX, USA;* [2]*JES Tech, Houston, TX, USA;* [3]*NASA, Houston, TX, USA*

Original Research

INTRODUCTION: Crewmembers of future space missions will face challenges associated with living and working in extreme conditions for long periods of time. The Human Factors and Behavioral Performance Exploration Measures (HFBP-EM) suite is a set of standardized measures to assess behavioral health and performance related to spaceflight, including the Profile of Mood States (POMS)and a robotics simulator, the Robotic On-Board Trainer (ROBoT). Although previous space analog studies documented fluctuations in POMS ratings, no studies have examined impacts on operationally relevant tasks such as ROBoT. **METHODS:** HFBP-EM were collected from 32 individuals (mean age: 38.53, SD=7.15; 31% female;) during two Human Exploration Research Analog (HERA) campaigns. HERA is a habitat designed to simulate future exploration spaceflight missions. Each campaign consisted of four 45-day missions. All crewmembers submitted daily POMS ratings and performed the ROBoT task twice weekly. POMS subscales were generated for anger/hostility, confusion/bewilderment, depression/dejection, fatigue/inertia, tension/anxiety, and vigor/activity. Linear mixed models examined the relationship between each subscale and ROBoT accuracy and time to successful completion. **RESULTS:** Crewmembers rated fatigue/inertia highest (*M*=3.18, *SD*=4.13), followed by confusion/bewilderment (*M*=0.72, *SD*=1.34), tension/anxiety (*M*=0.51, *SD*=1.33), anger/hostility (*M*=0.36, *SD*=1.18), and depression/dejection (*M*=0.26, *SD*=1.09). Average vigor/activity was 6.55 (*SD*=5.04). Models predicting ROBoT time to completion revealed significant interactions between days in-mission and negative affect, including tension/anxiety (β=-0.05, p<.001), depression/dejection (β=-0.08, p < .001), anger/hostility (β=-0.10, p<0.001), fatigue/inertia (β=-0.02, p<0.001), and confusion/bewilderment (β=-0.07, p<.001). Specifically, the improvements in ROBoT completion time over days in mission increased with greater POMS ratings. Better scores on ROBoT overall was associated with lower ratings of vigor/activity (β=-0.59, p=.003) only. **DISCUSSION:** Crewmembers who self-report mild psychological distress appear to emphasize performance speed, without an overall cost to accuracy, during operationally relevant tasks. These results present preliminary evidence suggesting cognitive resilience in astronaut-like individuals. Further analyses will examine relationships between POMS surveys and cognitive performance.

Learning Objectives

1. Astronaut-like crew in isolated, confined, and controlled space analog environments generally report low ratings of negative affect.
2. Very mild elevations in negative mood and affect are associated with changes in performance on behavioral tasks that are operationally relevant to long duration spaceflight.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany C,D,E

[S-25]: PANEL: NASA'S EXPLORATION ATMOSPHERES AND EVA STRATEGY

Chair: Alejandro Garbino

PANEL OVERVIEW: *The International Space Station (ISS) operates at a sea level atmosphere, which was an important choice to enable biomedical research while ensure that the atmosphere would not be a confounding variable to Earth based controls. As NASA begins missions beyond the ISS, the focus of the science will transition from biomedical science occurring inside the vehicle towards astrogeology and astrobiology research requiring samples from outside the vehicle collected via extravehicular activity (EVA). In order to facilitate this effective EVA, NASA's Artemis program is moving forward with a strategy to use the "Exploration Atmospheres" (EA) of 8.2 psia, 34% oxygen and 66% nitrogen for Lunar surface operations and 10.2 psia, 27% oxygen and 73% nitrogen in cis-Lunar space. The focus of this panel will be to describe the rationale for an exploration atmosphere, the research approach towards validating the use of this atmosphere and advancements towards using this atmosphere to optimize mission success and human performance.*

[116] VALIDATION OF DECOMPRESSION SICKNESS RISK MITIGATION PROTOCOLS FOR PLANETARY SPACEFLIGHT MISSIONS

Andrew Abercromby[1], Alejandro Garbino[2], Jason Norcross[3], Robert Sanders[4], Joseph Dervay[1]
[1]*NASA Johnson Space Center, Houston, TX, USA;*
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[4]*UTMB, Houston, TX, USA*

Education - Program/Process Review

BACKGROUND: Apollo missions used a 100% O2 cabin atmosphere which effectively eliminated the risk of decompression sickness (DCS) during extravehicular activity (EVA) on the moon. NASA's future missions to the moon and Mars are expected to use nitrox gas mixtures of up to 34% O_2, 66% N_2, which will reduce flammability risk compared with Apollo, but will necessitate Oxygen prebreathe prior to EVA to reduce DCS risk to acceptable levels. Prebreathe protocols used on the space shuttle and International Space Station are validated for microgravity EVAs, but the significantly increased risk of DCS during equivalent ambulatory EVAs make these protocols inapplicable to planetary EVA. An "exploration atmosphere" of 56.5 kPa (8.2 psia), 34% O2, 66% N2 has been recommended by NASA as a compromise that balances prebreathe duration, hypoxia, and flammability risk, assuming a 29.6 kPa (4.3 psi) spacesuit. However, this atmosphere may not be used for vehicles that do not support frequent EVA, and with commercial providers and international providers expected to provide landers, pressurized rovers, habitats, and spacesuits, different combinations of vehicle and spacesuit atmospheres are possible and will each require validated prebreathe protocols. **DESCRIPTION**: Key components of a multi-year strategic roadmap include: 1) Establish hypobaric chamber facility capable of supporting 8-person EVA prebreathe validation tests at saturation atmospheres up to 36% O2; 2) validate an EVA physical workload simulation for use during prebreathe validation testing; 3) validate the recommended "exploration atmosphere" prebreathe protocol; 4) validate prebreathe protocols for additional atmospheric combinations that bound the most likely potential operating ranges of future vehicles and spacesuits;

and 5) update DCS risk estimation models based on results of prebreathe validation studies. **DISCUSSION**: The first two steps of the strategic roadmap have been completed, and the third step is currently underway. Steps four and five are expected to begin in 2022 and will require a multi-year series of chamber tests; potential collaborations with organizations outside of NASA are being pursued. The accompanying papers in this panel provide details of work completed to date.

Learning Objectives

1. The audience will learn about NASA's long term strategy to mitigate decompression sickness across exploration class missions.
2. The audience will learn that the approach to mitigating DCS during exploration class missions involves accurate research, proper transition to operations, and regularly updating models for prediction and treatment.

[117] REDUCTION OF DECOMPRESSION STRESS USING SUITPORTS AND INTERMITTENT RECOMPRESSION

Michael Gernhardt[1], Omar Bekdash[2]
[1]*NASA Johnson Space Center, Houston, TX, USA;* [2]*The Aerospace Corporation, Houston, TX, USA*

Original Research

INTRODUCTION: A pressurized rover with a cabin atmosphere of 8.2 psia/34% O2, combined with suitports (a device which allows the crewmember to don/doff an externally stowed suit via a rear entry hatch) enables the operational flexibility to perform multiple short (~1-2 hr) or single long duration (~8hr) EVAs. Intermittent recompression occurs when the crewmember ingresses the cabin, returning from the 4.3 psia suit pressure to the 8.2 psia cabin pressure. **METHODS**: The Tissue Bubble Dynamics Model (TBDM) was used to predict the DCS risk following a 15-minute, 85% O2 prebreathe protocol for a 1x8-hr, 4x2-hr, and 4x1-hr EVAs with a 1-hr interval at cabin pressure between EVAs. The TBDM provided a significant prediction ($p<0.001$) and goodness of fit (McFadden's rho-squared=0.214) with 84 DCS cases in 668 altitude exposures with an average metabolic rate of 800BTU/hr. **RESULTS**: The predicted DCS risk for the 1x8-hr, 4x2-hr, and 4x1-hr EVAs were 10.9%, 6.9%, and 3.7% respectively. **CONCLUSIONS**: The decompression stress associated with the multiple short EVAs is less than a single long EVA because bubbles have less time to grow through a time-dependent diffusion-limited process, while recompression to cabin pressure resolves them on a time scale much faster than the limiting 360min half-time tissue on-gasses nitrogen. These DCS risk predictions, using the regression calibrated to 800BTU/hr, are likely to be lower than Artemis EVAs which will have estimated peak metabolic rates > 2000 BTU/hr.

Learning Objectives

1. The audience will learn how a pressurized rover works to enhance the capability of an astronaut crew while reducing overall DCS risk.
2. The audience will learn how short duration decompressions combined with intermittent recompression back to site pressure reduce overall DCS risk as compared to a single long decompression.

[118] NITRIC OXIDE SUPPLEMENTATION

Robert Sanders[1], Aaron Lacy[2], Millennia Young[3], Rahul Suresh[3]
[1]*KBR, Houston, TX, USA;* [2]*Vanderbilt University, Nashville, TN, USA;* [3]*NASA Johnson Space Center, Houston, TX, USA*

Original Research

INTRODUCTION: Hypoxic exposures result in diminished oxygen to the brain reducing time of useful consciousness (TUC) and potentially catastrophic consequences for astronauts/aviators. Improving oxygen delivery may extend TUC providing additional time for corrective actions. The naturally occurring molecule nitric oxide (NO) improves blood flow and oxygen delivery to tissues. Neo40® is an oral NO supplement shown in clinical trials to improve blood flow. We hypothesize that this will increase performance on psychomotor vigilance testing (PVT) during hypobaric hypoxia. **METHODS:** A double-blinded, randomized, placebo-controlled crossover trial in 16 non-astronaut volunteers compared PVT results during altitude chamber hypobaric hypoxia exposures (18,000 and 25,000 feet = FL 180 and FL 250) after supplementation with Neo40® (N = 8) or placebo (N = 8). Participants took either placebo or Neo40® for 28 days. PVT testing was administered at minutes 1, 7, and 12 in FL 180, and at minute 1 in FL 250. Participants then underwent crossover to the other arm of the study. **RESULTS:** The treatment group saw improvement in mean reaction time (RT) (352 +/- 70ms in placebo vs 296 +/- 63ms in Neo40 group; $P < 0.001$), median RT (AA +/-B_ vs XX +/- Y $P < 0.0003$), mean fastest and slowest 10% RT (AA +/-B_ vs XX +/- Y; $P < 0.0005$, $P < 0.0001$), error of omissions and commissions ($P < 0.001$, $P < 0.0032$), and mean percent oxygen saturation ($Sp0_2$) (AA +/-B_ vs XX +/- Y; $P < 0.0001$). One participant developed type II decompression sickness (DCS) after completing FL 250. **DISCUSSION:** In this study Neo40® improved PVT results and SpO_2 compared to placebo, and improved performance during hypoxic exposures. The study was powered to detect a 10% difference in PVT performance, but it is yet unclear if this has clinical significance. While Neo40® is safe, it has vasodilator effects and consideration of its administration in aviators/astronauts who may undergo high G forces must be considered. These results show promise in improving performance in hypoxic conditions, and future studies are needed to test supplementation time periods, dosing, washout periods, and results in other analogue environments.

Learning Objectives

1. The audience will understand nitric oxides' mechanism of action in increasing oxygen delivery to tissues.
2. The audience will understand the role of psychomotor vigilance testing as an analogue for performance.

[119] DEVELOPMENT OF AN EXTRAVEHICULAR ACTIVITY PHYSICAL WORKLOAD SIMULATION FOR USE IN GROUND VALIDATION OF EXPLORATION PREBREATHE PROTOCOLS

Patrick Estep[1], Jocelyn Dunn[2], E. Lichar Dillon[3], Alejandro Garbino[1], Jason Norcross[2], Robert Sanders[3], Joseph Dervay[4], Andrew Abercromby[4]
[1]*GeoControls Systems, Houston, TX, USA;* [2]*KBR, Houston, TX, USA;* [3]*UTMB, Houston, TX, USA;* [4]*NASA Johnson Space Center, Houston, TX, USA*

Original Research

BACKGROUND: An increased risk of decompression sickness (DCS) has been correlated with physical exercise while in a lower pressure environment. Exploration prebreathe protocols must protect astronauts from DCS during potentially lengthy extravehicular activities (EVAs). It is paramount that exploration prebreathe protocols are validated in ground-based trials prior to future exploration missions, and that those validations are conducted against representative types and intensities of functional tasks that will be conducted during surface EVAs. **METHODS:** To identify EVA task selection for planetary EVA simulation, a candidate list of 61 tasks was identified from NASA's Exploration EVA ConOps, decomposed into 126 subtasks, and then categorized based on functional movements and other characteristics of the workload required for performing each subtask. A portion of the subtasks were downselected for inclusion in a custom 40-minute activity circuit intended to simulate planetary ambulation, equipment transfer, maintenance, geology, and module deployment. Human in the loop testing (n=8) was conducted to test the fidelity of the protocol and methods for individualizing metabolic workloads across periods up to 6 hours. Using suited system limitations and DCS risk considerations, the task circuit included one task that allowed reaching 70 – 80% VO_{2peak} effort for 2 minutes per 40-minute cycle while targeting an average work rate that has been demonstrated as sustainable for durations of 6 hours or more (30 – 40% VO_{2peak}). **RESULTS:** The average metabolic rate during the final simulations was approximately 38% VO_{2peak}. The activity circuit tasks ranged between 600-2300 BTU/hr and were suitable for long-duration simulations of common EVA-like procedures. **DISCUSSION:** Decomposed tasks were nearly evenly split between full-body and upper- or lower-body work, and between stationary and mobile work. Testing confirmed that

targeted average work rates of 35-40%VO_{2peak} were sustainable for up to 6 hours in subjects with varying fitness levels, and also that the selected subtasks are suitable to simulate a number of EVA-like procedures. Future work should include refinement and validation against the specific planned activities that are anticipated for Artemis missions, and should also consider constraints imposed by partial gravity environments and spacesuits.

Learning Objectives

1. The audience will learn how activity type and intensity may impact the likelihood of decompression sickness.
2. The audience will learn how a diverse set of exploration EVA tasks were broken down and then reconfigured into an exercise protocol for use in chamber studies for the development of prebreathe protocols.

[120] DEVELOPMENT AND TESTING OF A FACILITY TO STUDY SPACECRAFT AND SPACESUIT ATMOSPHERES AND DECOMPRESSION PROTOCOLS

Alejandro Garbino, Andrew Abercromby, Robert Sanders, Patrick Estep, Jason Norcross
NASA-JSC, Houston, TX, USA

Education - Program/Process Review

BACKGROUND: The last 40 years of low Earth orbit (LEO) operations focused on conditions similar to Earth's surface (101kPa, 21% O_2) as a key scientific goal. For conducting frequent spacewalks ('EVAs') at suit pressures as low as possible, lowering the partial pressure of N_2 is preferable to decrease decompression sickness risk and any associated prebreathe (PB) requirements. Although some slightly decreased pressure (70.4kPa/26.5% O_2) atmospheres have occasionally been used in the last few decades, one must go back to the Apollo program for EVA-focused atmospheres (34.5kPa, 100%O_2). With NASA's new focus on Exploration Missions, a new EVA-focused atmosphere is needed. **OVERVIEW:** In 2005, the Constellation Program "Exploration Atmosphere" (EA) panel recommended a lower pressure, higher O_2 cabin to minimize prebreathe prior to egress. In 2019, as part of NASA's Artemis program, the need for high frequency, low overhead EVAs on the Moon returned to the forefront. A 56.6kPa/34% O_2 atmosphere was selected for initial prebreathe validation. A test facility was needed that allows subjects to live for days in those conditions – NASA 20ft chamber at JSC. The facility required significant upgrades – these will be reviewed in the context of both ensuring test subject safety and as potential risks and testing of flight hardware. Extensive decompression modeling and treatment algorithms were developed to ensure ground studies would be representative of expected flight conditions, including EVA metabolic workloads, variable pressure suits with field-adjustable pressure settings (capable of operating between 29.7-56.6kPa); and the infrastructure to treat DCS. Furthermore, hardware and procedures to characterize the impact of living in a reduced pressure environment with a mild hypoxic stress were also implemented – although all atmospheres through Skylab were normoxic/hyperoxic, EA allows a 127mmHg piO_2 to minimize decompression risk. **DISCUSSION:** This presentation will discuss the necessary changes that were needed to stand up a facility to allow various atmospheric compositions to simulate different vehicle and space suit conditions, EVA workloads, and characterize the impact of any associated hypoxia, while meeting modern standards for fire protection, egress, flammability controls. The decompression model results of the various configurations will be reviewed and compared to previous NASA and USAF decompression studies and NASA's spaceflight experience.

Learning Objectives

1. Participants will earn about the different risks of decompression during spacewalks, and procedures to decrease the risk.
2. The audience will understand the use of the equivalent air altitude model to compare hypoxic stress.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany A

[S-26]: PANEL: FROM LAB TO COCKPIT: BIOMARKERS OF IN-FLIGHT EXPOSURES

Chair: Ryan Mayes
Co-Chair: Richard Arnold

PANEL OVERVIEW: *The military aviation environment poses multiple physiologic challenges to aviators; tactical/high-performance aviation in particular presents physiologic burdens from altitude, acceleration, and mask-on breathing. In order to better mitigate performance effects of these exposures, a clearer understanding of the physiologic impacts of cockpit exposures is needed. This panel will present the results of studies examining biomarkers associated with flight; establishing biomarkers of interest is a critical step toward better understanding physiologic impacts of tactical aviation. The first presentation will describe a laboratory study on the effects of oscillating breathing gas pressure using a small animal model. The remaining four presentations will cover multiple results from an in-flight study of instructor pilots, beginning with a presentation of physical examination, pulmonary function tests, blood chemistry, and urine specific gravity changes due to flight. This will be followed with a presentation of levels of proinflammatory cytokine changes associated with flight. The fourth presentation will then examine the linkage between cytokine levels and fatigue. The final presentation will discuss linkages between fatigue and other exposures such as diet and sleep.*

[121] THE PHYSIOLOGICAL AND NEUROLOGICAL EFFECTS OF RAPID HYPOBARIC PRESSURE FLUCTUATIONS IN AN ANIMAL MODEL

Karen Mumy[1], Andrew Keebaugh[2], Shannon Romer[3]
[1]*Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA;* [2]*Oak Ridge Institute for Science and Education, Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA;* [3]*Odyssey Systems, Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA*

Original Research

INTRODUCTION: The act of flying and flight operations present various physiological stressors. Specifically, military flight operations may involve extremes such as hypoxia and hyperoxia within the same flight, acceleration, and altitude/pressure fluctuations. Questions surrounding rapid changes in cabin pressure have been raised, particularly with regard to performance and potential neurological effects. To address these concerns, our laboratory designed a system to expose rodents to hypobaric pressure fluctuations, under normoxia or hyperoxia, and assessed real-time and post-exposure effects. **METHODS:** Animals were exposed to cycles of fluctuating hypobaric pressure (+/- 94% O2) over 25 min. Animals were evaluated for signs of barotrauma, decompression sickness (DCS), neurological symptoms (during and post-exposure) through behavioral assessments, and various biomarkers. Imaging was employed during exposure to determine the presence of vascular gas emboli. Brain tissue was harvested to evaluate changes in synaptic plasticity and samples collected for biomarkers (inflammatory cytokines, markers of endothelial dysfunction). Changes in respiratory parameters were determined and histopathology performed to observe signs of lung injury and lung fluid was analyzed for indicators of inflammation or impaired barrier function. Lastly, brains were evaluated three days post-exposure for astrocyte activation as an indicator of neuroinflammation. **RESULTS:** There was no indication of pulmonary barotrauma or DCS in animals that experienced pressure fluctuations. Behavioral decrements were observed during fluctuations, and electrophysiology confirmed a reduction in long-term potentiation in the hippocampus immediately following exposures to high altitude; whereas reduced spontaneous activity was observed in hippocampi of animals exposed

to both high altitude and pressure fluctuations. There was an increase in activation of astrocytes within the hippocampus three days post-exposure to fluctuations and high altitude. **DISCUSSION:** Effects were observed with pressure fluctuations in a rodent model at rates that are comparable or slightly higher than those known to occur within the cockpit. The cause of both the behavioral effects and astrocyte activation are not yet understood and could be a result of ischemia, blood brain barrier disruption, or trauma. Further studies are ongoing to better define mechanisms and the threshold and timeline of exposure and effect.

Learning Objectives

1. The participant will better understand the potential physiological effects of rapid pressure fluctuations in an in vivo model.
2. The audience will be able to describe the possible mechanisms underlying the outcomes of exposure to hypobaric pressure fluctuations.

[122] STUDY DESIGN, RATIONALE AND FINDINGS OF POTENTIAL MECHANISMS CONTRIBUTING TO PROGRESSIVE ONSET OF FATIGUE IN AVIATORS

Anthony Turner[1], Elizabeth Damato[2], Ryan Mayes[3], Michael Decker[2], Lidia Ilcus[4], Seunghee Margevicius[2], Molly McCarthy[7], Ian Vannix[2], Jonathan Somogyi[5]

[1]*USAF School of Aerospace Medicine, Muskegon, Michigan, USA;* [2]*Case Western Reserve University, Cleveland, OH, USA;* [3]*USAF School of Aerospace Medicine, Columbus, OH, USA;* [4]*USAF AETC, Enid, Oklahoma, USA;* [5]*USAF Reserves, San Antonio, TX, USA*

Original Research

INTRODUCTION: Mitigating root causes of fatigue within aviators is an emerging priority. Fatigue can be a symptom of increased blood serum proinflammatory cytokines levels. Muscle duress, routinely experienced by Instructor Pilots (IPs) during tactical aviation training, contributes to release of proinflammatory cytokines. We hypothesized that increasing blood serum levels of proinflammatory cytokines occur in IPs across their flying schedule, and when levels reach a critical threshold, symptoms of cognitive fatigue emerge. This study sought to establish biologic plausibility for that hypothesis by characterizing blood serum profiles, fatigue, and multiple other physiologic variables within a cohort of T-6A Texan II instructor pilots (IPs). **METHODS**: Twenty-two IPs were studied. Data were collected on three separate days across the week-long long flying schedule: Sunday (baseline), Tuesday (midpoint), and Thursday (endpoint). Data collected included fatigue levels, a physical assessment, pulmonary function tests (PFTs), urine samples for measures of specific gravity, and venous blood samples for measures of blood chemistry and serum analytes. **RESULTS**: The study cohort was comprised of primarily males, aged 37.95 ± 4.73 years with a BMI of 26.63± 3.15 kg/m^2. No participant was febrile at any time during the study period. Measures of blood pressure were within normal limits. No difference between baseline and endpoint PFTs were found; mean percent predicted Forced Vital Capacity (FVC) was 101.73 ± 17.38 vs. 99.36 ± 10.52 and mean Forced Expiratory Volume (FEV1) was 98.05 ± 13.43 vs. 97.18 ± 9.713. Urine specific gravity baseline values (1.021 ± 0.01) did not differ from endpoint values (1.012 ± 0.09). Baseline and endpoint values of 12 blood chemistry measures were not significantly different. In contrast, endpoint values for serum proinflammatory cytokines and fatigue were significantly increased over baseline values. **DISCUSSION:** Neither physical examination findings, PFTs, blood chemistry nor urine specific gravity corresponded with increased levels of fatigue and proinflammatory cytokines that emerged within IPs. This suggests a mechanism other than apparent pathology or temporary illness contributed toward those increases. These findings argue against an infectious etiology and lend support for repetitive muscle duress as a possible causative mechanism of increased proinflammatory cytokines accompanied by fatigue.

Learning Objectives

1. Understand the study design and rationale for a recent field study of cognitive fatigue experienced by T-6A Texan II instructor pilots.
2. Appreciate that increased serum proinflammatory cytokines may play a role in the development of cognitive fatigue in military aviators.

[123] BLOOD SERUM PROFILES OF T-6A TEXAN II INSTRUCTOR PILOTS ACROSS A ONE-WEEK FLYING SCHEDULE

Michael J. Decker[1], Elizabeth G. Damato[1], Seth J. Fillioe[1], Ian S. Vannix[1], Seunghee P. Margevicius[2], Jonathan E. Somogyi[3], Lidia S. Ilcus[4], Ryan S. Mayes[5]

[1]*Center for Aerospace Physiology, Department of Physiology & Biophysics, Department of Neurosciences; School of Medicine, Case Western Reserve University, Cleveland, OH, USA;* [2]*Department of Population and Quantitative Health Sciences, Center for Aerospace Physiology, Department of Physiology & Biophysics, School of Medicine, Case Western Reserve University, Cleveland, OH, USA;* [3]*U.S. Air Force Reserves, San Antonio, TX, USA;* [4]*U.S. Air Force, Enid, Oklahoma, USA;* [5]*711th Human Performance Wing, USAFSAM, Wright-Patterson AFB, OH, USA*

Original Research

INTRODUCTION: Increased blood serum levels of proinflammatory cytokines, an adaptive response to exercise or tissue injury, emerge following high performance athletic activities. Short term increases in those cytokines contribute to restorative processes. However, persistently elevated levels can initiate biochemical cascades contributing to onset of fatigue, malaise and reduced physiologic resiliency. Circulatory levels of proinflammatory cytokines are well studied in professional sports athletes. Yet, a knowledge gap exists in our understanding of those levels within tactical aviators, who are also high-performance athletes. Our objective was to characterize blood serum proinflammatory cytokines and other analytes across a week-long flying schedule in a cohort of T-6A Texan II instructor pilots (IPs). **METHODS:** Venous blood was collected on 22 IPs on three separate days across the week-long flying schedule; Sunday, Tuesday, and Thursday. Serum was analyzed with multi-array electrochemiluminescence technology using preconfigured 96-well plates. **RESULTS:** The study cohort was comprised of primarily males, aged 37.95 ± 4.73 years with a BMI of 26.63 ± 3.15 kg/m^2. Of 37 measurable serum analytes, 20 differed significantly between baseline values with those measured at the study endpoint, as defined by a two-tailed significance (p-value) <0.05, following Bonferroni corrections. Of seven analytes measured with the proinflammatory plate, two increased while one decreased. Six out of nine analytes measured on the chemokine plate increased, while five out of six measured on the cytokine plate also increased. Two of six analytes measured on the angiogenesis plate were decreased and one of the four analytes measured on the vascular injury plate also decreased. Of five analytes measured on the obesity plate, one increased and two decreased. **DISCUSSION:** Our results suggest that blood serum levels of proinflammatory cytokines increased across the flying schedule. Specific mechanisms triggering release of those cytokines and other analytes are yet to be determined. However, certain patterns of serum analyte levels suggest repetitive inflammatory responses may exist within some IPs. Increased levels of other analytes may reflect physiologic responses to hyperoxia, positive airway pressure, or temporary hypergravity-induced changes in lung volumes. Well-controlled laboratory-based studies are necessary to establish the exact mechanisms contributing to our findings.

Learning Objectives

1. The participant will understand that increased blood serum levels of proinflammatory cytokines is an adaptive response to exercise or tissue injury.
2. The participant will learn that blood serum levels of selected proinflammatory cytokines increase across the week-long flying schedule in instructor pilots.

[124] INCREASING SERUM PROINFLAMMATORY CYTOKINES ACCOMPANY INCREASED LEVELS OF FATIGUE IN T-6A TEXAN II INSTRUCTOR PILOTS: A CHICKEN OR EGG RELATIONSHIP?

Elizabeth G. Damato[1], Ryan S. Mayes[2], Molly M. McCarthy[1], Seunghee P. Margevicius[3], Seth J. Fillioe[1], Jonathan E. Somogyi[6], Lidia S. Ilcus[5], Anthony M. Turner[2], Michael J. Decker[1]
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Original Research

INTRODUCTION: Cognitive fatigue, a constant threat to human performance and aviator safety is the "likely cause of the next mishap," as described by the National Commission on Military Aviation Safety, December 2020. Preventing that mishap is hampered by an absence of quantitative physiologic biomarkers corresponding with increasing levels of cognitive fatigue. Our prior studies suggest that chronically elevated blood serum levels of proinflammatory cytokines evoke reductions in central nervous system function, which become manifest as cognitive fatigue. Yet, a knowledge gap exists in our understanding of whether blood serum proinflammatory cytokine levels correspond with fatigue levels in tactical aviators. To address that knowledge gap, we characterized the relationship between measures of fatigue and blood serum proinflammatory cytokine levels across a week-long flying schedule in a cohort of T-6A Texan II instructor pilots (IPs). **METHODS:** Fatigue was measured in 22 IPs using the Multidimensional Fatigue Inventory (MFI) on three separate days, Sunday, Tuesday, and Thursday across their week-long flying schedule. Following completion of the MFI, a venous blood sample was collected and the serum analyzed with multi-array electrochemiluminescence technology using preconfigured 96-well plates. **RESULTS:** The study cohort was comprised of primarily males, aged 37.95 ± 4.73 years with a BMI of 26.63 ± 3.15 kg/m^2. Thirteen of the IPs experienced elevated MFI scores across their flying schedule whereas nine of the IPs did not. No difference existed in baseline MFI scores between those who would become Fatigued (F) versus those who were Not Fatigued (NF). Of the 37 detectable serum analytes, one was significantly higher at baseline (Sunday) in the F versus NF. By the end of the flying schedule (Thursday), four additional serum analytes were significantly increased in the F versus NF. Following Bonferroni correction, two of the five serum analytes retained statistically significant differences. **DISCUSSION:** Cognitive fatigue in aviators has almost solely been attributed to sleep loss, nocturnal sorties, or disrupted circadian rhythmicity. Our study findings suggest an additional mechanism; chronically elevated blood serum levels of proinflammatory cytokines. This hypothesis implies that cognitive fatigue can be induced by mechanisms that are fundamentally different from those attributed to perturbed sleep.

Learning Objectives

1. The participant will understand that cognitive fatigue in instructor pilots may be induced by mechanisms other than sleep loss, nocturnal sorties, or disrupted circadian rhythmicity.
2. The participant will learn that cognitive fatigue may accompany changes in blood serum levels of proinflammatory cytokines in instructor pilots.

[125] MECHANISMS CONTRIBUTING TO INCREASING FATIGUE LEVELS MAY EXTEND BEYOND THE USUAL SUSPECTS OF DIET AND SLEEP

Ryan Mayes[1], Elizabeth Damato[2], Ian Vannix[3], Molly McCarthy[3], Jonathan Somogyi[4], Lidia Ilcus[5], Anthony Turner[7], Michael Decker[2]
[1]*711th Human Performance Wing, USAFSAM, Wright-Patterson AFB, OH, USA;* [2]*Naval Medical Research Unit Dayton & Case Western Reserve University, Wright-Patterson AFB, OH, USA;* [3]*Case Western Reserve University, Cleveland, OH, USA;* [5]*USAF 340 FTG, JBSA, TX, USA;* [6]*71st Medical Group, Vance AFB, Oklahoma, USA;* [7]*U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*

Original Research

INTRODUCTION: Fatigue diminishes cognitive and physical performance as well as resiliency against physiologic challenges posed by tactical aviation. Many aviators report increased fatigue across their flying schedules, but attribute it to age, diet, or lack of sleep. Other proposed causes include muscle duress or increased operations tempo. Fatigue severity can rapidly and insidiously increase without self-awareness of deteriorating cognitive and physical status. An immediate need exists to define objective physiologic markers corresponding with increasing levels of fatigue. To address that need, we performed physiologic and cognitive assessments of T-6 Instructor Pilots (IPs) across a one week flying schedule. Our objective was to determine whether increased fatigue levels were accompanied by changes in blood serum candidate proteins. We also recorded dietary information and metrics of self-reported sleep, behaviors that can modulate serum protein levels, to inform our data analyses and interpretations. **METHODS:** 22 IPs were studied on three separate days, Sunday, Tuesday, and Thursday across a week-long flying schedule. Fatigue was measured with the Multidimensional Fatigue Inventory and blood serum analyzed with electrochemiluminescence technology. Dietary Inflammatory Scores (DIS) were calculated for the previous day's dietary intake. Self-reported sleep metrics included total sleep time (TST), frequency of night awakenings (NA), and self-rated sleep quality (SQ). **RESULTS:** 13 IPs experienced increased levels of fatigue accompanied by changes in serum proteins. In contrast, DIS were unchanged (mean ± SD) between Sunday and Thursday (0.85 ± 1.08 vs. 0.37 ± 1.49, p=0.19). Frequency of night awakenings (1.77 ± 1.15 versus 1.45 ± 1.50, p=0.28) and SQ ratings (3.64 ± 0.66 versus 3.45 ± 0.80, p=0.30) were also unchanged. Although TST decreased significantly for IPs across the week (484.32 ± 60.99 versus 434.55 ± 65.17, p=0.01), DIS, TST, NA, and SQ did not differ between fatigued and non-fatigued IPs. **DISCUSSION:** Increased fatigue, accompanied by changes in blood serum proteins, emerged in 13 of 22 IPs. We found no linkage between those outcomes with measures of diet and sleep. This suggests that well controlled studies, either including the cockpit environment or emulating it in a laboratory, are necessary to define mechanisms contributing to the increased fatigue and changes in blood serum we observed.

Learning Objectives

1. Understand that cognitive fatigue in instructor pilots may be induced by mechanisms other than diet and poor sleep.
2. Describe possible interpretations and implications of this study's findings, as well as next steps.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany B

[S-27]: PANEL: MAKING SENSE OF SPECIAL SENSES: MISHAPS AND NEAR MISHAPS

Sponsored by the Aerospace Human Factors Association (AsHFA)

Chair: Harriet Lester
Co-Chair: David Schall

PANEL OVERVIEW: *In continuing pursuit of "Making Sense f Special Senses", this panel will discuss examples of mishaps and near mishaps related to visual, auditory, and vestibular systems. Seeing, hearing and vestibular function are integral to the pilot's aviation environment. Intact perception, and cognitive processing of the accuracy of these perceptual inputs, enable timely action and reaction. These "Special Senses" are intertwined with what we regard as human factors. Malfunction, misinterpreted cues, and sensory illusions can lead to mishaps. For example, spatial disorientation is one of the most common causes of fatal accidents in the aviation environment. Color*

misperception has also been linked to aviation accidents. We will present aviation mishaps and near mishaps related to vision, vestibular, and auditory function, and dysfunction. The cases include vestibular and visual Illusions, as well as examples of sensory misperception. The mishaps and near mishaps occurred at different altitudes: in the air as well as on the runway. Visual, vestibular, and auditory performance will be discussed in relation to the aviation environment and risk mitigation. Human factors affecting sensory information processing; as well as additional contributory factors such as technical and atmospheric, will also be discussed.

[126] MAKING SENSE OF VESTIBULAR SENSES AFTER MISHAPS

David Schall[1]
[1]*Federal Aviation Administration, Oklahoma City, OK, USA*

Education - Case Study

INTRODUCTION: Incorrectly perceived Vestibular input in the aviation environment can have fatal consequences. **BACKGROUND:** Somatogravic illusions were first described in the late 1800's, as man took to the air, this illusion began to manifest itself in a various portions of the flight envelope. Whether flying a small GA aircraft or a commercial jet, pilots are susceptible to this potentially fatal illusion. Awareness and training for this illusion has been less than optimal. **CASE PRESENTATION:** An example of fatal accidents involving Somatogravic illusions, from both General Aviation and Commercial aviation will be discussed. Specifically, The crash of a C-182T near Mobile Regional Airport on 1 Feb 2016, and the crash of Atlas Air 767, Flight 3591 into Trinity Bay, Tx. on Feb 23, 2019. **DISCUSSION:** Cases will be analyzed and current mitigation strategies will be discussed.

Learning Objectives

1. The participant will be able to understand the role the Vestibular system plays in various aspects of the flight envelope potentially leading to fatal consequences.
2. The participant will be able to understand current mitigation strategies to prevent fatal accidents from Somatogravic illusions.

[127] BLACK-HOLE APPROACH ILLUSION

Kevin Gildea[1], Harriet Lester[2]
[1]*Federal Aviation Administration, Norman, OK, USA;* [2]*Federal Aviation Administration, Jamaica, NY, USA*

Education - Case Study

INTRODUCTION: A Black-Hole Approach Illusion can occur during a dark night approach over water or unlighted terrain to a lighted runway beyond. This illusion is particularly hazardous when approaching a runway with no lights before the runway and with city lights or rising terrain beyond the runway. This can create the illusion of being high on final approach, resulting in the pilot flying a dangerously low approach. **BACKGROUND:** Misinterpreting the visual cues present on a night visual approach with conditions conducive to the black hole illusion can lead to a lower than normal approach and potentially controlled flight into terrain. **CASE PRESENTATIONS: 1.)** Beech 65-A90-1, Slidell, Louisiana Municipal Airport (ASD), April 19, 2016. Aircraft hit power-line towers on final approach to Slidell. Both pilots were killed in the accident. According to the NTSB the probable cause(s) included: "The unstable approach in black-hole conditions, resulting in the airplane … descending well below a safe glidepath for the runway." 2.) Rockwell NA-265-65, Kaunakakai, HI, May 10, 2000. Six fatalities. Aircraft impacted mountainous terrain on a visual night approach. The NTSB report listed the black hole illusion as a probable cause. **DISCUSSION:** Training, experience, and attention to the increased safety threats at night are three of the primary countermeasures to avoid low approaches associated with the black hole illusion. At airports where they are available, observing approach path lighting and flying instrument approaches even when in visual conditions are also effective tools for avoiding these dangerously low approaches. A pilot should use all tools available as needed to offset limitations of the human visual system.

Learning Objectives

1. The audience will learn about 2 cases where the black hole illusion contributed to fatal accidents
2. The audience will learn about countermeasures to mitigate the safety threat of the black hole illusion.

[128] MAKING SENSE OF SPECIAL SENSES–VISION AND TWO RUNWAY NEAR MISHAPS

Harriet Lester[1], Kevin Gildea[2], Benisse Lester[3]
[1]*Federal Aviation Administration, Jamaica, NY, USA;* [2]*Federal Aviation Administration, Oklahoma City, OK, USA;* [3]*Consultant, Washington D.C., USA*

Education - Case Study

INTRODUCTION: Two "Runway Safety" cases will be presented. Both Near Mishaps involved less than 100 feet of vertical separation, with very different scenarios. Visual misperception caused both errors, while accurate visual perception and timely reactions enabled lifesaving corrections. **BACKGROUND:** Aerospace visual perception involves sensory input, as well as cognitive processing of this input. Safe aviation requires high functioning visual systems plus timely and accurate information processing. Visual cues can be degraded by environmental factors; and may be under-processed due to human factors, such as fatigue, distraction, and cognitive bias. Healthy visual function, situational awareness, experience, and preparation mitigate safety risk. **CASE PRESENTATIONS: 1.)** Wrong Surface "WS" Operation, San Francisco Airport (SFO). July 7, 2017—This attempted Wrong Surface Landing involved visual misperception. Closed Runway 28L was marked with an illuminated flashing X. A320-211 using visual approach was cleared to land on adjacent Runway 28R, however mistook the parallel Taxiway C for Runway 28R, and lined up with 4 passenger airplanes waiting for takeoff. "Something did not look right" to the pilots, and a last minute go-around averted a catastrophic accident. Human factors included fatigue and expectation bias. Subsequent preventive measures were put into effect. 2.) Runway Incursion, John F. Kennedy Airport (JFK). July 6, 2005–This Category A Pilot Deviation near mishap involved visual misperception. B767 was instructed to taxi to Runway 22R via Taxiway H, left onto Taxiway B. B767 did not turn left onto Taxiway B and crossed Runway 22R via Taxiway H without authorization. A Cargo DC8 was departing Runway 22R, and was past decision speed when detected B767, so continued at rotation speed and increased rotation angle to get better climb, narrowly avoiding the B767. Heavy rain had worsened visibility and interfered with alerts. Concerned about the rain and his aircraft performance, the DC8 first officer had obtained permission from the captain to use max power for takeoff (fortunately). Taxiway geometry was subsequently modified. **DISCUSSION:** Two Runway Near Mishaps with close vertical separation both involved visual misperception. Human factors, environmental factors, technology and airport configuration were additional considerations. Preventive measures were instituted in response to both occurrences, to support "Runway Safety."

Learning Objectives

1. The audience will learn about 2 "runway safety" cases where visual misperception led to near mishaps.
2. The audience will learn about an example in which human factors contributed to incorrect processing of visual information.

[129] COLOR VISION ASPECTS IN A FEW SELECTED AVIATION MISHAPS: DEAD MEN TELL NO LIES!

Douglas Ivan[1]
[1]*ADI Consultants, San Antonio, TX, USA*

Education - Tutorial/Review

In many cases, the impact of visual problems on aircraft mishaps or near mishaps may go undetected or unreported. The old adage that "*dead men tell no lies*" is far too often a reality when accident investigators try to unravel the events and assign causality to an aviation mishap, especially when there are no identifiable mechanical issues. This presentation, however, will join with the other special senses presentations to address

the role of color perception in a few selected mishaps. Due to panel time constraints, this paper will limit its scope to only two notable examples of aircraft events, drawn from a larger database of color vision related transportation accidents and incidents, that involved color perception and the lack thereof. Two specific accidents, the *FedEx* Boeing 727 crash in Tallahassee, Florida in 2002 and the unnecessary loss of a McDonnell-Douglas US Navy F4J "*Phantom*" in the Philippines back in 1980, will be dissected with respect to how color vision and color vision testing contributed to them, including the role that the *Farnsworth Lantern* (Falant) played in these events as well. Fortunately, both of these mishaps did not involve any crew fatalities, making it possible to uncover a great deal of useful information directly from the surviving mishap pilots themselves. However, both accidents did involve the total loss of the aircraft involved.

Learning Objectives

1. The audience will learn about the role of color vision in two notable aviation accidents.
2. The audience will learn about color vision testing and particularly the role of the Farnsworth Lantern (Falant) in these events.

[130] HEARING LOSS, STANDARDS, AND PERFORMANCE – THEY DON'T ALWAYS ALIGN

John Allen
Space Operations Mission Directorate NASA, Washington, DC, USA

Education - Case Study

INTRODUCTION: Hearing loss of varying types and degrees can result in equally varying impacts. **BACKGROUND:** Conductive and sensorineural hearing losses are represented by a wide variety of configurations when looking at a pure tone audiogram. Those configurations may have significant impact on one's ability to hear and understand speech communication and/or respond to warning signals. These can lead to flight safety issues, regardless of your position/role in the aircraft. **CASE PRESENTATION:** The first case describes the impact of a progressive, high frequency sensorineural hearing loss on word discrimination. The second case discusses the impact of a profound, unilateral sensorineural hearing loss. The final case demonstrates the impact of a bilateral conductive hearing loss on communication and flight status. In each case, current Air Force standards for hearing are discussed and how word discrimination is evaluated. **DISCUSSION:** Aviators may experience a wide variety of hearing losses that may or may not be directly related to flying, yet may have an impact on flight safety and continued flight certification. However, it is fascinating the extent to which individuals can compensate for what on paper looks to be a major hearing loss and continue to fly successfully. The cases above will be used to demonstrate the impact such a loss may or may not have based on standards and performance.

Learning Objectives

1. The clinician will understand the variety hearing loss possibilities that may impact the aviator, how they are assessed, and mission impacts that may occur.
2. The clinician will understand how word discrimination is measured and how it factors in to assessing flight safety.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany F

[S-28]: PANEL: SAFETY CENTERS: YEAR IN REVIEW

Chair: Tyler Brooks
Co-Chair: Robert Krause

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.*

[131] TRANSPORT CANADA: YEAR IN REVIEW

Tyler Brooks
Transport 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 topics of interest arising in over the past year. **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 medicine issues encountered over the past year. **DISCUSSION**: Aviation medicine practices and policy respond not only to changes in medicine, but also to changes in society, politics, and global events. The CAM Branch of Transport Canada shares its experience responding to a variety of issues.

Learning Objectives

1. Understand the mission of the Civil Aviation Medicine Branch of Transport Canada.
2. Understand Transport Canada's experience in responding to specific issues related to aviation medicine, including the COVID-19 pandemic.

[132] U.S. ARMY AVIATION SAFETY: FY 2021 YEAR IN REVIEW

Eric Olins, Robert Dickinson
U.S. Army Combat Readiness Center, Fort Rucker, AL, USA

Education - Program/Process Review

BACKGROUND: FY2021 data was obtained from the USA Combat Readiness Center database (ASMIS2.0) for Class A thru C manned aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards. **OVERVIEW:** In the manned aircraft category, Army aviation experienced 60 Class A - C manned aircraft Flight mishaps in FY21. This was an increase of 28% from the 47 Class A-C Flight mishaps reported in FY20. The US Army experienced seven Class A manned aviation Flight mishaps during FY21, 40% above the five Flight mishaps reported for FY20. The accident rate for Class A Flight mishaps (per 100,000 flying hours) was 0.87 in FY21, a 38% increase from the 0.63 Class A record rate recorded in FY20. There were 13 aviation mishap fatalities in FY21 compared to seven in FY20. Four (57%) of the seven Class A Flight mishaps occurred at night. Two of the Class A Flight mishaps involved controlled flight into terrain (CFIT), one under day conditions and one at night. In addition, there was one inadvertent entry into instrument meteorological conditions at night. Human error remains the primary cause factor in manned aircraft mishaps. In FY21, all seven of the Class A Flight mishaps and 41 (68%) of the 60 Class A – C Flight mishaps were attributed to human error. There were eight unknown or not yet reported cause factors. Performance-Based Errors (Active failures or actions) in the mishaps included failure to follow correct procedures, over controlled/under controlled the aircraft, breakdown in visual scan resulting in ground strikes, inadequate real time risk assessment associated with flight into poor weather conditions and failure to properly execute an emergency procedure-training maneuver. Latent failures or conditions included environmental conditions affecting vision (poor visibility, low illumination), overconfidence, and complacency. Teamwork failures included critical information not communicated and failure to effectively communicate. **DISCUSSION:** Human error was the primary cause factor

in all seven of the Class A Flight mishaps. The FY21 Class A Flight mishap rate of 0.87 was 7% below the five-year rate of 0.94 mishaps per 100,000 flight hours and the fourth time in the last six years to be below the 1.0 mark. Hours flown in FY21 were 2% more than hours flown in FY20.

Learning Objectives

1. Review the overall trend in US 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.

[133] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEAR IN REVIEW 2021

Ajiri Ikede
Canadian Armed Forces, 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 2021 were reviewed to identify human factors which may have caused or contributed to these occurrences. The Self-Administered Interview (SAI) was adopted as the standard operating procedure for collecting witness statements. **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, while facilitating the international distribution and use of SAI for accident investigations.

Learning Objectives

1. Understand the overall trends in RCAF flight occurrences in 2021.
2. Understand the effectiveness of the SAI in the collection of information from witnesses, especially when timely face-to-face interviewing is not possible.

[134] NAVAL AVIATION SAFETY: 2021 YEAR IN REVIEW

Robert Krause, Jonathan Erpenbach, Daniel Immeker, Jefferson Grubb
Naval Safety Center, Norfolk, VA, USA

Education - Program/Process Review

BACKGROUND: 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 2021 (FY 2021) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 2021 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. **DISCUSSION:** HFACS is a useful tool in safety investigation analysis and assists in identifying causal factors to focus mitigation strategies to prevent future mishaps. Its standardization across the Department of Defense facilitates cross-analysis and shared efforts to prevent future mishaps.

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.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany 3

[S-29]: PANEL: SPACEFLIGHT OPERATIONS IN THE TIME OF COVID-19

Chair: William Valencia
Co-Chair: Serena Auñón-Chancellor

PANEL OVERVIEW: *The COVID-19 global pandemic has challenged healthcare professionals around the globe in unprecedented ways. The field of aerospace medicine is no exception, and practitioners in the field have been tasked with ensuring the safety of the aerospace medicine community, from aviators to astronauts, during these troubling times. While spaceflight operations have continued during the pandemic, innovative methods for preventing infection, testing in the field and contingencies for infected crew members have needed to be developed. This panel will highlight some of these approaches carried out by space medicine practitioners, both from NASA as well as commercial space agencies. The first presentation will provide an overview of our initial approach to developing clinical practice guidelines for returning crewmembers to duty after infection with SARS-CoV-2. The second presentation will describe the medical operations during the COVID-19 pandemic at the Johnson Space Center Flight Medicine Clinic. This will be followed by a presentation that will similarly describe medical operations at SpaceX during the pandemic, at a time when the company launched its first crewed mission. The final two presentations will describe screening and monitoring guidelines developed at NASA for crewmembers that have been infected by COVID-19. One will describe screening for the cardiopulmonary and hematologic systems, while the other will focus on neurologic, ophthalmologic, and dermatologic considerations. Overall, this panel will provide an overview of the innovative response to a global pandemic from the space medicine community to continue spaceflight operations while ensuring the health and safety of crewmembers. The lessons learned may be applied to future pandemics, which require regular reassessment to address modulating factors such as the rise of variants and vaccination.*

[135] COVID-19 FROM 1,300,000 FEET: A SUMMARY OF THE PATHOPHYSIOLOGY, DIAGNOSIS, TREATMENT OPTIONS, AND IMPLICATIONS FOR SPACEFLIGHT

Stephen Kunkel[1], Matthew Pecha[1], John Marshall[1], William Valencia[2], Ronak Shah[2], Serena Auñón-Chancellor[2]
[1]*UTMB, Galveston, TX, USA;* [2]*NASA Johnson Space Center, Houston, TX, USA*

Education - Program/Process Review

INTRODUCTION: SARS-CoV-2 can damage multiple organ systems, and the full complement and extent of chronic sequelae remain to be elucidated. These sequelae could potentially be exacerbated by the unique hazards of spaceflight, which presents a continuing risk for crewed missions. In an effort to prevent disruptions to ongoing and future missions, we surveyed the literature for chronic sequelae that may hinder an astronaut's ability to perform in order to compile evaluation, surveillance, and treatment information for target organ systems. We will discuss that process here. Companion submissions address organ system-specific consequences, propose guidelines to return astronauts to duty, and enumerate SARS-CoV-2 testing, screening, and quarantine protocols at Johnson Space Center and SpaceX. **TOPIC**: A broad survey of the existing COVID-19 literature was undertaken to identify major organ systems affected by the virus and the clinical implications most relevant to aerospace medicine. During this survey, particular consideration was given to the unique environment experienced by astronauts and how SARS-CoV-2 sequelae might impact their health and mission fitness. For example, SARS-CoV-2 sequelae impairing cardiovascular function may reduce G-load tolerance during launch and landing, and abnormalities in clotting function may compound with the increased risk of thrombosis in space. These data were compiled into diagnostic guidelines for each organ system, which

were in turn presented to a panel of NASA flight surgeons and expert consultants. This process bestowed consensus protocols for each organ system, which were compiled into a general diagnostic algorithm and presented to NASA's Aerospace Medicine Board, whereupon clinical and operational utility and subsequent impacts were considered. These guidelines provide a framework through which to evaluate, treat, and monitor astronauts recovering from SARS-CoV-2 so they can return to full operational status. **APPLICATION**: Owing to the breadth and severity of possible COVID-19 symptoms and sequelae, complications could jeopardize an astronaut's ability to fly or have severe ramifications in the flight environment. Correlating acute COVID-19 symptoms and long-term sequelae with the unique physiologic environment of space and astronaut fitness requirements will optimize astronaut assessment and monitoring to ensure their safe return to duty and prevent unforeseen mission complications.

Learning Objectives

1. Understand the major pathophysiology, diagnosis and treatment options for SARS-CoV-2 infection.
2. Understand broad implications for spaceflight operations stemming from SARS-CoV-2 infection.

[136] IMPACT OF COVID-19 TO JSC MEDICAL OPERATIONS AND CONSIDERATIONS FOR DEVELOPMENT OF A CLINICAL PRACTICE GUIDELINE

Ronak Shah, Serena Auñón-Chancellor
NASA Johnson Space Center, Houston, TX, USA

Education - Tutorial/Review

INTRODUCTION: In order to protect and ensure successful spaceflight operations in low earth orbit, COVID-19 forced an immediate response from the National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC) medical operations team to preserve crew training, critical personnel, aircraft operations, and mission control facilities. **TOPIC:** COVID-19 brought America to a standstill in the spring of 2020. The International Space Station (ISS), however, continued 24/7 operations and was dependent on a continuous influx of crew and cargo to maintain a presence in low earth orbit. The response team at NASA Johnson Space Center was a multi-disciplinary effort that warranted rapid consideration of multiple factors, including changes to launch and landing operations both domestic and international, health stabilization programs, potential spread within the center and preventive measures to limit that spread, aircraft operations, clinic procedures and testing capability, and continuous operations within the mission control center. More recently, the launch of DM-2 with our commercial partner proved to be even more challenging as the first launch from American soil in many years was now occurring in the midst of a global pandemic. **APPLICATION:** This particular talk will discuss the complexity of NASA Johnson Space Center's response at a local, national, and international level to ensure continuous and safe spaceflight training and mission operations.

Learning Objectives

1. Understand NASA Johnson Space Center's operational considerations related to the COVID-19 pandemic.
2. Understand NASA Johnson Space Center's responses to the COVID-19 pandemic endeavoring to ensure continued safe operations.

[137] SPACEX OPERATIONS DURING THE COVID-19 PANDEMIC

Eric Petersen[1], Anil Menon[2]
[1]*University of AZ College of Medicine Phoenix/SpaceX, Phoenix, AZ, USA;* [2]*SpaceX, Hawthorne, CA, USA*

Education - Tutorial/Review

INTRODUCTION: The Covid-19 global pandemic forced rapid changes within SpaceX to continue operations through the Demo-2 mission that returned manned launch capabilities to the International Space Station from the United States, commercial satellite operations, and Starship development. **TOPIC:** The COVID-19 pandemic brought many challenges to commercial spaceflight operations in order to continue to meet deliverable milestones in both crewed and non-crewed missions. The formation of a multi-disciplinary COVID-19 response team allowed for rapid assessment of disease and workplace-based literature to craft and implement policies for site and mission-specific responses. This team allowed for large-scale decisions to be deployed, monitored, and altered as the pandemic progressed and priorities adjusted. Disease screening and workplace adaptations were critical to provide a safe environment for mission critical tasks, including astronaut training and the Health Stabilization Program for DM-2. Lessons learned from that response were adapted and applied to other missions including offshore recovery operations. Engineering, administrative, and PPE policies also allowed the design and manufacturing teams to continue to make rapid progress on commercial satellite contracts and Starship development while promoting the health and safety of each team. **APPLICATION:** This particular talk will discuss the complexity of SpaceX's response at a local, national, and international levels to ensure continuous and safe spaceflight training and mission operations.

Learning Objectives

1. The participant will understand how the crewed health stabilization program for DM-2 was adapted by a commercial provider to the COVID-19 pandemic.
2. The participant will learn how engineering, administrative, and PPE adjustments allowed for the continuation of satellite and Starship design and development.

[138] COVID-19: ASTRONAUT MONITORING AND RETURN TO DUTY: CARDIOPULMONARY AND HEMATOLOGIC CONSIDERATIONS

Brian Rodriguez[1], William Fernandez[1] Quinn Dufurrena[1], Michael Rhode[1], Omar Leonards[2], Serena Auñón-Chancellor[3], Matthew Pecha[1], Ronak Shah[3]
[1]*UTMB, Galveston, TX, USA;* [2]*Louisiana State University, New Orleans, Louisiana, USA;* [3]*NASA Johnson Space Center, Houston, TX, USA*

Education - Program/Process Review

INTRODUCTION: COVID-19 affects organ systems with varying acute, sub-acute, and chronic manifestations. Understanding potential complications is essential for determining when astronaut crew members can return to the ground, flight, and spaceflight operations. The diversity of chronic disease progression across cardiopulmonary and hematologic systems necessitates a rigorous, conservative testing regimen to ensure crew member health and readiness for return to duty. **TOPIC:** COVID-19 can result in chronic cardiopulmonary and hematologic manifestations. These include myocarditis, heart failure, venous thromboembolism, pulmonary hypertension, pulmonary fibrosis, and a persistent inflammatory state. Given this disease diversity, a variety of screening tests are required to ensure acceptable crew member health prior to returning to duty. The battery of tests required prior to return to duty would be determined by many factors, including; vaccination status, the severity of illness, and time to recovery. Such tests that may be carried out on crew members include: cardiac/inflammatory biomarkers, electrocardiogram (ECG), pulmonary function testing, echocardiogram (echo), duplex ultrasound imaging of all extremities, and cardiac magnetic resonance imaging. If the above tests are reassuring, the crew member may then proceed to exercise treadmill testing with simultaneous VO2 max testing before returning to duty. If any of the above tests are abnormal, the crew member will not proceed to exercise testing and will instead resume post-COVID-19-recovery treatment until test results return to baseline. Additionally, if testing indicates a pulmonary disease pattern (e.g. certain ECG abnormalities, elevated right atrial pressure on echo) or if a deep vein thrombosis is found, the crew member will then progress to computed tomography with angiography and right heart catheterization. The need for such a stringent testing regimen stem from the markedly increased risk of decompensation in the microgravity environment, in conjunction with a lack of adequate resources to fully manage possible complications on-orbit. **APPLICATION:** The severity of COVID-19 and associated chronic sequelae require novel clinical

practice guidelines to ensure the health and continued safety of the astronaut population on the ground, in atmospheric flight, and during spaceflight

Learning Objectives

1. The audience will learn about Cardiopulmonary and Hematologic Considerations of COVID-19.
2. Participants will be able to understand the necessity to develop novel clinical practice guidelines to ensure the health and continued safety of the astronaut population on the ground, in atmospheric flight, and during spaceflight.

[139] COVID-19: ASTRONAUT MONITORING AND RETURN TO DUTY: NEURO/NEUROCOGNITIVE, OPHTHALMOLOGIC, AND DERMATOLOGIC CONSIDERATIONS

Genevieve Korst[1], John Marshall[2], William Valencia[3], Stephen Kunkel[2], Ronak Shah[3], Serena Aunon-Chancellor[3]
[1]*Baylor College of Medicine, Houston, TX, USA;* [2]*UTMB, Galveston, TX, USA;* [3]*NASA Johnson Space Center, Houston, USA*

Education - Tutorial/Review

INTRODUCTION: COVID-19 affects multiple organ systems and may have effects weeks, months, or years into the future. Crew members developing COVID-19 related neurologic, neurocognitive, ophthalmologic and dermatologic sequelae may require thorough testing and monitoring to ensure safe return to duty. **TOPIC:** Mild to moderate neurologic manifestations of COVID-19 include anosmia and ageusia, as well as more severe illnesses such as strokes, meningoencephalitis, inflammatory polyneuropathies and neurocognitive deficits. These illnesses may cause severe impairment of crew members, and deficits may be subtle in early stages, complicating diagnosis and monitoring. In the COVID-19 afflicted crew member, we recommend a thorough clinic based, comprehensive neurologic and neurocognitive exam with neurology consultation and further testing as clinically indicated. Ophthalmologically, conjunctivitis is most common but typically resolves without major consequence. A small percentage of patients with more severe disease may develop cotton wool spots and microhemorrhages. Evidence is conflicting regarding changes to the Retinal Nerve Fiber Layer (RNFL). No vision loss or visual disturbances have been attributed to COVID-19-associated microcirculation defects or RNFL changes. Given Spaceflight Associated Neuro-Ocular Syndrome (SANS) risks in astronauts and its overlap with COVID-19 ophthalmologic manifestations, we recommend monitoring via Ocular Coherence Tomography, fundoscopy and retinal photographs if COVID-19 is diagnosed. Associated dermatologic manifestations include pseudo-chilblain, vesicles, urticaria, maculopapular, livedo or necrosis with possible pruritis, burning or pain. Preexisting skin conditions may be exacerbated during infection. Full skin survey is recommended if COVID-19 is diagnosed. If a new skin lesion is found, it should be monitored for resolution. If an alternative etiology is suspected, laboratory testing and dermatology consultation may be considered. **APPLICATION:** Known and impending COVID-19 sequelae necessitate new clinical practice guidelines to return crew members to duty. These guidelines involve a comprehensive approach befitting the rigorous standards for crew member functional performance.

Learning Objectives

1. Understand major neurologic, neurocognitive, ophthalmologic, and dermatologic manifestations of COVID-19 and their impacts on astronaut function and fitness for duty.
2. Understand the need for and the bases of novel clinical practice guidelines for returning astronauts diagnosed with COVID-19 to duty.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany 4

[S-30]: PANEL: CLINICAL CASE PRESENTATIONS AND AEROMEDICAL DECISION MAKING

Chair: Albert Lee

PANEL OVERVIEW: *Every day in aerospace medicine clinic, we encounter countless number of medical conditions and are called to evaluate and disposition the aircrew member. In this panel, RAMs (Resident in Aerospace Medicine) will bring clinical cases from various aerospace medicine clinics around the world. Whether a case with a rare diagnosis or a common diagnosis, each case brings a unique learning objectives. Through each case presentation, we will increase the understanding of the epidemiology, treatment, and prevention of the disease. The panel will discuss the aeromedical decision making process for each case. The cases discussed in this panel will help the audience perform better as aeromedical practitioners.*

[140] SOPITE SYNDROME: A MALADAPTATION TO MOTION

Brett Matzek[1]
[1]*School of Army Aviation Medicine, Fort Rucker, AL, USA*

Education - Case Study

INTRODUCTION: Flight surgeons are intimately familiar with the classic symptoms of motion sickness including nausea, dizziness, cold sweats and difficulty concentrating. A less commonly discussed, but no less important, mal-adaptive condition is Sopite Syndrome. This condition, first described in the literature in 1976 was described as a constellation of symptoms including fatigue, drowsiness, irritability and decreased cognitive function in the setting of motion exposure. **CASE PRESENTATION:** A 35 year old active duty Army Critical Care Flight Nurse presented with concerning symptoms following a prolonged transport flight. She reported approximately an hour into the flight she developed overwhelming drowsiness and difficulty concentrating. These symptoms persisted for more than six hours. She denied nausea, headache, hot sweats, or other motion sickness symptoms. She had no recent illness. As a flight nurse she had a current flight duty physical. She reported occasional motion sickness when flying in turbulence, especially when reading during the flight or when using night vision devices. However, these episodes had been mild and did not affect duty performance. She had no history of seasickness or motion sickness in ground vehicles. These symptoms had occurred in the past during long flights but was blamed on simple fatigue. The patient had a normal clinical evaluation. The symptoms improved during subsequent flights and the patient was able to complete her deployment without changes in duty status. **DISCUSSION:** Classic symptoms of motion sickness are not compatible with the flight environment. Flight students who are unable to increase tolerance early in their flight training are medically disqualified. Sopite syndrome may present with or without the typical motion sickness symptoms and may be harder to detect during shorter training flights. The aviation environment is one filled with noise, extremes of temperature, vibration and complex tasks. Fatigue and irritability may be blamed on these exposures, however, in cases where the symptoms are more severe or longer lasting than expected, the symptoms may be due to motion mal-adaptation. Standard desensitization techniques, medications and behavioral therapies can be trialed to improve symptoms. Uncontrolled symptoms would compromise the safety of flight and would require waiver or suspension.

Learning Objectives

1. The audience will learn about the causes and symptoms of Sopite Syndrome.
2. The audience will learn about the aeromedical implications and flight considerations of patients with Sopite Syndrome.

[141] RUDDER FORCE SIMULATION IN COMMERCIAL PILOT WITH MOVEMENT DISORDER

Woodrow Sams
Mayo Clinic, Rochester, MN, USA

WITHDRAWN

[142] OPTIC NERVE DRUSEN IN AN INITIAL PHYSICAL

Ann Charlot
USASAM, Enterprise, AL, USA

Education - Case Study

INTRODUCTION: This case report depicts the decision-making process for approval of an initial flight physical for an applicant with optic nerve drusen. **BACKGROUND:** The eyes are an important organ, especially in aviation, as it plays a role not only in vision but also in spatial orientation. It is important to be judicious in the selection of pilots with medical conditions that may acutely or chronically affect their vision. Visual defects constitute additional risks that could result in inappropriate responses leading to accidents. **CASE PRESENTATION:** The patients was a 26-year-old Caucasian male, completing an initial flight physical to apply to the US Army Flight School. He reported no chronic medical conditions, and his medical record did not reveal anything concerning. Dilated fundoscopic examination showed elevation of the optic nerves bilaterally, blurry margins of the optic discs and deposits on both optic nerves. He was diagnosed with bilateral optic disc drusen. Repeated visual field evaluations showed some inconsistencies, but they were determined not to be due to drusen. The applicant was given an exception to policy and allowed to proceed to flight training. He will require close follow-ups with ophthalmologic evaluations throughout his career. **DISCUSSION:** Optic drusen is a condition in which protein and calcium accumulate and deposit within the optic nerve. The changes in the optic nerve have the propensity to cause loss of peripheral vision. In some advanced cases, it may cause neovascularization and/or bleeding. There are no cure or treatment. As the optic nerve deform and enlarge, it pushes against the rod-rich area in its surroundings, affecting peripheral vision and night vision which are critical for a pilot. In this case, the importance of reliable vision with a full visual field is stressed in the pilot selection process. Pilots rely on their visual, proprioception and vestibular cues to accurately assess their position. Optic nerve drusen tends to progress to loss of visual field and peripheral and night vision impediment, which adds unnecessary risk to flight. This case demonstrates an appropriate evaluation of optic nerve drusen.

Learning Objectives

1. At the end of this case report, participants should be able to understand and interpret the discussed ophthalmologic exams and tests.
2. Participants should be able to recognize Optic Nerse Drusen diagnosis.
3. Participants should understand or be familiar with the aerospace implications of Optic Nerve Drusen.

[143] PRIMARY ADRENAL INSUFFICIENCY RESULTING IN CHRONIC HYPONATREMIA IN A COMMERCIAL PILOT

Emily Stratton[1], Clayton Cowl[2]
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Education - Case Study

INTRODUCTION: This case report describes a commercial pilot with insidious symptoms, who after being misdiagnosed, later was discovered to have primary adrenal insufficiency. **BACKGROUND:** Addison's disease results when the adrenal cortex is destroyed by an autoimmune process causing a failure of cortisol, aldosterone, and androgen production. Its presentation is often vague with symptoms that include fatigue, nausea, weight loss, hyperpigmentation, and even postural hypotension. The condition may also first appear as adrenal crisis, a severe, life-threatening emergency. As a result, the potential for the adverse consequences of Addison's disease may have a significant impact on pilot and passenger safety. **CASE PRESENTATION:** This 41-year-old commercial airline pilot with a past medical history significant for hypothyroidism and vitiligo, presented to an Emergency Department for hypotension, dizziness, and GI distress. Labs revealed hyponatremia and azotemia. He was treated with 2% saline intravenously, fluid restriction, and demeclocycline. He was discharged with a presumptive diagnosis of idiopathic syndrome of inappropriate antidiuretic hormone secretion (SIADH). His Class I FAA medical certificate was then suspended. At that time, cortisol was normal. Ultimately, the pilot sought a second opinion. Although the serum electrolytes were similar, the cortisol level was low and the adrenocorticotropic hormone (ACTH) was elevated, consistent with primary adrenal failure. He was started on hydrocortisone and fludrocortisone with improvement in symptoms. Aeromedical certification was granted under Special Issuance Authorization by the FAA with the stipulation that the airman must carry additional corticosteroids as needed in an emergency and to ensure sodium levels normalized. **DISCUSSION:** This case highlights the need for the clinician to maintain a high degree of clinical suspicion for Addison's Disease as a potential etiology of hyponatremia, recognizing the critical action of ACTH and the need for cortisol testing. Making a correct diagnosis was important, not only for providing appropriate therapy, but also from an administrative perspective since this pilot was able to return to flight duties. This case highlights the importance of early recognition of adrenal insufficiency when initial laboratory values include hyponatremia and hyperkalemia.

Learning Objectives

1. The audience will learn about the importance of early recognition of adrenal insufficiency when initial laboratory values include hyponatremia and hyperkalemia.
2. This case highlights the need for the clinician to maintain a high degree of clinical suspicion for Addison's Disease as a potential etiology of hyponatremia, recognizing the critical action of ACTH and the need for cortisol testing.
3. The audience will learn the importance of a correct diagnosis, not only for providing appropriate therapy, but also from an administrative perspective since this pilot was able to return to flight duties.

[144] A HEART-BREAKING CASE OF MILITARY INTEGRITY

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Education - Case Study

INTRODUCTION: A 31-year-old male presented with a report of intermittent chest pain. Initially believed to be a non-cardiac musculoskeletal condition, the ultimate diagnosis would involve specialists around the world with a life-changing outcome for the young aviator. This case-study reviews the patient's presentation, the diagnostic path, the final diagnosis, and includes a follow-up with the patient to hear about his current condition. **BACKGROUND**: Chest pain is a very common presenting symptom to Emergency Departments and primary care practitioners, and is especially prevalent in highly athletic organizations such as the U.S. military. A broad differential can sometimes make chest pain a diagnostic challenge that requires astute history taking, strong physical examination skills, and discerning use of studies to differentiate between benign and life-threatening causes. This is especially true in the case of aviation, in which safety is sometimes balanced against careers, and where even benign conditions can have considerable aeromedical implications. **CASE PRESENTATION**: A seemingly uncomplicated case of non-cardiac chest pain in a young, healthy aviator developed into a medical mystery that challenged the diagnostic acumen of his medical team. Rare episodes of sharp, briefly incapacitating chest pain raised safety-of-flight concerns, but never occurred in flight. The increasingly complex work-up proceeded to rule out serious medical conditions, but the results ironically meant that his aviation career was in jeopardy. Demonstrating exceptional professional integrity and an understanding of what such an episode might mean in flight, the patient did not downplay or deny his symptoms despite their rarity. He was ultimately diagnosed with Precordial Catch Syndrome, which resulted in permanent removal from flight status and required a career change into a different military profession. **DISCUSSION**: This case will discuss the prevalence and work-up of chest pain, and particularly focus on Precordial Catch Syndrome, which was first described in 1955 and remains a common yet relatively unrecognized condition within the general population, and potentially within the aviation community. It will also discuss how aeromedical risk assessment diverges from standard medical risk assessment for this type of diagnosis. The presentation is intended for Aerospace Medicine residents and military flight surgeons, but may be of interest to civilian aeromedical examiners.

Learning Objectives
1. The audience will be informed about Precordial Catch Syndrome, a common but relatively unknown benign medical condition with aeromedical safety implications.
2. The audience will receive a review of the most current evidence for chest pain workups in aviation personnel.

[145] COSMIC RADIATION AND SKIN CANCER

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Education - Case Study

INTRODUCTION: A 50yo military veteran and Department of Army Civilian pilot contracted a non-healing ulcer on his right brow after more than 22 years of military aviation service. This is an evaluation of the lesion and risk factors that led to it, and an evaluation of emerging risk factors as aviation evolves towards space. **BACKGROUND:** High altitude activities includes the risk of increased exposure to ionizing cosmic radiation. Although the Earth itself is a reservoir of ionizing radiation the surface is protected from the extreme cosmic radiation by the magnetosphere and various shielding effects of the atmosphere. Aviation activity bypasses much of these shielding effects even at relatively low altitudes, leading to increased exposures and a higher rate of various skin cancers and other physiologic injury such as myocardial damage. **CASE PRESENTATION:** The patient is a 50 year old Caucasian male recently retired from active service and continuing service as a Department of the Army Civilian. He had a slowly developing right brow ulcerating and scaly lesion that he did not bring to his health care provider's attention. He was concerned it was due to "picking" at the lesion. A flight surgeon flying with him incidentally noted it and recommended biopsy and investigation for skin cancer due to higher risks with aviation exposure to elevated levels of ionizing radiation. The pilot successfully received treatment for early Basal Cell Carcinoma. **DISCUSSION:** Aviation activity is currently undergoing a massive paradigm shift aiming at higher targets with the advent of new VTOL systems, space tourism, private companies entering suborbital and orbital altitudes, and private and public plans for Mars missions. These new goals and the creation of civilian astronauts require a review of known and anticipated risks of radiation to high altitude, orbital, and space travel and current concepts for the design of shielding from cosmic radiation. This explosion of exploration may eventually cause a trickle down of new data, physiologic, and engineering solutions to radiation exposure of atmospheric travel as well as the emerging field of space travel.

Learning Objectives
1. Understand the risks of aviation activity with regards to ionizing radiation.
2. Understand options for engineering and physiologic solutions to ionizing radiation in aviation.

Tuesday, 05/24/2022 ***2:00 PM***
Tuscany 12

[S-31]: SLIDES: SPACEFLIGHT ANALOG MODEL TOPICS

Chair: Bonnie Posselt
Co-Chair: Matthew Manoj

[146] CARDIOPULMONARY RESPONSES TO CENTRIFUGE SIMULATED PARABOLIC FLIGHT

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Institute of Aerospace Medicine, Bangalore, India

Original Research

INTRODUCTION: Parabolic flights, by producing short periods of weightlessness, simulate microgravity. However, they are expensive, incur a significant logistics support, and occurrence of any adverse events during such simulation is undesirable. The present study was formulated to explore the feasibility of using a human centrifuge for simulation of parabolic flight to study the cardiopulmonary parameters as an alternative ground-based model. **METHODS:** 12 healthy male volunteers were subjected to simulated parabolic flight, the profile of which involved exposure to 20 repetitions of hypogravity periods (+0.5 Gz), each interposed between periods of hypergravity phases (+2 Gz), using High Performance Human Centrifuge. Heart rate (HR), respiratory rate (RR) and arterial oxygen saturation (SpO_2) were recorded and analyzed using one-way repeated measures ANOVA. Motion Sickness Assessment Questionnaire was administered to the participants after the run. They were also asked to rate their subjective feeling of weightlessness experienced during the run. **RESULTS:** Comparison of HR revealed a significant difference ($F=22.167$, $p<0.001$) across different gravity phases. Post-hoc analysis revealed that, mean HR of hypergravity phases was significantly higher compared with Pre-run 1 G values and that of hypogravity phases. Similarly, HR showed a significant difference across Pre-run 1 G, 10th and 20th loops of hypogravity phases ($F=5.672$, $p=0.01$). Post-hoc analysis, however, revealed that the reduction in HR at 20th loop was significant than both Pre-run 1 G ($p=0.023$) and 10th loop ($p=0.042$) values. No significant differences were observed in RR and SpO_2. The mean Overall Motion Sickness Score was 23.6%. Participants rated their subjective feeling of weightlessness between 4 and 6 (Mode=5) on a scale of 1 to 10. **DISCUSSION:** It can be concluded from the results that HR increased during hypergravity conditions and reduced during hypogravity conditions, an expected outcome during parabolic flight. The significant reduction in HR during the 20th loop of hypogravity phase compared to 10th loop and Pre-run 1 G conditions indicate a possible association with duration of exposure. The centrifuge simulated parabolic flight profile designed in our study was able to emanate physiological changes similar to those experienced in actual parabolic flight for HR, RR and SpO_2.

Learning Objectives
1. The audience will learn about the simulation of parabolic flight using a ground-based human centrifuge and its effects on the human cardiovascular system.
2. The audience will learn about the opportunities for exploring the possibilities of utilizing ground-based human centrifuges for studies related to microgravity and hypogravity states.

[147] CONTINUOUS BLOOD GLUCOSE MONITORING OF SUBJECTS DURING CENTRIFUGE-SIMULATED SPACEFLIGHT

Karen Ong, Josie Rossitto, Quinn Durfurrena, Kristi Ray, Rebecca Blue
UTMB, Galveston, TX, USA

Original Research

INTRODUCTION: The growth of the commercial spaceflight industry is dependent upon the ability to expand access to space to a broader pool of individuals than those traditionally selected as astronauts. Potentially, this expanding pool may include individuals with medical conditions previously excluded from spaceflight, such as diabetes mellitus. While previous studies have demonstrated that individuals with type 1 and type 2 diabetes are able to tolerate centrifuge-simulated spaceflight, there are little data regarding the potential effects of spaceflight stressors such as hypergravity on blood glucose (BG) in either non-diabetic or diabetic individuals. Continuous blood glucose monitoring (CGM) offers a means to continuously, remotely, and non-invasively collect BG data on subjects, eliminating the need for repetitive, invasive sampling or procedural expertise. In other analog environments, CGM has been used to provide real-time BG monitoring in aviation and hyperbaric and diving activities; however, such technologies have not been utilized or explored in spaceflight-related activities. We present results from a small pool of subjects who underwent continuous BG monitoring during hypergravity exposures in centrifuge-simulated spaceflight. **METHODS:** Continuous BG monitoring was performed on four subjects participating in centrifuge-simulated spaceflight profiles. Subjects underwent up to 5 centrifuge runs in a single day, including profiles inclusive of both $+G_x$ and $+G_z$

exposures (peak exposures +4G_z, +6G_x). The results of CGM monitoring were correlated with biometric data (heart rate, respiratory rate, and blood pressure) obtained during the profiles. **RESULTS:** Subjects demonstrated variable BG levels throughout the day. Moderate increases in BG were seen immediately during and after centrifuge-simulated spaceflight profiles, correlating with elevated heart rate indicative of sympathetic responses expected during hypergravity exposures and with muscular strain from anti-G straining maneuvers utilized during +G_z exposures. **DISCUSSION:** These results suggest that CGM may be a viable method for monitoring BG during spaceflight and analog activities. Further, initial data provide a baseline understanding of BG variability resulting from hypergravity stressors. BG variability observed may result from sympathetic stimulation associated with centrifugation and physical exertion of anti-G-straining maneuvers.

Learning Objectives

1. The audience will learn about continuous blood glucose monitoring and potential applications in spaceflight and analog environments.
2. The audience will learn about alterations of blood glucose during hypergravity stressors.

[148] MAKING SPACE FOR ALL: A PRIMER FOR THE PARASTRONAUT PHYSICIAN

Sheyna Gifford[1], Jim Vanderploeg[2], Erik Viirre[3]
[1]*Washington University St. Louis, St. Louis, Missouri, USA;* [2]*University of Texas Medical Branch at Galveston, Galveston, TX, USA;* [3]*Univeristy of CA at San Diego, San Diego, CA, USA*

Education - Case Study

INTRODUCTION: The traditional paradigm of astronauts as representing the most physically abled members of our species is rapidly shifting. This evolution is accompanied not only by the rise in commercial spaceflight, where paying-to-fly travelers with a variety of functional levels must be accommodated, but also by the long-in-coming change to the functional definition of "ability." ESA's 2021 call for parastronauts with limb loss, leg length discrepancies, and/or short stature highlights how physical abilities and features long considered essential for high performance on Earth are not necessarily required or even optimal for high performance in spaceflight. This opening of space exploration to humans of all physical permutations and presentations is likewise an opportunity for aerospace medicine to broaden its scope of practice. In order to successfully integrate parastronautics into our practice, Aerospace physicians supporting parastronaut flights must be prepared to care for a broader range of physiologic states and preexisting conditions than ever before. **BACKGROUND:** The AstroAccess initiative began in 2021 with the goal of making space travel accessible to flyers of as many functional abilities and variable physiologies as possible. Two experienced flight surgeons, a rehabilitation physician, and occupational therapist were engaged to assist in screening the applicants; planning flight experiments; modifying the ZeroG cabin for comfort, safety, and accessibility; and consulting with the crew and mission administration to develop preflight policies and procedures. **CASE PRESENTATION:** On October 17, 2021, 12 flyers with three categories of disabilities were flown on a Zero G flight parabolic flight out of Long Beach, California. Four flyers with visual impairments, including total blindness, two with deafness, and six with mobility impairments propelling via wheelchair or prosthetics flew fifteen parabolas: one lunar, two martian, and twelve microgravity. All were offered premedication for motion sickness. **DISCUSSION:** The first AstroAccess flight was a medical and public relations success. Following the established protocols, flyers of all three ability types were able to successfully and safely navigate the cockpit cabin within their designated areas, perform assigned tasks, and return to their mats on cue for flight hypergravity segments. Lessons learned will inform future parastronaut flights and flight selection.

Learning Objectives

1. The audience will learn about procedures for providing medicine consultation on, screening of, and medical support for space crews with known visual, aural, and/or mobility limitations.
2. The participants will be able to name some challenges that may be faced the the flight surgeon when preparing a crew of disabled flyers for their first parabolic flight.
3. The audience will learn about adaptations that may be make to the cabins of parabolic flights to safely and comfortably accommodate disabled passengers.

[149] WEIGHTLESSNESS ASSOCIATED CEPHALAD FLUID SHIFTS; THE POTENTIAL TO EVALUATE VENOUS AND LYMPHATIC DYSFUNCTION WITH POINT OF CARE THERMOGRAHY

Ari Sofer[1], Matthew Melin[2], Heather Hettrick[3]
[1]*Nova Southeastern University adjunct, Soffer Health, Aventura, FL, USA;* [2]*M Health Fairview, Plymouth, MN, USA;* [3]*NSU, Ft . Lauderdale, FL, USA*

Education - Tutorial/Review

INTRODUCTION: Spaceflight crew exposure to weightlessness results in a 2 liter fluid shift from the legs to the neck and head within 6-10 hours of attaining orbit with adaptation over the following 4 days. Invasive methods have been utilized to measure transcapillary fluid shifts in a head down tilt (HDT) analogue, central venous pressure catheter measurements in orbit and internal jugular venous duplex ultrasound in both parabolic flight and on the International Space Station (ISS). **TOPIC:** Point of care (POC) evaluation using non-invasive, decreased mass/weight, validated tools may further improve the evaluation and understanding of cephalad fluid shifts venous distension, and lymphatic dysfunction2 contributing to Spaceflight Associated Neuroocular Syndrome (SANS) research. Thermography has been used for evaluation of chronic venous insufficiency (CVI), lymphedema, and deep tissue injuries (pressure injuries). Thermography has an established orbital use as a noncontact handheld inspection tool for Shuttle wing evaluations. Thermography devices have continued to decrease in size, mass/weight with improved thermal image signal acquisition, tissue differentiation and increased pixel count. The goal of this presentation is a review of POC Thermography (POCT) for use in spaceflight analogue and weightlessness assessment as a component of SANS research. Current peer reviewed published data will be presented for CVI, lymphedema and pressure injuries. Current handheld POCT technology will be detailed and compared to standard of care duplex ultrasonography (DUS). The theoretical potential for three-dimensional imaging will be reviewed. Astronaut core body temperature (CBT) increases by 1°C gradually on ISS and was associated with increased inflammatory markers. POCT may serve as an adjunctive monitor for elevated crew CBT. Thermography has been studied for the accurate continuous analysis of core body temperature patterns in mice. Determining core body temperature patterns and relative changes may be beneficial. **APPLICATION:** POCT is an emerging technology that offers a low mass/weight handheld noncontact device with clinical application for CVI, lymphedema and early detection of skin temperature thermal pattern abnormalities. POCT has high potential for application and use in spaceflight analogue testing, on parabolic flights, ISS, and other spacecraft for fluid shifts (acute and chronic), SANS, and crew CBT evaluations.

Learning Objectives

1. Describe the historical methods used for evaluating fluid shifts in weightlessness.
2. Describe Thermography technology applicability on earth regarding venous and lymphatic disease.
3. Describe the historical use of thermography in weightlessness and potential future crew uses.

[150] SUBORBITAL FLIGHT EVALULATION OF HEALTHCARE TECHNOLOGY FOR EXPLORATION SPACEFLIGHT

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University of Louisville, Louisville, ky, USA

Original Research

INTRODUCTION: Suborbital spaceflight provides the opportunity for research procedures in reduced gravity beyond what is available from parabolic flight. We report the experience of a suborbital spaceflight evaluation of a fully automated surgical fluid management system (SFMS). **METHODS**: Surgical treatment requires reliable wound control and containment in reduced gravity. The aqueous immersion surgical system (AISS) is a transparent, rigid dome attached to the skin over a surgical site. The dome is filled with an immersion fluid to control bleeding, cleanse the wound, and maintain a clear visual field. A multifunction surgical device (MFSD) provides fingertip control of suction and irrigation as well as illumination. Surgical instruments can be introduced into the AISS dome via leak-free trocars incorporated into the dome wall. The SFMS is an integration of pumps, sensors, and fluid reservoirs that controls fluid flow to and from the AISS and MFSD. The SFMS is operated by custom software running on a National Instruments myRIO microprocessor in real-time. The integrated system was attached to an experiment board inside a custom-designed glovebox made of aluminum and polycarbonate. The glovebox is the equivalent size of two stacked ISS stowage lockers (18.5" x 23" x 21.5"). **RESULTS**: Following five days of pre-flight preparation including safety assessments, power interface check, payload mounting, electromagnetic and communication interference checks, the fully automated payload flew a suborbital flight profile on the Virgin Galactic SpaceShipTwo spacecraft that provided nearly three minutes of continuous microgravity (μ-g). After satisfying a four-step algorithm verifying that μ-g (<0.05g) had been achieved, the SFMSs successfully initiated the evaluation protocol and executed a 32-step sequence. Subtle differences between 1-g baseline and μ-g data were observed, including the degree of dome filling and pressure ramp levels, due to the dome compliant base simulating skin in the absence of hydrostatic pressure. This data indicates the need to revise the control algorithm for optimal AISS operation in μ-g. **DISCUSSION**: This flight experience demonstrated the value of suborbital flight for conducting initial μ-g performance evaluation of medical technology for exploration spaceflight. The ability to fly human-tended systems where human interactions are required for comprehensive system performance evaluation is anticipated in the near future.

Learning Objectives

1. Understand the difference in the exposure to reduced gravity experienced in a drop tower test, parabolic flight, suborbital flight, and orbital flight.
2. Learn how evaluation of medical technology for crew heath care anticipated for exploration spaceflight can be conducted in suborbital spaceflight using automated payloads and human tended payloads.

[151] THE MORTALITY OF AEROSPACE SPECIALISTS IN RUSSIA

Igor Bukhtiyarov[1], Evgeny Zibarev[1], Kristina Betts[1], Igor Ushakov[2], Yuri Voronkov[3], Marina Bukhtiyarova[4]

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Original Research

INTRODUCTION: Employees of the aerospace industry are of particular interest to researchers due to the fact that the working conditions of cosmonauts and civilian aviation (CA) pilots cannot be found or fully modelled on Earth. At the same time, a complex of adverse occupational factors, including psychological and emotional stress, affects the health of cosmonauts and pilots throughout their working life which may subsequently be reflected in the causes and rates of mortality after retirement. **METHODS:** A series of cohort studies were carried out aimed at studying the mortality of male USSR and Russian cosmonauts and the mortality of male Russian CA pilots. Two cohorts of cosmonauts were formed: 118 cosmonauts with spaceflight experience (SFE) (cohort 1) and 145 cosmonauts without SFE (cohort 2). The follow-up period lasted 60 years (01.01.1960-31.12.2019), 8508.9 person-years obtained. The all-cause mortality risk for the cosmonauts with SFE was assessed compared to the cosmonauts without SFE in order to eliminate the "healthy worker" effect. The cohort of CA pilots included 18 254 pilots who completed their flight activities and retired. Due to the peculiarities of the Russian legislative system the follow-up period for the pilots' cohort was 5 years (01.01.2015-31.12.2019), 78453.7 person-years obtained. The all-cause mortality risk for pilots was assessed compared to the male Russian population. In both studies the standardized mortality ratio (SMR) with 95% confidence interval (95% CI) were used. **RESULTS:** As of December 31, 2019, 40 cosmonauts deceased in cohort 1 (33.9%) and 64 cosmonauts deceased in cohort 2 (44.1%). The all-cause mortality risk for cosmonauts with SFE compared to the cosmonauts without SFE was 70 (95% CI 50-95). In the cohort of CA pilots 1381 people deceased (7.6%). The SMR for pilots compared to the male Russian population was 52 (95% CI 50-56) for all causes. **DISCUSSION:** The legislative system in Russia restricts researchers' access to anonymous personal data of employees in various fields, including aerospace industry. The study results show the need for further research on aerospace specialists' mortality with special attention to cause-specific mortality. The careful analysis of cosmonauts' and CA pilots' mortality will help to identify the measures necessary to preserve the health of employees and prolong their working longevity.

ACKNOWLEDGMENTS*:* The reported study was funded by RFBR, project number 19-315-90023.

Learning Objectives

1. The audience will learn about the occupational factors that influence the health of cosmonauts and civilian aviation pilots throughout their working life.
2. The participant will learn about methods to assess the mortality risks of aerospace specialists in the distant period and challenges the researchers face in order to do so.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany C,D,E

[S-32]: PANEL: MANAGEMENT OF DECOMPRESSION SICKNESS AND CREW INJURY DURING EXPLORATION EVA

Chair: Robert Sanders

PANEL OVERVIEW: *Decompression sickness (DCS) and acute suited injuries are a known risk associated with spaceflight extravehicular activity (EVA). For DCS, NASA has used an approach primarily focused on the prevention of DCS and has done so quite successfully with no known reports of DCS. In addition to prevention of DCS, there is also a DCS treatment protocol and a disposition policy that describes the time off and any needed medical assessment prior to return to duty. As NASA moves towards Exploration class missions with different Exploration Atmospheres (EA), spacesuits, vehicle designs and mission success completely dependent on EVA performance, there is a need to evaluate the overall strategy to DCS management. The approach to DCS prevention is being discussed in a separate panel and the focus of this panel will be to review the DCS treatment approach when performing EVA from Exploration Atmosphere, to evaluate the how other organizations disposition the return to duty status of personnel post successfully treated DCS and to evaluate the overall impact of how this return to duty disposition affects the likelihood of mission success. Beyond DCS, there are many other possible reasons that an astronaut may not be able to complete an EVA. The analysis of mission impacts due to DCS was also readily applied to any acute injury that would limit the astronaut for 1-3 days. Finally, although DCS is not likely to lead to significant incapacitation if identified early, the possible causes of acute injury during EVA that could lead to some degree of consequence from needing help to full incapacitation has been identified to help identify possible*

developments or operational strategies while ensuring astronaut safety and mission success.

[152] DCS TREATMENT FOR EXPLORATION ATMOSPHERE STUDY

Robert Sanders[1], Steven Piper[2], Leisa Deutsch[1], Joseph Dervay[2], Alejandro Garbino[3]
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Original Research

INTRODUCTION: Living at 8.2 psi (≈15,000') and working at 4.3 psi (≈30,000') does not has a terrestrial equivalent, nor has it been tested. Approximately 93% of altitude DCS (exposures sea level to 4.3 psi) cases resolve upon repress (Conkin et al., 2015). With a baseline saturation of 8.2 psi/34% oxygen, the initial nitrogen load will be less when exposed to the same 4.3 psi, thus one would expect greater than 93% resolution. However, ambulatory missions are far more provocative than non-ambulatory (Conkin et al., 2017), thus a lunar surface mission needs to be prepared to treat persistent DCS. A two-hour ground-level oxygen (GLO) breathing is first-line treatment for altitude DCS. Effective in many cases, research by Webb and others have shown even this to have a measurable failure rate, thus a contingency therapy must exist for research and operations. **METHODS:** Using the following constraints, a treatment plan for this research and that could be utilized on a lunar mission was developed: 1)a patient with a mild DCS case can return to the study; 2)exceeds the minimum acceptable terrestrial standard of two hours of GLO; 3) minimize the chance of symptomatic recurrence when back to 8.3 PSIA; 4) a fully equipped chamber must be available to treat type II DCS cases. **RESULTS:** A "GLO" treatment plan utilizing four hours of 14.7 psia oxygen was proposed. The four hours came from the amount of oxygen breathed during a standard U.S. Navy Treatment Table 6 with air breaks and travel time removed. A decision tree of 10 min. of GLO for symptom resolution was determined to be a safe trial period to allow subjects to remain in the study versus being routed to the hyperbaric chamber. **DISCUSSION:** Similar to in-water recompression, treatment of DCS on the lunar surface will not be a "gold standard" treatment, but rather a "best effort" combination of pressure and oxygen to control bubble growth and tissue hypoxia in an austere environment. Using known parameters and 2-hour GLO as a baseline therapy, but also ensuring no nitrogen intake and minimal chance of recurrence, this plan was drafted.

Learning Objectives

1. The audience will learn the approach and rationale for the selection of a DCS treatment protocol for an Earth based study of NASA's Exploration Atmosphere Prebreathe protocol.
2. The audience will learn how operational logistics and mission limitations affect the choice between a "gold standard" and "best effort" treatment.

[153] EVALUATION OF DCS TREATMENT CAPABILITIES WHEN PERFORMING EVA FROM REDUCED PRESSURE ENVIRONMENTS

Joseph Dervay[1], Robert Sanders[2], Alejandro Garbino[3], Jason Norcross[2], Andrew Abercromby[1], James Pattarini[1], Johnny Conkin[4]
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Original Research

INTRODUCTION: NASA plans to operate Exploration vehicles at reduced pressure environments including 56.5 kPa (8.2 psia) on the Lunar surface and 70.3 kPa (10.2 psia) in cis-Lunar space. Although the rationale for these environments is to reduce oxygen prebreathe time prior to EVA, the reduced pressure cabin atmosphere could limit the ability to treat decompression sickness (DCS) should it occur. **METHODS**: Two models, the hypobaric DCS treatment model and a biophysical model of bubble growth, were used to compare predicted DCS symptom and bubble resolution of the current ISS DCS treatment protocol against possible Exploration scenarios. Assumptions common to all scenarios were that DCS risk was consistent with NASA's acceptable risk, the extravehicular activity (EVA) suit was pressurized to 29.6 kPa (4.3 psia) during EVA, suit delta pressure and an FiO2 of >95% were maintained during repressurization and DCS treatment. Assumptions for the ISS scenario included a 30 min EVA terminate time before repressurization to 101 kPa and the ability to increase suit pressure from 4.3 psid to 6-8 psid. Exploration assumptions included the ability of the EVA suit to increase pressure to 8.2 psid during EVA and 1-hour EVA terminate duration prior to repressurizing to 56.5 or 70.3 kPa cabin pressure. **RESULTS**: The ISS DCS treatment protocol showed a probability of symptom resolution of 92-98% with repressurization to 101 kpa cabin plus suit pressure at 29.6 kPa and 95-99% with suit pressure at 55.2 kPa. Peak bubble growth index (BGI) was 18.6 and the time to bubble resolution was 2.45 hours. For Exploration scenarios, the probability of symptom resolution was 89-97% with repressurization to 56.5 kPa cabin and 91-97% at 70.3 kpa cabin; both scenarios had suit pressure at 56.5 kPa. Peak BGI was 14.6 and the time to bubble resolution was 1.75 hours for cabin pressure of 56.5 kPa and 1.65 hours for 70.3 kPa. **DISCUSSION**: Two different models showed that effective DCS treatment can be provided during spaceflight scenarios. Return to a cabin pressure of 101 kPa is not required to adequately treat spaceflight DCS when an EVA suit can pressurize to 8.2 psid during the EVA, providing an initial arrest of bubble growth. Symptom resolution probabilities for all scenarios were high and not statistically different. Exploration vehicles planning to operate at reduced pressure atmospheres are no longer required to be able to pressurize to 101 kPa for DCS treatment.

Learning Objectives

1. The audience will learn how two different models were applied to evaluate the likelihood of successful DCS treatment.
2. The audience will learn how rapid application of pressure immediately after a DCS incident can assist with the treatment of DCS.

[154] REVIEW OF TYPE I DECOMPRESSION SICKNESS DISPOSITION POLICIES FROM 18 ORGANIZATIONS

Joshua Zamarron[1], Grant Harman[1], Jason Norcross[2], Robert Sanders[2], Alejandro Garbino[3], Keith Brandt[2], Andrew Abercromby[7]
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Original Research

INTRODUCTION: NASA's current disposition policy for alternobaric duty requires a 72 hour off-duty timeframe following successful and uncomplicated recovery from a Type 1 DCS event. There is no current physiological rationale that would necessitate a minimum return to duties timeframe after successful decompression sickness (DCS) treatment. A lack of a clear minimum success threshold is reinforced by the Undersea and Hyperbaric Medical Society (UHMS): There is no compelling evidence at present to support any specific waiting period for return to diving after treatment of DCS. **METHODS:** A list of DCS type 1 disposition policies from organizations throughout the globe was compiled for comprehensive review. Disposition policy review was focused on organizations that contribute to diving or aerospace medicine. For organizations that do not publicly publish their disposition polices, direct consultation with organizational medical officers was conducted. Due to limited data surrounding altitude DCS, diving DCS disposition policies were also included in the review. **RESULTS:** The minimum timeframes outlined in the following data set assume uncomplicated recovery of a DCS Type 1 event. 18 different DCS type 1 disposition policies were reviewed. 9 organizations do not have a specific timeframe, opting for medical professionals to provide approval on an individual case basis. 1 organization does not have a disposition policy. 8 organizations had minimum specific timeframes listed with a range of 24 hours to 7 days. Of those 8, 3 organizations follow a 24 hour timeframe, one of which does not require medical clearance, 3 organizations follow a 72 hour timeframe, and while only 2 organizations

use a 7 day timeframe. **DISCUSSION:** A mechanism of self-perpetuation becomes evident as the reviewed disposition policies often include similar language, timeframes, and checklists. The wide range of clustered disposition policies is indicative of a restrictively cautious approach exemplifying the latency period between policy and research. Assuming uncomplicated and successful treatment of DCS Type 1, NASA recognizes the potential for reducing disposition policy timeframes with no measurable increase on DCS risk for subsequent EVAs. Acknowledgment of this potential places the responsibility of determining reasonable disposition policies upon the research and medical experts of an organization.

Learning Objectives

1. The audience will learn that there is no overarching clear guidance towards a standard disposition policy for return to duty after a DCS incident.
2. The audience will learn that the return to duty disposition of personnel who experience DCS can be tailored to achieve safety while meeting the operational needs of a given mission.

[155] ANALYSIS OF MILD TYPE I DECOMPRESSION SICKNESS RETURN TO ALTERNOBARIC OPERATIONS FOR SHORT DURATION LUNAR MISSIONS

Grant Harman[1], Joshua Zamarron[1], Kevin Dolick[2], Jason Norcross[3], Robert Sanders[4], Andrew Abercromby[5], Alejandro Garbino[2]

[1]*JES Tech, Houston, TX, USA;* [2]*GeoControl Systems, Houston, TX, USA;* [3]*KBR, Houston, TX, USA;* [4]*UTMB, Houston, TX, USA;* [5]*NASA Johnson Space Center, Houston, TX, USA*

Education - Program/Process Review

BACKGROUND: NASA's current downtime policy due to mild type 1 decompression sickness (DCS) with an uncomplicated recovery is 72 hours if symptoms resolve upon repress, otherwise the time to return to duty is 7 days after treatment and resolution of symptoms. With an expected increase in the frequency of Extravehicular Activity (EVAs) during early Artemis missions, there is an interest in analyzing the potential mission impacts due to DCS. Currently for microgravity EVAs, the likelihood of DCS is low, but the risk of DCS is expected to increase for equivalent ambulatory EVAs during exploration missions. To understand the potential mission impacts due to DCS, it is important to quantify how different disposition policies, e.g., 24 and 72 hours, will affect the timeline and success of various exploration class missions. **OVERVIEW**: Early Artemis and planetary mission profiles are expected to have an increase in the frequency of EVAs compared to current microgravity operations. This analysis utilized the assumptions that all EVAs meet the following criteria: all DCS events are mild with a full, uncomplicated recovery, that no crewmembers will exceed 24 hours of EVA in a one-week timeframe, only one DCS event occurs per crewmember, and that all EVAs require all crewmembers. For these short missions with a profile of 4 EVAs per week, up to 3 EVAs may be missed with a 72-hour return to duty standard; up to 75% of EVAs missed for one week, and up to 37.5% for 2-week missions. Using a 24-hour standard up to 50% of EVAs missed for one week, and up to 25% for 2-week missions. **DISCUSSION**: For short duration lunar missions, 1 or 2 weeks in length, longer downtime policies due to a mild type 1 DCS event, such as the current NASA policy of 72 hours, will have significant impacts on the mission timeline and objectives. Along with the review of disposition polices for various industry and government organizations, which is also discussed in this panel, NASA recognizes that there is potential in reducing the current downtime policy due to mild type 1 DCS from 72 to 24 hours, with no measurable increase on DCS risk for subsequent EVAs. Beyond DCS, this analysis was also applied to cute EVA related injuries to look at differences in needed recovery time.

Learning Objectives

1. The audience will learn how medical disposition policy can affect exploration operations.
2. The audience will learn how evaluation of operational impacts from existing medical policies must be performed regularly especially when new programs with different mission objectives are established.

[156] BOOTS ON THE MOON INCAPACITATED CREW RESCUE (ICR) AND ACUTE INJURY

Marlei Walton, Jason Norcross, Robert Sanders

[1]*KBR/JSC-NASA, Houston, USA*

Original Research

INTRODUCTION: Return to the partial gravity environment of the moon outside of the protection of low earth orbit presents risks associated with unique injury scenarios during extravehicular activity (EVA) on the lunar surface, especially during early Artemis missions. Credible causes of astronaut injury requiring action from the other crewmember (rescuer) require identification and characterization to appropriately assess these risks and enable solutions to ensure crew health and safety. **METHODS:** Subject Matter Experts (SMEs) identified a list of medical conditions as potential credible ICR causes based on events that had either occurred during spaceflight or were of concern for EVAs during early Artemis missions. SMEs defined an ICR/Acute Injury "consequence" spectrum with scenarios to categorize these credible causes: low (help), medium (assistance), and high (incapacitated) where the affected astronaut respectively required either temporary or continuous partial assistance, or continuous full assistance from the rescuer. A subset of "Drivers" was further characterized with associated incidence based on astronaut, astronaut analog, general population, and model data to determine event probability (likelihood) associated with an early Artemis mission using the five established Exploration System Directorate (ESD) probability thresholds. **RESULTS:** Of the 264 medical conditions initially identified, 157 were categorized as potential credible causes during EVA on the lunar surface with 54 Drivers during an early Artemis mission. The distribution of these Drivers on the ICR/Acute Injury spectrum were predominantly in the low (help) to medium (assistance) categories, with less incapacitated events requiring continuous full rescuer assistance. ESD Very High and High probability groups were only associated with low or medium credible causes with representation of all three ICR/Acute Injury scenarios in the remaining Moderate, Low, and Very Low ESD probability groups. **DISCUSSION:** Given the Very High probability of one or more acute injury events requiring help or assistance from the rescuer during an early Artemis EVA, resources should be prioritized to ensure prevention and mitigation solutions are available such as suit hand-holds or "walking sticks". Although lower in probability, incapacitation is still a risk that may need additional load, transport, and lift capabilities that are currently lacking.

Learning Objectives

1. Learn about the credible cause medical conditions that lead to possible incapacitation and acute injury during an early Artemis EVA on the lunar surface.
2. Learn about probability and consequence risk associated with Driver credible cause medical conditions during an early Artemis EVA on the lunar surface.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany A

[S-33]: PANEL: SENSORY, PERCEPTUAL, AND COGNITIVE CONTRIBUTORS TO PILOT SPATIAL DISORIENTATION

Chair: Richard Arnold
Co-Chair: Brennan Cox

PANEL OVERVIEW: *Spatial Disorientation (SD) remains one of the leading causal factors in flight mishaps. Indeed, efforts to reduce the incidence of SD-related flight mishaps, for example through SD familiarization training, appear to have had negligible measurable effects on SD mishap rates, which have remained high and relatively stable for decades. Emerging technologies and research approaches may hold promise for a better understanding and*

ultimately mitigation of pilot spatial disorientation. This panel will highlight recent research efforts across the US DoD and academia to understand, characterize, and model sensory, perceptual, and cognitive factors involved in spatial orientation, such as vestibular sensation and perception, visual perceptual illusions, and cognitive workload. The panelists will also discuss research gaps to inform future SD research, development, and modeling initiatives, in addition to how such efforts may ultimately inform safety mitigations.

[157] HEAD ON NECK TILT PERCEPTION IS MODULATED BY BODY TILT

Daniel Merfeld[1], Torin Clark[2], Jamie Voros[2], Richard Folga[3], Kyle Pettijohn[3], F. Eric Robinson[3], Mariateresa Sestito[4], Sarah Sherwood[3]

[1]*The Ohio State University, Columbus, OH, USA;* [2]*University of Colorado-Boulder, Boulder, CO, USA;* [3]*Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA;* [4]*Oak Ridge Institute for Science Education - NAMRU-D, Wright-Patterson AFB, OH, USA*

Original Research

INTRODUCTION: Pilots frequently tilt their heads relative to the gravito-inertial force (GIF), and investigators occasionally cite disorientation caused by head movements as a contributing factor to mishaps. A variety of evidence indicates that nonvestibular gravireceptors (e.g. somatosensors) contribute to spatial orientation. Given this state of knowledge, we performed this low-*N* study to investigate how somatosensory signals combine with signals from the vestibular system. **METHODS:** Using the NAMRU-D Disorientation Research Device (DRD) we applied passive tilts of the head-on-neck (0, ±10˚, ±20˚) and body-in-space (0, ±20˚, ±40˚) at 5 different amplitudes each for a total of 25 different test conditions. On each trial, we recorded subjective perceptions of tilt. Specifically, we instructed subjects to make 3 verbal reports on each trial: perceived head-on-neck tilt, perceived body-in-space tilt, and perceived head-in-space tilt. In addition to these verbal reports, subjects also performed two common psychophysical tasks for tilt perception (subjective assessments of the perceived horizon). We performed our studies in a 1G environment and then replicated the measures in a 1.5G environment. To simplify the presentation of data, we focus on the head-on-neck verbal report perceptions herein. **RESULTS:** We found that head-on-neck tilt was influenced by the subject's body tilt relative to gravity. Specifically, there was a tendency for the direction of body tilt in space (e.g., right or left) to bias the perception of head-on-neck tilt in that same direction. These trends persisted in a 1.5G environment. We emphasize that this result is preliminary and broad conclusions should be avoided. Ongoing experiments will enhance this dataset and help make the outcomes more generalizable. **DISCUSSION:** By quantifying human perception of head-in-space, body-in-space, and head-on-neck tilt in this initial study, we begin to understand the mechanisms by which the brain integrates sensory information from the somatosensors and otoliths. More data beyond this low-*N* study are needed to define both average responses and individual differences. Using this information, we have begun to update our model of human spatial orientation. Improving this model will allow us to better understand spatial disorientation so that we can better mitigate its impacts on pilots.

Learning Objectives

1. Understand that perception of tilt results from multisensory integration of visual, vestibular, and somatosensory cues.
2. Understand that perception of the tilt of the head relative to the torso is influenced by body tilt.

[158] HUMAN ORIENTATION PERCEPTION DURING TRANSITIONS IN THE PRESENCE OF VISUAL CUES

Jamie Voros, Victoria Kravets, Kieran Smith, David Temple, Torin Clark

The University of Colorado Boulder, Boulder, CO, USA

Original Research

INTRODUCTION: Existing models of visual-vestibular integration for human orientation perception do not accurately predict perceived orientation during the transitionary period between visual cue states (e.g., when flying into a cloud, the presence of visual orientation cues suddenly disappears). Aviation mishaps happen during periods of spatial disorientation and sudden loss of visual cues can lead to disorientation. Therefore, it is important that we understand dynamic orientation perception during such visual cue transitions. We begin by considering perception of rotation (primary stimulating the semicircular canals) about an Earth-vertical axis. **METHODS:** Nine subjects (1 female) were asked to report their perception of rotation by pressing a left/right button every time they felt like they had rotated 90 degrees to the left/right. Subjects were instructed to hold down triggers when they felt they were not rotating. A head mounted display provided the visual rotation cues subjects had available to them. When present, visual cues were always congruent with inertial rotation. We used 4 different visual cue conditions: no visual cues, visual vection, visual vection transitioning to no visual cues, and no visual cues transitioning to visual vection. We used 6 different rotation profiles per visual cue condition for a total of 24 trials per subject. Based on the timing of subject inputs, we inferred their perception of angular velocity. **RESULTS:** During and immediately after a transition in visual cues, we found there was approximately a one second period in which reported rotation perception transitioned based upon the available cues. For example, when visual cues appeared after vestibular cues have decayed, there was a one second delay before rotation perception converged to that associated with the visual vection. **DISUCSSION:** Our results indicate that the brain does not disregard past cues immediately after a visual transition. Existing models could be updated to reflect our findings with the addition of low pass filtering at the cue integration stage. This would also resolve discontinuities during visual transitions. A limitation of our study is that subjects were only able to report rotation perception every 90 degrees and not continuously, providing a bound for how quickly perceptual reports could transition.

Learning Objectives

1. The participants will be able to understand what happens to perception of orientation when flying into a cloud.
2. The participants will be able to understand how variable the orientation perception response is in changes to visual cues.
3. The participant will be able to recognize certain cases when existing models of orientation perception are not correct.

[159] EXPERIMENTAL RATINGS OF SPATIAL DISORIENTATION FOR TUNING AND ASSESSMENT OF A REAL-TIME COMPUTATIONAL DETECTION METHOD

Jordan Dixon[1], Torin Clark[1], Tristan Endsley[2]

[1]*The University of Colorado Boulder, Boulder, CO, USA;* [2]*Draper, Cambridge, MA, USA*

Original Research

INTRODUCTION: Pilot spatial disorientation (SD) remains a leading cause of Class A mishaps, even with the introduction of SD-specific training. Active countermeasures (CMs), such as adaptive displays, have the potential to mitigate SD. However, constantly allocating attention to instruments can have adverse effects such as increased workload. To intervene most effectively for an SD event, a method is needed to unobtrusively detect pilot SD in real-time. Models of human perception provide a means by which to estimate the impacts of misperceptions, over time, on the SD event being experienced. We developed a tool for real-time detection of SD, and collected subjective ratings of SD events on a motion simulator for tuning of the algorithms involved in processing orientation perception model outputs. **METHODS:** The 'Observer' model of human orientation perception was leveraged in series with candidate algorithms to capture the temporal dynamics of SD events. Critically, these algorithms combine multidimensional orientation states to compute a unidimensional metric of SD used as a trigger for active CMs.

To identify appropriate configurations for the computational tool, we gathered subjective ratings of SD from persons exposed to motion stimuli in a flight simulator. Our motion device was used to provide coronal plane motion (lateral drift and roll-tilts) in various coupled relationships to emulate wind disturbances of a helicopter in hover, in a degraded visual environment. **RESULTS:** Subjects provided SD ratings at 15-30s into the motion profile at the instant in which attitude instruments were displayed depicting the veridical orientation of the vehicle. Ratings were bounded on a visual analog scale, which subjects were trained in using prior to testing. The optimal SD metric produced from the algorithm candidates was able to predict the empirical ratings accurately. **DISCUSSION:** An important finding from the first experiment in this investigation is that model-based detection of SD can, and likely should, be tuned to the specific environment in which it is expected to be used. Signal detection performance has been shown to impact operator usability of assistive systems, and as such, use of the system may also warrant personalization by the individual pilot. The next experiment to be performed will add human-in-the-loop control of the simulated helicopter in hover, and look to characterize the potential performance and safety benefits of integrating a real-time detection and aiding system into the cockpit.

Learning Objectives

1. Understand effective ways to mitigate spatial disorientation via unobtrusive modeling.
2. Learn the necessary system training needed for realizable SD mitigation systems.

[160] EFFECTS OF COCKPIT WORKLOAD, MOTION, AND VISIBILITY ON INCIDENCE OF SPATIAL DISORIENTATION IN SIMULATED FLIGHT

Henry Williams, Dain Horning, Cortland Etgen, Charles Powell
Naval Medical Research Unit – Dayton, Wright-Patterson AFB, OH, 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 increased cockpit workload has been cited as a potential contributing factor to SD, few studies have examined the effect of different types of workload. Fixed- and motion-base simulators have been compared on their effectiveness in flight training in general, but not specifically on their effectiveness in inducing SD. **METHODS:** Twelve pilots flew simulated formation-flights in the Naval Medical Research Unit-Dayton's Disorientation Research Device (DRD). Three different workload conditions were presented. The baseline condition imposed no additional workload, while the other conditions added either a verbal Working Memory Task (WMT) or a spatial Variable-Following-Distance Task (VFDT). Pilots flew half of their flights with DRD motion disabled, and half with it enabled. Each flight encountered visual and instrument meteorological conditions (IMC). **RESULTS:** Workload ratings increased with added workload, and both workload and SD ratings increased in IMC. The VFDT condition resulted in a statistically significant twofold increase in the number of control reversal errors, as well as a significant increase in formation-flight altitude error. The VFDT also showed a tendency to increase unusual attitudes in IMC, but this trend was not significant. Adding motion did significantly increase realism ratings but otherwise had little effect. **DISCUSSION:** Compared to the WMT, the VFDT condition showed more indications of SD. The VFDT is a spatial task, as is maintaining spatial orientation. An explanation for the increased incidence of SD could be spatial resource competition, where the VFDT and maintaining spatial orientation competed for the same cognitive resources. This explanation is consistent with Multiple Resource Theory. The finding that DRD motion did not increase incidence of SD is likely due to the flight profile itself; the profile required no aggressive or especially disorienting maneuvers. Future work should aim toward expanding the DRD dynamic envelope to incorporate common flight maneuvers that are known to increase the probability of SD.

Learning Objectives

1. The audience will learn that spatial disorientation is one of the leading causes of fatal mishaps in military and civilian aviation.
2. The audience will learn that subjective ratings of workload and spatial disorientation are both likely to increase in instrument meteorological conditions.
3. The audience will learn that, when possible, it is usually advisable to employ more than one measure of spatial disorientation to detect a spatial disorientation event.

[161] ANALYTICAL COMPARISON OF NAMRU-D'S BLACK HOLE ILLUSION MODEL WITH AN NTSB IDENTIFIED BLACK HOLE AIRCRAFT ACCIDENT

Fred Patterson, Henry Williams, Richard Folga
Naval Medical Research Unit – Dayton, Wright-Patterson AFB, OH, USA

Original Research

INTRODUCTION: During a visual night approach, a Boeing 727 crashed 1,556 ft short of the runway. Fortunately, all three crewmembers egressed the aircraft before it was engulfed in flames. The National Transportation Safety Board (NTSB) investigated the mishap and determined the landing approach created Black Hole Illusion (BHI) visual conditions that contributed to controlled flight into terrain. Previous Naval Medical Research Unit - Dayton (NAMRU-D) BHI experiments identified three sequential True Aim Point (TAP) model components to BHI. These components were defined as BHI I - excess push-over; BHI II - improper TAP selection; and BHI III - failure to recognize incorrect TAP position. To evaluate the validity of NAMRU-D's BHI error model, a retrospective analysis of the Boeing 727 landing approach data was made to determine whether the hypothesized BHI errors (I, II, and III) were present during a confirmed "real world" BHI mishap. **METHODS**: Mishap flight recorder data (1.0 Hz, aircraft heading, attitude, altitude, airspeed, and runway distance) were downloaded from the NTSB website and evaluated against the NAMRU-D BHI model. Aim point variations in the mishap glide path (3.5 nm with 85 sec duration) were evaluated using 2,500 ft ground distance increments that averaged 10 sec per segment. **RESULTS**: The initial 10 second runway lineup generated an excess pitch down attitude with a peak TAP error 8,445 ft short of the runway (BHI error I). The following 30 sec involved a partial correction; however, the TAP remained 6,544 ft short of the runway (BHI error II). During the final 40 sec of flight, both pilots recognized they were low; however, the TAP remained 1,100 ft short of the runway (BHI error III). **DISCUSSION**: Results of this mishap analysis indicate the NAMRU-D BHI model is an accurate predictor of "real world" BHI errors. Additional studies should be conducted for the purpose of further validating NAMRU-D's BHI error model as an incident analysis tool where BHI is suspected. Further investigations focused on methods for avoiding, recognizing, and recovering from BHI I, II, and III errors are warranted.

Learning Objectives

1. Define spatial strategies used during day and night landing approaches.
2. Identify causes and error types of spatial disorientation that occur with black hole illusion landing approaches.
3. Identify how to recognize and avoid illusions encountered during black-hole approaches.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany B

[S-34]: PANEL: WOMEN IN SPACE: LESSONS ON LEADERSHIP

Sponsored by Aerospace Nurses and Allied Health Professionals Society

Chair: Marian Sides
Co-Chair: Nora Johnson

PANEL OVERVIEW: *This panel is an educational event of the Mary F Foley Endowment, established in her honor, to perpetuate her legacy, in aviation and space medicine and to encourage other women to follow in her path. The panel is designed to portray the dynamics of leadership of women who persevered through diversity, courage and determination. The qualities and virtues that shaped their leadership will be portrayed by exemplifying the highlights of their professional journeys. The first presenter will profile the legacy of the former Secretary of the Air Force, Ambassador Barbara Barrett, and the current Command Surgeon of the Unites States Space Command, Colonel Ingrid Ford, as women who are impacting policy to deter aggression and develop combat ready forces, to preserve USA and allied space superiority. The panel will recognize and honor Colonel Eileen Collins as the first woman to be a space shuttle commander and highlight her unique leadership qualities. Presenters will profile and honor Air Force Maj Gen. Valentina Tereshkova, Russian cosmonaut, first and youngest woman to have flown a solo space mission. She is followed by the recognition of Dr. Sion Proctor, first Black female to win a seat on Space X commercial flight and Haley Arceneaux, a young cancer survivor at St Jude Hospital. Both women flew as crew members on Inspiration 4. Lastly, Dr. Mae Carol Jamison, former NASA astronaut, first African American women to fly in space will be honored for her contribution to bone cell experimentation, in life sciences research. Similarities and differences in leadership styles and the extraordinary qualities of these women will be discussed, and how they handled adversity and challenges will be highlighted. The event will model illuminating insights and inspiration, that will provide mentoring and learning opportunities in leadership development for AsMA members.*

[162] SECURING THE SPACE ENVIRONMENT: LESSONS IN LEADERSHIP OF TWO PIONEERS

J. Karen Klingenberger
Williamsburg, VA, USA

Education - Program/Process Review

INTRODUCTION: Former Secretary of the Air Force Ambassador Barbara Barrett noted, how dependent people are "in our day-to-day lives on space…our information, our navigation and our communications are all space-dependent. It's ubiquitous, but it's invisible." An accomplished aviator, who has trained as an astronaut, Ambassador Barrett has been on the cutting edge of military space. Another leader, also enhancing US space capabilities, is the Command Surgeon (SG) of US Space Command, Colonel Ingrid Ford, who is impacting policy affecting combat ready forces so as to preserve United States and allied space superiority. **TOPIC**: Colonel Ford, was a direct commission in the Air Force Nurse Corps. She ascended through clinical, instructor, evaluator and administrative leadership positions in military treatment facilities, the Air Staff, and aeromedical evacuation units, before assuming roles as SG of two USAF Commands. Colonel Ford is now serving as the first woman assigned as primary medical advisory to a combatant commander at USSPACECOM. Colonel Ford is continuing to secure the peaceful utilization of space which Ambassador Barrett advanced by the launch of U.S. Space Force, during her tenure as Air Force Secretary. Ambassador Barrett publicly advocated for a service focused on our needs in space. She brought her unique credibility to her position as secretary while bringing the US Space Force to life. Experienced in flying jet aircraft, she also trained, in her 50s, as an astronaut in Russia. **APPLICATION:** Today's space missions operate as space becomes a larger factor in international power politics. These women's leadership contributions ensure that our economic reliance and continued exploration of space occur in a secure environment.

Learning Objectives

1. The learner will be able to describe worldwide daily dependence on space capabilities.
2. Identify two leadership qualities in each of the pioneering women working to secure our space domain.
3. Identify applications of their leadership journey to inform your leadership challenges and aspirations.

[163] LEADERSHIP LESSONS FROM THE FIRST FEMALE SPACE SHUTTLE COMMANDER: EILEEN COLLINS

Cathy DiBiase
Kennedy Space Center, Cape Canaveral, FL, USA

Education - Program/Process Review

INTRODUCTION: Colonel Eileen Collins was the first female space shuttle commander after serving as a pilot on two previous missions. She commanded a second space shuttle missions and ended her NASA career with four flights. **TOPIC:** This presentation will highlight the achievements and obstacles that Colonel Collins overcame to achieve her goal and inspire the next generation of explorers. Colonel Collins is a woman of determination and many firsts who met each challenge she faced. After joining the US Air Force, she was one of four women chosen for the first female pilot training class. Prior to this time women were not allowed to serve as pilots in the US military. Several years later, Colonel Collins was the second woman to graduate from Test Pilot school. During her career she flew over 6000 hours in 30 different aircraft. She interviewed for an astronaut position and when she was told she was selected it was for a position as a pilot. Several women had been selected to NASA for astronaut roles, but they had been for mission specialist positions. Colonel Collins was selected as a pilot from the start, she was the first female shuttle pilot. As a shuttle pilot Colonel Collins went on to command two shuttle missions. The last mission she commanded was the most significant as this was the first mission "Return to Flight" following the Columbia accident. **APPLICATION.** There will be lessons in leadership that we can all use to better our lives and inspire others to explore and reach for the stars.

Learning Objectives

1. Describe the challenges Colonel Collins faced in preparing for the Return to Flight mission.
2. The learner will describe how to apply one lesson to your leadership practices.

[164] PRINCIPLES AND PRACTICES OF VALENTINA TERESHKOVA, INTERNATIONAL WOMAN COSMONAUT: UNSURPASSED LEADERSHIP IN SPACE DYNAMICS

Marian Sides
Grayslake, IL, USA

Education - Tutorial/Review

INTRODUCTION: Women in Space around the world, create legacies on leadership that add value in advancing scientific knowledge, understanding behavioral attributes and developing collaborative solutions in future space travel challenges. This presentation will highlight the principles, qualities and practices of Valentina Tereshkova, Russian Cosmonaut, that shaped her achievements. **TOPIC**: Tereshkova was the youngest and first woman to fly into space. In 1963 she launched her Vostok 6 spacecraft, spent nearly three days on a solo mission, and orbited the Earth 48 times. While in space Tereshkova carried out a series of physiological tests to learn about the effects of weightlessness and space travel on humans. Her flight confirmed that women had the same resistance as men to the physical and psychological stresses of space. After her return to Earth, Tereshkova was named Hero of the Soviet Union. As symbol of emancipated Soviet women, she toured the world, and was hailed as a beacon of hope for womanhood worldwide. An aerospace engineer in the Space program, she earned a Doctorate in Aeronautical Engineering and retired from the Air Force at the rank of Major General. **APPLICATION**: This presentation will exemplify the unique qualities of Tereshkova, as an ambitious, adventuresome, fearless and compassionate role model, with a love for humankind and an advocate for world peace. From space, she saw Earth as a beautiful, but vulnerable place, that we must preserve. She had a curiosity, and a determination at a young age to experience and explore space. Despite having no pilot training, she was accepted into the space program based on 126 parachute jumps. She is a

brave and pioneering woman, who expresses interest in a one-way ticket to Mars, where she would live among other aliens. Presentation of the legacy of Valentina Tereshkova will illuminate these leadership qualities for others to emulate.

Learning Objectives

1. Describe two contributions to Space exploration that characterize the legacy of Valentina Tereshkova.
2. Identify three leadership qualities of Tereshkova described in this presentation.
3. Name a leadership quality of Valentina Tereshkova portrayed in this presentation that would add value to you.

[165] HOPE AND PROSPERITY IN COMMERCIAL SPACE: THE LEADERSHIP OF INSPIRATION4'S HAYLEY ARCENEAUX AND DR. SIAN PROCTOR

Aubrey Florom-Smith
Stanford Health Care, Menlo Park, CA, USA

Education - Program/Process Review

INTRODUCTION: In September 2021, the first all civilian-crewed flight on a SpaceX Crew Dragon orbited the Earth for three days. While initiating a new era of human space exploration with expanded access for all, this groundbreaking mission also raised over $200 million for St. Jude Children's Research Hospital. Two crewmembers, Hayley Arceneaux and Dr. Sian Proctor, exemplified the mission pillars of Hope and Prosperity. This presentation highlights the experiences and characteristics of these women that represent leadership qualities of resilience, dedication, creativity, diversity, and inclusion. **TOPIC:** A pediatric cancer survivor, 29-year old Ms. Arceneaux was the youngest person, and the first with a prosthetic body part, to travel to space. While receiving treatment for osteosarcoma at St. Jude, Ms. Arceneaux exhibited strength and positivity under challenging circumstances, and demonstrated an early sense of altruism while serving as an unofficial hospital ambassador. Determined to return as an adult to help care for patients, Ms. Arceneaux is now a physician assistant at St. Jude. She served as the medical officer of Inspiration4. Dr. Sian Proctor, a geoscientist, explorer, NASA astronaut finalist, analog astronaut, and science communicator, was awarded her seat on Inspiration4 as the winner of the Shift4Shop competition. Through poetry, art, and science education, Dr. Proctor advances justice, equality, diversity, and inclusion (JEDI) in space to support and promote women of color in space-related activities, including working in the space industry. As just the fourth woman of color to travel to space, Dr. Proctor was the pilot of Inspiration4. **APPLICATION:** In their roles of medical officer and pilot, Ms. Arceneaux and Dr. Proctor demonstrated that individuals with a wide range of experiences and of diverse backgrounds have indispensible leadership qualities needed to successfully contribute to advances in human spaceflight. Further, as the embodiment of Hope and Prosperity, these women inspire and motivate girls, women and other underrepresented individuals to pursue their own goals of participating in and advancing human space exploration for all. Knowledge of the challenges and contributions of these women to commercial spaceflight may help to increase diversity and inclusion among those involved in the space industry.

Learning Objectives

1. Learners will identify two individual leadership characteristics of Hayley Arceneaux and Dr. Sian Proctor.
2. Learners will describe two issues related to diversity and inclusivity that can be applied to expanding human space exploration through commercial spaceflight.

[166] HEATHER ANN WILSON: EXEMPLARY DRIVE AND LEADERSHIP THROUGHOUT AS DEDICATED PUBLIC SERVANT IN AEROSPACE, EDUCATION, AND NATIONAL SECURITY

Annette Sobel
[1]*Texas Tech University Health Sciences Center, Lubbock, TX, USA*

Education - Tutorial/Review

INTRODUCTION: Exemplary aerospace leadership is an exceptional trait, both innate and learned. Great responsibility and effective response to opportunities accompanies this trait and is embodied in the Honorable Heather Ann Wilson and the life of Mary F. Foley. **TOPIC:** Her early aviation role model was her grand- father, a WWI Royal Air Force pilot, WWII courier pilot, barnstormer and founder and wing commander of the New Hampshire Civil Air Patrol. APPLICATION**:** Following in his footsteps, Heather was accepted as an Air Force Academy cadet, and was the first woman to command basic training and the first woman Vice Wing Commander. She graduated in 1982 as a Distinguished Graduate (magna cum laude equivalent). She was subsequently selected as a Rhodes Scholar. The next phase of her career was politics. Beginning as a Cabinet member for New Mexico Governor Gary Johnson, then advancing to the national scene. Congresswoman Wilson was the first woman to represent New Mexico since Georgia Lusk in the 1940s. After being nominated by President Donald Trump on January 23, 2017, and confirmed by the U.S. Senate on May 8, 2017, Wilson became the first U.S. Air Force Academy graduate to be sworn in as Secretary of the Air Force on May 16, 2017. As the 24th Secretary of the Air Force, she was responsible for the matters of the Air Force Department, including the emergence of a new United States Space Force, to counter rapidly evolving space threats. On March 8, 2019, Wilson announced she would transition to become President of the University of Texas at El Paso. Heather is mother of three children and married to Mr. Jay Hone, former New Mexico Air National Guard JAG. **APPLICATION:** As a scholar, servicemember, politician and academic leader, Heather demonstrated total commitment to aviation leadership and National Security. Her life is an exemplar of the myriad of factors that influence and impact the richness of aerospace service.

Learning Objectives

1. The participant will be able to understand the many facets of aviation leadership.
2. The participant will learn about the comprehensive, expanding opportunities for women in aerospace leadership.
3. The audience will recognize the consistent leadership traits across individuals exemplifying the traits of Mary F. Foley.

[167] 100-YEAR STARSHIP MAE JEMISON

Leroy Gross
InoMedic Health Applications, Hampton, VA, USA

Education - Program/Process Review

INTRODUCTION: Mae Jemison graduated as an engineer from Stanford University and received her medical degree from Cornell University. She served in the Peace Corps and was a general practitioner, prior to being selected for NASA. She became the first black woman to travel into space when she served as a mission specialist aboard the Space Shuttle Endeavour. Jemison joined NASA's astronaut corps in 1987 and was selected to serve for the STS-47 mission, during which she orbited the Earth for nearly eight days on September 12–20, 1992. **TOPIC**: Mae Jemison's legacy began as a physician in the Peace Corps and at NASA. In 1993, she left NASA and founded a technology research company. She later formed a non-profit educational foundation and through the foundation is the principal of the 100 Year Starship project funded by Defense Advanced Research Project Agency (DARPA). Jemison also wrote several books for children and appeared on television several times, including in a 1993 episode of Star Trek: The Next Generation. She holds several honorary doctorates and has been inducted into the National Women's Hall of Fame and the InternationalSpace Hall of Fame. **APPLICATION:** Mae Jemison's vision for the 100-year Starship: "We are leaving earth to navigate the stars… Humanity and our planet stands as an inflection point… Do we come together for humanity's next giant leap forward? At 100 Year Starship we are calling on members of our generation to complete a clear mission; make the capabilities for travel to another star a reality within the next 100 years. Just as past exploration pushed breakthroughs in agriculture, communication, energy, materials transportation, and medicine, the greatest rewards will be felt here at home."

Learning Objectives
1. Describe the vision and goals of the 100-year starship.
2. Identify two leadership qualities in Mae Jemison to be the first black woman in space and lead the 100 year starship project
3. Identify applications of her leadership journey to inform the challenges of executing your visions.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany F

[S-35]: PANEL: ADVANCING TECHNOLOGY FOR HYPOXIA RESEARCH AND TRAINING NEEDS IN AEROSPACE MEDICINE

Chair: John French

PANEL OVERVIEW: *BODY: Hypoxia remains a deadly threat to air/space crews and progress into mitigation strategies have been decades in the making. Hypoxia is likely the oldest aerospace medical issue and unlike hardware problems that are quickly engineered away, hypoxia remains. This panel examines the technologies currently used in hypoxia research and training settings and describes ways scientific advancements in AI, machine learning and electronics can advance progress in mitigation strategies. In the first presentation, R. Christiansen describes new science-based technologies that are being tested to improve the training and early detection of hypoxic events. Our second presenter, J.A. Kjeserud describes current practices in hypobaric training and the means to improve important assessment biomarkers like the pulse oximeter, that are often overlooked. Next J. French presents some evidence of the utility of the individual On Demand Hypoxia Trainers (ODHT) in economically conducting hypoxia research into a possible link between mild hypoxia and spatial disorientation. The fourth panelist, J.Thropp will explain how established eye blink measures can be used to assess hypoxia and mental focus; possibly leading to pattern recognition algorithms that will signal hypoxic impairment. Our last panelist, K. Divers explains why hypoxia research is important, the constantly evolving craft designs that may put the pilot at risk and what technologies can be used to identify the risks early in testing. This panel encourages the discussion of renewed awareness of hypoxia dangers and new approaches to facilitate and improve current research and training efforts.*

[168] TITLE: HOW CAN "SCIENTIA EX MACHINA" HELP ADDRESS THE CONTINUING PROBLEM OF HYPOXIA FOR AVIATORS?

Rowena Christiansen
The University of Melbourne, Melbourne, Australia

Education - Tutorial/Review

INTRODUCTION: This retrospective literature review examined three questions concerning hypoxia; what the effects hypoxia on aviators are, why it continues to be a threat to both civil and military aviation even in the present day, and what can be done to mitigate its effects. Our goal was to highlight and improve current technologies for aerospace medicine needs. A focused search 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 2021). **TOPIC**: Relevant articles were identified using the search terms "hypoxia", "hypoxic", "hypoxemia", "oxygenation", and "anoxia". Articles were then categorized as falling into one (or more) of the following categories: "Hypoxia effects", "Still an issue?", "Countermeasures", "Hypoxemia and 'fitness to fly' studies", "Altitude medicine", "Equipment and technical aspects", and "Microgravity exposure". We identified 136 articles related to the hypoxia categories. This published body of research reveals that, particularly over the past few years, there has been a shift from a focus on the 'tried and true' approach of hypoxia awareness training to a consideration of the potential utility of technology-based ('*scientia ex machina*') countermeasures, particularly biometric monitoring, early detection and predictive technologies. Together with existing environmental and aircraft performance monitoring, the potential role of technologies such as forehead and finger pulse oximetry, real-time neuroimaging techniques, pupillary and sensory monitoring, wearable technologies and biometrics will be described. For example, a new direction in nutritional research, a ketone ester supplement (KE) has shown promise in reducing the effects on cognitive performance during hypoxia. **APPLICATION**: Research continues to advance knowledge about the effects of hypoxia, and the utility of various countermeasures. By summarizing various emerging technologies, we hope to expand future research areas and speed the progress in hypoxia mitigation. The next panelist will describe the 'tried and true' methods in place today and a precaution for the main assessment tool, the oximeter.

Learning Objectives
1. The audience will learn about new approaches to research associated with hypoxia training.
2. Participants will gain insights into the types of technology being investigated as potential countermeasures against hypoxia.
3. The audience will learn about nutritional and other interventions aimed at improving cognitive function during hypoxia.

[169] HYPOXIA TRAINING: VALIDITY OF PULSE OXIMETERY AND FUTURE MEASUREMENTS DURING PROFOUND HYPOXIA

Jon-Arild Kjeserud
Norwegian Institute of Aviation Medicine/University of Oslo/, Oslo, Norway

Education - Tutorial/Review

INTRODUCTION: Hypoxia awareness training is a vital part of the initial and refresher training of military flight personnel in Norway. Hypoxia training is completed using both hypobaric chambers and reduced oxygen fraction gas blenders. All training exposures to hypoxia are led and supervised by medical personnel using medical electronic sensors such as pulse oximeters. **TOPIC**: In Norway both hypobaric chamber and reduced oxygen blends are used with protocols adhering to NATO standards. Norwegian hypobaric hypoxia training consists of three profiles: for helicopters 16000 ft, fighter and multiengine pilots, both trained from 25000 ft with 3/12 sec rapid decompression exposures. The time above 18000 ft is usually about 11 minutes and hypoxia time at 25000 ft is 4-5 min, tittered to ensure good hypoxia awareness. Pulse oximeter sensors are used for medical monitoring of participants during both normo- and hypobaric hypoxia training. During exposure to 25000 ft subjects may endure profound hypoxia and oxygen saturation (SpO2) may drop towards 50%. However, pulse oximeters are empirically validated by manufacturers only between 70 and 100% saturation and previous research has shown that measurement variation also increases at decreased O2 saturation levels. To improve the safety and quality of the training we will report on our assessment of the validity of several pulse oximeters and anatomical placements during more realistic exposures – towards 50% oxygen saturation. **APPLICATION**: In order to move training forward safely greater efforts for ensuring the accuracy of the technology seems apparent. Oximeters have been an important means to assess hypoxia training results but our results show that they need to be calibrated to the SpO2 levels used. There are other biomarkers that could be collected and examined as research data that are routinely 'tossed out' at the end of hypoxia training. We recommend routinely collecting balance, coordination data, any simple cognitive responses that could be associated with the oximeter readings to get a better understanding of the physiological underpinnings of operational hypoxia. The next panelist will explain how useful this broader understanding of routine hypoxia might be to identifying other effects of hypoxia on pilot error.

Learning Objectives
1. According to NATO STANAG 3114 aviators need hypoxia training every 5 years.

2. Current oximeters are only calibrated to 70% SpO2 and many hypobaric training regimens require accurate readings below that.

[170] ASSESSING MILD HYPOXIA EFFECTS ON THE CORIOLIS ILLUSION

Jon French, Grayson Iller, Chloe Crichton, Alyssa McMandon, Linda Delgado, Kaylin Juarez, Jamie Talley
Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

Education - Tutorial/Review

INTRODUCTION: The costs and difficulties of maintaining a hypobaric chamber for hypoxia awareness training has been circumvented by normobaric hypoxia chambers and the On Demand Hypoxia Trainer (ODHT) devices. The present discussion shows the ODHT could also be an asset for research into the neurophysiological consequences of mild hypoxia. **TOPIC**: The ODHT was found to be an adequate, convenient and inexpensive means to induce hypoxia. The ability of the ODHT to quickly reach and maintain hypoxic oxygen saturation levels between 90-80% was first examined. There was considerable individual variation but average levels of 84% were observed after 15 minutes of donning the close-fitting mask and maintained through the test period of 30 minutes. Once the mask was removed, normoxic levels were re-established within 2 minutes on average. The Coriolis illusion was used to assess the effects of mild hypoxia (84%) on the standard Subjective Symptoms Questionnaire (SSQ). Participants were slowly spun 15 times in a Barany chair over 2 minutes with the head close to a 90 degree tilt from the upright. Upon returning to the upright, a profound disorientation was experienced for those made mildly hypoxic compared to the same people at sea level. **APPLICATION:** These ODHT have the potential to increase research into the neurological consequences of hypoxia. As a research and training tool, the device could be improved by incorporating an oximeter that could automatically shut off the device as a safety precaution, if the SpO2 fell below some preset number. Protocols should be automatically available that could be used to automatically generate a hypoxia training score based on color vision, disorientation tests, cognitive markers and subjective symptoms. Since hypoxia training is not currently available to general aviation pilots, those who stand to suffer the most from pilot error/SD effects, the devices could finally allow training for this group and potentially save many lives. The potential for other biomarkers of hypoxia to be utilized in research, perhaps simpler to obtain and more reliable than cognitive markers might be the eye blink response. This is the focus of the next discussion in the panel.

Learning Objectives

1. The participant will be able to understand how ODHT devices can be used as research tools.
2. The audience will evaluate the ODHT as a means to make hypoxia awareness training to more pilots than ever before, particularly GA.

[171] THE ENDOGENOUS BLINK DURING SLOW DECOMPRESSION HYPOXIA

Jennifer Thropp
Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

Education - Tutorial/Review

INTRODUCTION: Previous research has highlighted an inverse relationship between eye blinks on attentional demand as well as hypoxic exposure, possibly due to changes in endogenous neural mechanisms such as dopaminergic activity. The present investigation extends this prior research by comparing the effects of slow decompression on eye blinks at varying task loads and degrees of hypoxia severity. This oculometrics approach may be a useful new technique to quickly predict pilot hypoxia levels and possibly alertness levels. **TOPIC:** A within-subjects design used SpO2 level and task load as independent variables. Dependent variables were blink duration, interblink interval, and time to close the eyelid during a blink. Participants (n = 6; all male) were commercial instrument rated pilots and wore a head-mounted eye-tracker while performing a simulated flight inside a hypobaric chamber. The high task load condition involved ATC dictating heading, altitude, frequency changes, and transponder codes to input. The low task load condition involved passively observing the interface without receiving ATC instruction. Chamber pressure was decreased from baseline levels, pausing when SpO2 rates declined by approximate 5% intervals for task completion, until reaching 80% SpO2, followed by recovery. Across all SpO2 conditions, blink duration and lid closure time remained lower during high task load compared to low task load while interblink interval remained higher during high task load. Further, trends for all three oculometrics indicated demonstrated a general narrowing between task load conditions as SpO2 decreased, and the gap reappearing in the recovery condition. **APPLICATION**: Blink duration, interblink interval, and lid closure time were affected by hypoxia more so during active flight task performance than during passive instrument observation. The return to suppressed blink activity in the recovery condition suggests these effects are attributable to hypoxia rather than time-on-task. The overall increase in time in which the eyelids were closed reduces the registration of visual information, which could impair the quality of pilots' visual scans in flight and degrade decision-making and spatiotemporal perception. The next panelist will discuss the importance of operationally relevant measures of hypoxia and alertness levels.

Learning Objectives

1. The attendants will understand the relationship between oculometrics and hypoxia.
2. The audience will consider the use of eye blink measures to estimate pilot alertness levels.

[172] BACK TO THE FUTURE – IS RAPTOR COUGH ACTUALLY GONE OR HOW TO FINALLY KEEP IT THE PAST, USING THE PAST

Kevin Divers
U.S. Air Force Academy/Webster University, Brentwood, TN, USA

Education - Tutorial/Review

INTRODUCTION: Over the last 10 years, there has been a dramatic increase in hypoxia related physiological events in military aircraft, resulting in fatalities and the grounding of particular high-performance aircraft such as the T-6 and the F-22. These events have highlighted the continued need for hypoxia mitigation strategies. This discussion represents the perspective of a Developmental Test Team member for the F-22 tasked with determining why F-22 test pilots would spend a period of time "recovering" from a test flight where they would cough a lot and feel "off". The lessons learned suggest that important advice from test pilots needs to be a greater part of the overall assessment of the problems. Perhaps organizing and codifying this user information with advanced information technologies could lead to a broader picture of the causes and solutions. **TOPIC**: The F-22 Raptor 'coughs' have been subsequently defined as acceleration atelectasis, an impairment of lung function that can be extremely severe and last for several days. Interview data are an important technique of asking the user to detail their experiences and is often overlooked in a rush to solve the problem. There are budgetary and time concerns as well that prevent or slow the implementation of complete solutions, relying instead on partial fixes that seem more expedient. Too often, the user derived solutions are lost as the test program transitions to Operational Test and on to fielding the aircraft. **APPLICATION**: This discussion will argue that design ideas and insights can actually shorten the time and expense it takes to fully field innovative aircraft designs, particularly those experiencing design concerns. The F-22 is arguably the most powerful and sophisticated aircraft flying today. The solutions often presented by the test pilots in after action reports, can and should become a more important part of the considerations, digitally codified and supported by the weight of evidence. This panel has concerned future concepts and ideas to advance hypoxia research and training. It concludes with perhaps the simplest means, to get it right the first time early in the prototype process, ask the user.

Learning Objectives
1. The audience will understand the pilot's perspective of atelectasis, what if feels like.
2. The audience will consider the need to elevate the use of codified standardized interview data early in the design process.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany 3

[S-36]: PANEL: UNUSUAL SITUATIONS IN CLINICAL AVIATION MEDICINE: EASY TO MANAGE?

Sponsored by the Francophone Society of Aviation and Space Medicine

Chair: Olivier Manen
Co-Chair: Jonathan Monin

PANEL OVERVIEW: *The role of the aeromedical expert (AME) is to assess the risk for a medical event in one individual to jeopardize the flight safety and also the evolution of the aircrew's career, based on a medical report including anamnesis, physical exam and all investigations required when necessary. The final decision shall respect national or international norms such as the EASA regulations which allow more or less flexibility, depending on the status of the aircrew. Usually, there is a discussion about aeronautical fitness in case of a precise diagnosis, leading to the study of scientific data for one particular disease including the natural history, the possible complications and the risk of the treatment. Consequently, the AME may be at ease to back up the decision and to explain when temporary or permanent unfitness. However, is the situation so simple in the real life, particularly regarding the daily practice in Aeromedical Centres? Indeed, sometimes the diagnosis is possible but not definite, or a clear diagnosis is not associated with any argument for an aetiology. In other times, one pathology or syndrome is considered but is quite rare, and so the AME may neither have experience of it nor find a guide in the regulations like the EASA Acceptable Means of Compliance. There are also aircrews working in a very particular aviation speciality such as for civil fighter pilots flying with a Class 1 medical certificate only, and yet they are exposed to sustained +Gz accelerations. Pregnancy should also be considered as unusual situations in female aircrews if we refer to the low number of professional women who are able and decide every year to continue flying once they are aware of the diagnosis. Finally, the AME has to face, psychologically speaking, atypical applicants or confirmed pilots with some difficulties to manage despite the place of mental health in the European regulations. This panel will try to give key elements to the AME for the decision-making process in all these situations illustrated by different case reports.*

[173] HOW TO COPE WITH A DIAGNOSTIC DOUBT IN AEROMEDICAL EXPERTISE?

Nicolas Huiban[1], Laetitia Corgie[1], Farnçois-Xavier Brocq[1], Jonathan Monin[2], Sebastien Bisconte[2], Olivier Manen[2], Eric Perrier[2], Marc Monteil[1]
[1]*French Military Health Service, Toulon, France;* [2]*French Military Health Service, Clamart, France*

Education - Case Study

INTRODUCTION: These case reports illustrate situations where the fitness decision issue is confronted with uncertain diagnoses. **BACKGROUND:** Decision making in aviation medicine is most often part of a well-established framework in which epidemiological data allow to assess the risk of in-flight incapacitation through possible sequelae, complications and the recurrence risk. When clinical profile is less obvious, the challenge of expertise takes on a new dimension. **CASE PRESENTATIONS:** We will first present some doubtful EEGs in selection for military applicants before describing three case reports illustrating various situations. A case of poorly systematized deficient symptoms with evocative white matter lesions findings in an airline pilot will lead to discuss a demyelinated disorder or an isolated radiological syndrome. Then, we will describe the occurrence of lipothymic discomfort at the exercise height in a flight test experimenter, leading to document a hypoglycemia as well as a coronary disease without argument for paroxysmal arrhythmia or ischemia. We will last present a transient confusional episode in a young student helicopter pilot where no obvious etiology will consider a not typical transient global amnesia. **DISCUSSION:** Aviation medicine typically relies on making a double prognosis related to the in-flight medical incapacitation risk and the safety challenge. A fitness decision will therefore require a healthy status not modified by flight circumstances, allowing to perform all on-board duties without challenging mission safety. With no clear diagnosis after a medical event, this approach gives rise to new questions: Is it more appropriate to use the most frequent, the most probable or the most risky diagnostic hypothesis regarding aeronautical prognosis? Should doubt benefit fitness with regard to operational issues? Do flight duties then become the main determinant for decision? If so, could operational limitations be justified and which ones? Should the situations with uncertain diagnosis be considered equally for initial applicants and confirmed pilots? These questions thus define specific challenges in aviation medicine. In the end, a case-by-case approach will often take shape in the light of all these considerations and will highlight both the importance of the training and the interest of the practice of AME (which we would like to illustrate here).

Learning Objectives
1. To be aware of the aeromedical decision-making issues in case of uncertain diagnosis.
2. To know distinction between "prevention" and "protection" towards a risk.

[174] RARE DISEASES: HOW TO MANAGE THE AERONAUTICAL FITNESS?

Sébastien Bisconte, Marie Maréchal, Gaetan Guiu, Jonathan Monin, Caroline Brescon, Jean Francois Oliviez, Eric Perrier, olivier Manen
French Health Service, Clamart, France

Education - Case Study

PROBLEM STATEMENT: This case report highlights the difficulties for the aeronautical expert to manage fitness to fly for a pilot who suffers from a rare genetic disease. **BACKGROUND:** Pseudoxanthoma elasticum (PXE) is a genetic metabolic disease with autosomal recessive inheritance caused by mutations in the ABCC6 gene. The clinical prevalence of PXE has been estimated from 1 per 100,000 to 1 per 25,000. In the clinical description of PXE, there are dermatological signs (yellow papules on the nape and sides of the neck and in flexural areas), ophthalmological signs (angioïd streaks may trigger choroidal neovascularization and, ultimately, loss of central vision and blindness in late-stage disease) and cardiovascular lesions (peripheral artery disease, myocardial infarction, angina pectoris). There is no cure for PXE. **CASE PRESENTATION:** Routine screening during initial examination of a 19-yr-old helicopter pilot applicant revealed (an) angioïd streaks and loose and wrinkled aspect of the skin. He was referred to a national eye hospital where the diagnosis of PXE was confirmed. A detailed analysis of this case report will be presented, including the medical and aeronautical management, the risk assessment of in-flight incapacitation and the potential consequences of the exposure to specific aeronautical constraints. **OPERATIONAL/CLINICAL RELEVANCE:** The authors will try to extract general guidelines for the aeronautical fitness management in case of a rare disease.

Learning Objectives
1. The participant will learn about diagnosis of PXE and its clinical manifestations.
2. The participant will learn about rare disease management by an aeronautical expert.
3. The participant will learn about aeronautical considerations of rare disease.

[175] UNUSUAL DUTIES AND FITNESS ASSESSMENT: WHEN REGULATIONS ARE OF NO HELP

Jonathan Monin[1], Gaetan Guiu[1], Sébastien Bisconte[1], Nicolas Huiban[2], Eric Perrier[1], Olivier Manen[1]
[1]*AeMC Percy, Paris, France;* [2]*AeMC Sainte Anne, Toulon, France*

Education - Case Study

INTRODUCTION: The aeromedical assessment is generally based on the disease of the aircrew member. According to the severity of the disease, the risk of worsening in relation to flights, and the risk of occurrence of inflight symptoms, the aeromedical expert can take a fit or unfit decision. But another criterion is very important to consider: the real duty of the crew. **BACKGROUND**: In this presentation, the authors will present some unusual duties which could be a problem for the aeromedical decision. Based on case reports of aircrews followed in our AeMC, we will first discuss the problem of the aerobatics fitness in civilian aviation, and then discuss some other unusual specialties. **CASES PRESENTATION AND DISCUSSION**: The European civilian regulations don't talk about aerobatics, which can be a problem for several professional pilots, but also for the private pilots who regularly practice aerobatics, sometimes as a competitive sport. We will first present a civilian professional pilot flying in Rafale as an instructor. The systematic EKG showed a 1st degree atrioventricular block, associated with supraventricular rhythm disturbances and a mild aortic valve disease. An evaluation including non invasive then invasive cardiological tests, but also human centrifuge and inflight test was performed to allow a return to fly. During the follow-up, the valve heart disease and the rhythm disturbances worsened, which jeopardized his fitness to fly. We will then discuss a civilian fast jet team pilot who regularly performed cardiological investigations for the follow-up of premature ventricular beats. Six years after the onset of this arrhythmia, a Holter monitoring showed a non sustained ventricular tachycardia which led to a diagnosis of arrythmogenic right ventricular cardiomyopathy. Other unusual duties will be discussed like nurses working in hypobaric chambers who regularly suffer from decompression sickness whereas no regulation exists about their fitness, also the flight engineers and attendants in zero G flights who are asked to get a private pilot medical certificate to fly. **CONCLUSION**: This presentation shows that, when there is a lack in the official regulations when unusual but specific duties, the aeromedical decision must be taken according to science and a good knowledge of the aeronautical constraints.

Learning Objectives

1. To understand how to take a fitness decision when the aircrew duty is not described in regulations.
2. To understand how to assess aerobatics fitness in civilian aircrews.

[176] IMPLICATION OF PREGNANCY FOR PILOTS AND CABIN CREW FITNESS TO FLY

Dominique Luton[1], Marie Christine Bouton[2], Olivier Manen[3], Catherine Cardines[4], Pierre André Leduc[5], Jean Francois Paris[5], Michel Klerlein[5], Vincent Feuillie[5]
[1]*University of Paris APHP, Paris, France;* [2]*Service de santé au travail Air France, Roissy, France;* [3]*CPEMPN, Clarmart, France;* [4]*Service de santé au travail Air France, Roissy, France;* [5]*CEMA Air France, Roissy, France*

Education - Case Study

INTRODUCTION: Pregnancy is a non-pathological state which induce a particular vulnerability owing to profound physiological changes and specific jeopardizing conditions. The aeromedical expert will be confronted with standardized problems but also with unusual conditions necessitating sometimes multiple expertise. **BACKGROUND:** Medical issues in pregnancy implicates two beings: the mother and the fetus . For both the pilot and the cabin crew in flight duty is a physiological and potential emotional stress event that can interfere with the well being of the mother and the fetus. On the other hand some specific pregnancy risk can interfere suddenly and dramatically inducing a risk for the mother, the fetus and the flight security. The aim of the AME will have to deal with the wish of some pregnant staff to keep on flying with respect of the international rules and the ability to prevent at risk situation by either taking a decision of temporary grounding followed by a waiver or not. **CASE PRESENTATIONS:** One study and two type of cases will be presented. Our experience on a retrospective period of ten years will be presented giving the frequencies and the timing of flight for different crew categories mainly among our national airway company The main items to be check listed before flight authorization will be discussed, and the main contra indication due to specific health condition or environmental factors and kind of flight will be reminded. Specific recurrent conditions such as management of early pregnancy or post miscarriage period will be displayed. Aftereffect of serious obstetrical conditions such as placenta acreta will also be shown with the aim to help the AME to determine the best timing for flight duty authorization. Specific at risk infectious destination will also be discussed. **DISCUSSION:** The role of the AME for dealing with specific obstetrical condition need to have accurate knowledges and to have an available specialist network in order to take the best decision for the pregnant staff member but also for the flight security. As most of the obstetrical complications are difficult to anticipate one attitude could be to have a systematic grounding decision; but many staff individual wish to go on flying and therefore specific pragmatic rules have been established. One paradox is that early pregnancy which has a real risk of serious non predictable threatening complications is often not well considered in due time.

Learning Objectives

1. To be aware of the various pregnancy conditions which will indicate a decision of grounding or not.
2. To manage a pragmatic decision for a pregnant cabin crew wishing to fly that will preserve her own safety and the flight safety.

[177] ATYPICAL MEDICO-PSYCHOLOGICAL PRESENTATIONS IN AVIATION MEDICINE

Olivier Manen[1], Jonathan Monin[1], Gaëtan Guiu[1], Jean-François Oliviez[1], Caroline Brescon[1], Nicolas Huiban[2], Dominique Luton[3], Sébastien Bisconte[1], Eric Perrier[1]
[1]*Percy Military Hospital - Aeromedical Center, Clamart (Paris), France;* [2]*Sainte Anne Military Hospital - Aeromedical Center, Toulon, France;* [3]*Bichat - Claude Bernard Hospital, Paris, France*

Education - Case Study

INTRODUCTION: Aeromedical experts are regularly confronted with initial applicants or confirmed pilots with a borderline psychological presentation, but such an expertise is usually difficult to manage from the beginning to the final decision. **BACKGROUND:** The Germanwings tragedy has highlighted the importance of mental health in pilots and has recently led to a renewal of the European regulations with a serious change in the psychiatric and psychological part of the Acceptable Means of Compliance for civilian pilots. However, despite the practical impact of this official guide, there are situations where the AME may not be at ease. **CASE PRESENTATIONS:** Two categories of case reports will be presented: Firstly, there are applicants or pilots who have presented either a medical episode or a professional, personal or family event which clearly questions about the mental health, and yet the individual is not convinced about that, he/she may be opposed to a specific evaluation, and the trust relationship between him/her and the AME may turn into suspicion and conflict. Examples will be developed as these applicants coming with a strange tattoo or dreaming to become an astronaut, or these pilots who stopped their activity because of a stress or aviation-related disorder or because of protective measures decided by the aviation authority. Secondly, during their career several aircrews ask for a definitive unfitness and yet there is theoretically not enough medical or psychological argument to conclude in this way, including after a specific assessment. This situation is typically related to fatigue and demotivation, also to working conditions presented as unfavourable to continue flying, and sometimes to a conflict with the employer who is described as responsible for the medical condition of the aircrew ("aerotoxic syndrome"). **DISCUSSION:** The role of AME is crucial for the screening

and the management of atypical medico-psychological situations. The accessibility to a psychiatrist or clinical psychologist qualified in aviation medicine is generally not immediate. Consequently, AME are expected to determine which individual shall require such an evaluation and which shall continue flying while waiting for it. The decision is facilitated in the Aeromedical Centres by questioning about the feeling of the other members of the medical staff, a collegial thought if necessary, and a regular debriefing with colleagues about these cases to improve experience.

Learning Objectives

1. To be aware of several various and difficult situations when the mental health is jeopardized in aircrews during the aeromedical expertise.
2. To determine which of the pilots with a mental health questioned shall require a specific psychological assessment and what immediate decision is the most appropriate.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany 4

[S-37]: PANEL: SELECTED CASES AND NOVEL SOLUTIONS FROM JUNIOR FLIGHT SURGEONS

Chair: Thomas Powell

PANEL OVERVIEW: *This panel is meant to highlight the accomplishments of Junior Flight Surgeons and Aviation Medical Examiners despite being early in their careers in Flight Medicine. We will present a range of topics to include interesting aeromedical cases, highlight unique problems and their solutions, and provide a platform for discussion of these topics. It offers an opportunity for experienced and the inexperienced in the field to speak to one another directly as we chart a course together to the future of flight medicine. From these presentations, we hope to link these junior physicians with mentors interested in their respective for future projects and AsMA contributions. In the past, this panel has been widely anticipated and well attended by previous AsMA delegations. We hope to continue this tradition through the quality submissions, lectures and, and lessons from this panel.*

[178] SINUS BAROTRAUMA IN A NAVAL AVIATOR

John Curnes
U.S. Navy, Training Air Wing Four, Corpus Christi, TX, USA

Education - Case Study

INTRODUCTION: A student naval aviator was descending in a T-6B when he experienced a recurrent episode of severe frontal sinus pain necessitating operative treatment. **BACKGROUND:** Barotrauma is a disease process unique to the aviation and dive communities. For it to occur the patient must undergo a change in ambient pressure and have some anatomical obstruction which leads to tissue damage and pain. Some cases can be treated medically. Those that have recurrent symptoms need a Otolaryngology referral and evaluation. Surgical treatment is highly successful. **CASE PRESENTATION:** A 26 year old student naval aviator had a recurrent episode of sinus barotrauma. He had one previous episode of barotrauma which occured while descending in a T-6B aircraft. His symptoms were severe pain over the fronal sinus. He was sent for ENT evaluation and they recommended baloon sinuplasty. After a short recovery he underwent a pressure flight in a T-44 aircraft and then resumed training in the T-6B. Upon descent he had a third recurrence of his symptoms and returned for otolaryngolic evaluation. **DISCUSSION:** Sinus barotrauma is unique to the aviation and dive communities. It can negative impact careers and operational missions while also causing significant training delays. There are some cases that can be treated medically such as allergic rhinitis and chronic sinusitis. In recurrent cases, surgical evaluation and treatment is highly successful. Successful operations lead to decreased time in a med down status and decreased likelihood of recurrence.

Learning Objectives

1. Sinus Barotrauma is a common aeromedical and dive complaint. Some cases can be treated with medical management after taking a thorough history. Those who fail to respond or have complications from barotrauma need otolaryngology evaluation.
2. Sinus barotrauma with surgical indications is best treated with Functional Endoscopic Sinus Surgery. Balloon sinuplasty needs close follow up.
3. Barotrauma has significant occupational implications for the DoD and military. Prompt and successful treatment positively impacts those in a special duty work status.

[179] A CURIOUS CASE OF AN SMA

Ryan Thompson
U.S. Navy, Training Air Wing 4, Corpus Christi, TX, USA

Education - Case Study

BACKGROUND: U.S. Naval Aviation Primary training presents a situation where students are constantly graded to obtain a score that will determine their future platform or attrition in naval aviation. Most Student Military Aviators (SMAs) have no previous flight experience, and experience airsickness, performance stress, and other factors in a highly competitive environment that often manifest in somatic symptoms. **CASE PRESENTATION:** A 24-year-old SMA presented to flight surgeon during the contacts block of flight training with an unplanned, documented 20 pound weight loss over a 4 month period associated with abdominal pain/cramping, fatigue, early satiety, and multiple episodes of non-bloody/non-bilious emesis and nausea 3-4 times per week. He had history of mild airsickness but symptoms often occurred on the ground and without a defined relationship with actual flight. Initial workup was negative but symptoms persisted and continued to worsen, so GI referral was performed with normal EGD and biopsies. PUD, celiac, IBD, hyperthyroidism, and malignancy were ruled out. CT abdomen and pelvis with and without contrast showed distention of stomach with the third portion of the duodenum appeared focally narrowed as it passed between the aorta and the superior mesenteric artery. Based on the recommendation of GI and radiology, the clinical history and imaging were highly suggestive of the symptom constellation being the result of SMA (superior mesenteric artery) syndrome, triggered by weight loss related to pilot training program (stress, anxiety, motion sickness, and decreased oral intake). GI believed that resuming training would reignite the vicious cycle of stress, nausea, vomiting, and weight loss. Medical attrition from training, re-designation, and removal from triggers resulted in complete resolution of symptoms as evidenced by resolution of symptoms and regaining 15 pounds while on 3 months of medical hold. Interval CT angiogram showed no dilatation of the proximal duodenum or evidence of active SMA syndrome. **DISCUSSION:** This case highlights the need to for junior flight surgeons to understand and investigate the stresses of their patients and complaints, especially given the fact that chronic gastrointestinal complaints are one of the main complaints and causes of long term med down at Training Wing Four.

Learning Objectives

1. Audience will understand the unique stressors and somatic manifestations that can occur during an aviation training environment.
2. Audience will review the anatomical causes and nature of superior mesenteric artery syndrome.
3. Listeners will see an overview of current Navy Aeromedical policy with regard to common and uncommon gastrointestinal conditions that affect duty status and training.

[180] SPECIAL OPERATIONS CASUALTY EVACUATIONS IN AFGHANISTAN: TWO GMO'S PERSPECTIVES FROM 2019-2021

Evan Shawler, Christopher Jordan
US Air Force, Hurlburt Field, FL, USA

Education - Case Study

INTRODUCTION: This panel will discuss two GMO flight surgeons' aerospace medicine considerations while conducting casualty evacuation missions with special operations forces in Afghanistan. **BACKGROUND:** Data collected throughout the conflicts in Iraq and Afghanistan have shown a 98% casualty survival rate of patients who reached a Role III facility alive. The rapid and safe transport of combat casualties to higher levels of care has continually improved due to enhancements in operational procedures, new technology, and advanced medical training. Transporting patients in the combat environment requires the application of an operational mindset and specialized training for these events. Additionally, technologies like portable ultrasounds utilizing artificial intelligence and state-of-the-art patient documentation apps for phones have become force multipliers to en-route care providers. **CASE PRESENTATION:** A 30-year-old male partner force soldier was on patrol when a vehicle-borne IED detonated, causing severe shrapnel injuries to bilateral legs, left arm, and right chest. A field medic placed tourniquets on both legs, performed a needle decompression, and delivered analgesia. The patient was transported by rotary wing to a Role II facility where a surgical team achieved hemostasis, performed an intubation, and placed a chest tube. The in-theater medical care system coordinated transportation of the patient with Special Operations Forces to a Role III facility. Before departing the Role II facility, the patient's blood pressure dropped to 60/40 mmHg. Understanding the limitations in flight, the flight surgeon halted the transport until the medical team could further resuscitate the patient. After administering blood, the patient was resuscitated and flown to the receiving facility without complications. **DISCUSSION:** Resuscitating patients in a dark, loud, and cold aircraft is a complicated endeavor in an unfavorable setting. Combat flight considerations must include cabin pressurization, temperature control, and space and weight balance. Because of these factors, patients should be optimized for flight, but do not have to be definitively resuscitated. Furthermore, the technology utilized by medical providers in flight can enhance combat care; however, technology should not be relied upon without alternative solutions. Flight surgeons provide a unique perspective on casualty evacuations because of their operational understanding of patient care.

Learning Objectives

1. Casualty resuscitation is critical in ensuring the successful and safe transport of patients across AORs, theaters, and the globe. Regardless of moving a patient by foot, vehicle, aircraft, or boat, proper stabilization of patients before movement is pivotal in optimizing the survivability of casualties and minimizing morbidity and mortality.
2. Technology on aircraft is advancing to help medical providers care for patients during combat flying operations. However, understanding the capabilities and restrictions with each aircraft, equipment, and available personnel is essential for delivering safe and effective medical care.
3. While technological advances have profoundly impacted medical providers' administrative burden and task saturation, recognizing vulnerabilities in relying too heavily on such advances is essential. As the fight continues in the 21st century, neer-peer engagements and great power competition conflicts could see a battlespace where such technology is denied.

[181] AIRSICKNESS MANAGEMENT PROGRAM AT AFSOC FORMAL TRAINING UNIT

R. Daniel Barbera[1], OJ Williams[2], Brian Milner[2]
[1]*1st Special Operations Medical Group, Hurlburt Field, FL, USA;* [2]*492d Special Operations Training Support Squadron, Hurlburt Field, FL, USA*

Education - Program/Process Review

BACKGROUND: Airsickness is a common issue in aerospace medicine as the human body is not naturally acclimatized to the flying environment. This is especially important in aeromedical practice at a formal training unit (FTU) where most students have little to no experience flying in mission-capable aircraft. Lack of flying exposure, condensed flying syllabi, and academic anxiety can be a recipe for getting sick while flying. While motion sickness has no long-term health effects and often resolves with repeat exposure, it can be severe enough to incapacitate an aircrew member, thereby threatening the mission and safety of the aircraft. **OVERVIEW:** After review of various guiding documents – airsickness literature, AFSOCI 36-2902, AFMAN 11-403, AETCI 48-102 – and coordination led by 1SOMDG flight surgeon and newly-formed FTU Ambulatory Care Unit (ACU) team, changes were made to improve the Airsickness Management Program at Hurlburt Field. **DISCUSSION:** In Fall 2020, 1SOMDG Flight Medicine became aware of unclear communication and guidance to the local FTU in handling their airsickness cases. Without aerospace medicine leadership, the issues were: 1. Multiple students were experiencing airsickness without all available resources to overcome their difficulties leading to an increase in failed training rides and functional evaluation boards (FEB); 2. Upon FTU Commander review at an FEB, the students had not been provided all resources, so he was unable to justifiably eliminate from training in a timely fashion leading to repeated attempts at training flights and command frustration. Changes were developed by a monthly working group which included flight medicine, ACU, aerospace physiology, and FTU instructors. Final changes included active patient tracking by flight surgeon/IDMT, updating the FTU airsickness form used by students after an episode, earlier offering of pharmacotherapy to students, increased utilization of the new aviation psychologist at the ACU, improved communication and coordination with aerospace physiology, utilization of commander's awareness program (CAP). These changes achieved 12 airsickness 'saves' over the following 6 months, and no airsickness FEBs as opposed to the 3 that had been necessary in the preceding months.

Learning Objectives

1. Understand the medical literature and Air Force guidance on managing airsickness.
2. Understand what resources can be made available to aviation students to help them succeed in overcoming airsickness.
3. Understand the importance of aerospace leaders to communicate with line officers and take charge on local process improvement.

[182] BEYOND THE BASICS: THE NEED FOR ANCILLARY TRAINING AND EXPANSION OF JUNIOR FLIGHT SURGEON HORIZONS

Thomas Powell
U.S. Air Force School of Aerospace Medicine, Columbus, OH, USA

Education - Program/Process Review

BACKGROUND: Historically, Junior Flight Surgeons have completed the basics of their training before being sent out to the force to practice their craft with much of the first months being consumed by on-the-job training. Once this initial training has been completed, there are few courses that first assignment flight surgeons are encouraged to take but could have a broad impact on their knowledge and practice patterns. Here, several different training courses offerred by accredited organizations are highlighted for their applicability to flight medicine and the training they offer. **OVERVIEW:** Flight surgeons must be familiar with gas laws and physiology, indications for hyperbaric therapy, wilderness medicine, and deployment medicine. There exists a myriad of options, but no formal respository for these opportunities. **DISCUSSION:** Additional education and training through acredited third part institutions are important to forming well-rounded and experienced flight surgeons who can competently advise on issues of gas physiology and deployment medicine. Dive medicine courses offered by the Undersea and Hyperbaric Medicine Society can broaden a flight surgeon's understanding of gas physiology and hyperbaric indications. Wilderness medicine courses offerred through the Wilderness Medicine Society and Uniformed Services University are important primers on many wilderness topics vital to deployment medicine. Additional flight surgeon training through the FAA would allow flight surgeons to issue civilian aeromedical certificates to crew members and prepare them for a possible civilian flight surgeon practice. First assignment flight surgeons face numerous demands for their time and

energy but their commanders should be aware of and encourage these opportunities to have a more academically equipped flight surgeon corps.

Learning Objectives

1. Flight surgeons are asked to do many different jobs, several of which are considered "on the job" training. There are entities out there which can close the gap in this training if offered as optional courses.
2. A guide of the various extra-curricular trainings available will help junior flight surgeons to identify these opportunities and plan their continuing medical education accordingly.

Tuesday, 05/24/2022 ***4:00 PM***
Tuscany 12

[S-38]: SLIDES: SAFETY SALAD: A MEDLEY

Chair: Carlos Navarro
Co-Chair: Dwight Holland

[183] THE EFFECT OF AIRCREW HELMET FIT AND MAINTENANCE ON NOISE ATTENUATION

Soo James, Sara Rubio
QinetiQ, Farnborough, United Kingdom

Original Research

INTRODUCTION: The hearing protectors in aircrew flight helmets are designed to provide noise attenuation, communications and aid helmet stability. The attenuation afforded will be affected by the fit procedure, anatomy of the wearer and maintenance status of the helmet. Helmet attenuation is routinely assessed at accredited test houses on subjects unfamiliar with their fit and use. These assessments, therefore, produce measures with high variance. To accurately predict aircrew noise exposure an understanding is required of the real-world attenuation variance experienced by aircrew in the cockpit. Hence, the aim of this work was to conduct a laboratory evaluation of helmet attenuation using aircrew subjects, where the quality of fit could be more easily adjusted and observed. **METHOD:** Two studies were conducted. The first assessed how attenuation varies with repeated helmet use and involved aircrew fitted with their own helmet. Measurements were made following a helmet re-fit, again after eight weeks of routine flying and, finally, following another re-fit. The second study used test participants and was designed to assess how attenuation varies if helmet fit is compromised due to extreme head movement. Here measurements were made during head movements that could be consistently achieved by all participants. **RESULTS:** The first study showed that despite the status of the helmet fit the attenuation afforded was highly consistent and generally exhibited low intra and inter aircrew variance. Similarly, the second study showed that helmet fit generally remained stable, affording highly consistent attenuation regardless of head position. Only one participant demonstrated a compromised fit where the attenuation fell significantly short. Both studies did, however, show attenuation anomalies which were attributable to poorly fitting seals and grommets. **DISCUSSION:** These studies have shown that correctly fitted flight helmets should provide consistent levels of attenuation across all aircrew and that the protection is not likely to be compromised during extreme head movements in the cockpit or during extended periods of use. However, routine maintenance is important to ensure noise leakage paths are not introduced which will reduce the effective attenuation.

Learning Objectives

1. To understand how the attenuation of aircrew flight helmets varies with repeated use.
2. To understand how the attenuation of aircrew flight helmets varies if helmet fit is compromised due to extreme head movements.

[184] OXYGEN MASK DECONTAMINATION IN THE ERA OF COVID

Leonard Temme[1], Bobby Bowers[2]
[1]*U. S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA;* [2]*U. S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA*

Education - Tutorial/Review

WITHDRAWN

[185] FLOTATION STUDY ON AIRCREW LIFEPRESERVER FREEBOARD, AIRWAY PROTECTION AND DROWNING HAZARD

Matthew Lewis
RAF Centre of Aviation Medicine, Henlow, United Kingdom

Original Research

INTRODUCTION: Current buoyancy standards for life preservers (LP) are primarily driven by civilian requirements which are assessed either with subjects in swim wear or in representative civilian immersion suit flying clothing. The applicability of these standards in the military setting with aircrew encumbered with bulkier and heavier ensembles and equipment needs consideration. These standards prescribe a 120mm freeboard (FB) requirement (the distance of the airway from the waterline). To deliver this the design of the inflatable stole results in bulky and cumbersome jackets leading to neck pain and restricted movement for aircrew. The 120mm FB was determined on limited evidence so this study was set up to determine how the FB limits and stole size could influence drowning, with the aim of establishing if a reduction in stole size could be made without adversely affecting survival. **METHOD:** 11 military LP from the fast jet, rotary wing and multi-engine fleets with various FB measurements were selected for comparison. The LP were fitted to a RAMM immersion manikin which had been adapted to measure the volume of water aspirated through an open mouth, with water aspiration acting as a surrogate for drowning as it gives an estimation of the level of airway protection. Each LP was configured with representative survival aids and pocket contents. The manikin was immersed in an environmental wave pool and the volume of water aspirated was recorded over a 10-minute wave cycle for each LP manikin combination. The manikin was tethered at the ankles to a vertical plum-line which allowed it to pivot freely through 360 degrees in the wave profile. **RESULTS:** The measured FB of the LP ranged from 64mm to 152mm. The results demonstrated that a decrease in FB resulted in the greater volume of water aspirated, however, the shape of the inflated stole also affected the aspiration volume, in particular stoles which had a small rear neck cushion permitted water to track around the side of the neck to increase the volume aspirated. The findings showed that LP with approximately 110mm of FB the volume aspirated remained comparable with LP of greater FB and no additional significant benefit was seen with FB greater than this. **CONCLUSION:** It is unlikely that a reduction of FB to 110mm would adversely affect the protection afforded with the design of the stole shape also influencing airway protection.

Learning Objectives

1. Understand the risks associated with drowning from life preservers with limited freeboard.
2. Understand how a new methodology for testing life preservers could be established to reflect drowning risk.

[186] AUTOMATION ALGORITHMS AND SHIFTING PARADIGMS IN THE COCKPIT

Stacey Zinke
FAA/CAMI, Oklahoma City, OK, USA

Education - Program/Process Review

BACKGROUND: In the past automated algorithms have been looked at and incorporated to augment human capabilities in aircraft operations, when enabled or triggered by the human operator. The time is quickly approaching where the automated algorithms will be monitoring the performance of the human operator and will be able to intervene when it is detected that human performance has degraded. This talk will be looking at the different level of automation, and use lessons from other modes of transportation to discuss a likely path to change over to the new paradigm of who is 'the watcher' versus who is 'the watched.' **OVERVIEW:** This panel discussion explores some of the latest technologies and designs associated with automating operations in the cockpit, defines the different levels of autonomy of algorithms, and examines when and why you would want to use each level and how to safely transition to the new mindset of the algorithms watching the operators. We will briefly discuss the differences between Artificial Intelligence, Machine Learning, Deep Learning, Neural Nets, and Quantum computing. We will examine transitioning to the new paradigm, where the automation assesses the performance of the operator and takes over functionality in the event that the operator's performance degrades. We will look at the aviation industry with respect to user acceptance of automation, data collection and analysis capabilities for failure analysis, and briefly look into the impact of the new technologies along with ethical concerns. **DISCUSSION:** Automated algorithms in the cockpit are rapidly approaching a paradigm shift where the computer system will likely be watching and measuring the performance of the aircraft operators, and will be configured to take over for the human when deemed necessary. This talk will explain the differences between enabling technologies, and discuss user acceptance, and data that will be needed to allow the machine to take over for the human, along with a brief overview of the impact and ethical considerations, as we move to the future of single-piloted and/or fully autonomous commercial passenger flights.

Learning Objectives

1. Understand the differences between Artificial Intelligence, Machine Learning, Deep Learning, Neural Nets, and Quantum computing.
2. List at least two predicted impacts of future automation algorithms.
3. Define at least two levels of autonomous algorithms.

[187] HYPERSONICS, THE ASSOCIATED FLIGHT REGIME, CONTROLS AND DISPLAYS

Timothy Jorris[1], Dwight Holland[2]
[1]*Tehachapi, CA, USA;* [2]*INST, Roanoke, VA, USA*

Education - Program/Process Review

BACKGROUND: Hypersonic flight has a standard definition, yet it also involves a flight regime with a whole set of associated challenges. Hypersonics is defined by the unique properties related to aerodynamics, gas dynamics, and thermodynamics; however, of additional interest are the challenges levied by operating in a mission profile associated with hypersonic flight for person-controlled or Remotely Piloted (RPA) systems. It is currently a very 'hot' topic in the defense and aerospace worlds. **OVERVIEW:** The mission satisfied by hypersonic flight typically involves extended range in minimal time, with the physical Mach number not the sole parameter, but rather actual speed. To get the maximum speed at the lowest Mach number implies operating at extreme altitudes. Operating at extreme altitudes involves operating at low pressure/density environments. Also, a descent imposes yet another set of extremely of high pressures, speeds– leading to extreme temperatures. This complex multi-extreme environment is what makes hypersonic flight such a challenge. These environments not only impose a challenge for vehicle design such as a hypersonic weapon, but also imposes challenges for life support, and the navigation, guidance and controls/displays of manned platforms. For manned flight life support has challenges with oxygen, physiological protection, thermal endurance, and instantaneous and sustained G-loading limits. Some think that manned hypersonic flight is a lofty objective; however, programs such as X-15 and the Space Shuttle have already achieved this goal. And, future hypersonic systems that are unmanned still require control from a distance with time lags, etc. This RPA control problem also involves latency, and the need for well-designed controls and predictive displays. **DISCUSSION:** This presentation explores the definition of hypersonics. Armed with the definition, one can delve into the consequences associated with operating in this flight regime whether person-rated or not. A look at historic iconic hypersonic vehicles and programs is offered, and then project some lessons learned into considerations and risk posture for future programs. Furthermore, technical gain must always be assessed against the risk to personnel safety and monetary loss. Controls/Displays for RPA hypersonic systems must have the best human factors considerations in the system's design.

Learning Objectives

1. The audience will learn about the definition of hypersonic flight and the consequential flight environment.
2. The audience will learn the challenges of manned and unmanned hypersonic flight; to include life support, flight controls, displays, and remotely piloted considerations.

[188] WEATHER DECISION-MAKING FOR GENERAL AVIATION PILOTS DEFICIENT IN INSTRUMENT FLIGHT CURRENCY -IMPLICATIONS FOR FLIGHT SAFETY IN DEGRADED VISIBILITY

Douglas Boyd
Embry Riddle Aeronautical University, Daytona Beach, FL, USA

Original Research

INTRODUCTION: General aviation flights in instrument meteorological conditions (IMC-where visual references are lost) carry an elevated risk of a fatal accident relative to those in visual weather. Instrument-rated private pilots (PPL-IFR) are trained to fly in IMC and to ignore body sensory inputs that lead to spatial disorientation. Towards maintaining proficiency, PPL-IFR are required to complete 6 instrument approaches/6 months per FAA regulations. Herein, two hypotheses were advanced: (i) the majority of PPL-IFRs complete <6 in-flight instrument approaches/6 months (ii) with a subset of such aviators, nevertheless, departing into IMC and/or undertaking long distance cross-country trips. **METHODS**: Instrument approaches for light aircraft in single PPL-IFR ownership (aircraft/owners) in the state with the largest count of single piston engine aircraft (Texas) was determined using Automatic Dependent Surveillance-Broadcast (ADS-B) data. IMC accidents were identified from the National Transportation Safety Board database and rates determined using GA fleet time. Statistical testing used Poisson Distribution and Mann Whitney U-tests. **RESULTS**: The U.S general aviation IMC accident rate was unchanged over the 2013-2019 period ($p>0.595$) demonstrating that operations in degraded visibility represent a continuing hazard. Over the Aug 2020-Mar 2021 period, of 106 ADS-B-flight tracked aircraft/owners (completing 1,684 flights), 81.2% completed <six approaches (median=1.5). Importantly, of the latter, 24% departed into obscuration and 50% undertook long distance cross-country flights (252 nmi). **DISCUSSION**: The current study argues for (i) cautioning such aviators as to the risks of operating in IMC and (ii) future research to identify the reason(s) that PPL-IFR eschew maintaining instrument currency.

Learning Objectives

1. The audience will learn that by far the majority (80%) of IFR-rated pilots in the state (TX) most populous for single engine aircraft fail to complete the number (6) of in-flight instrument approaches mandated by the FAA for maintaining instrument currency.
2. The audience will learn that of the aircraft/owners who fail to meet the FAA-mandated instrument currency, nevertheless, 20% depart into instrument meteorological weather.
3. The audience will learn that of the aircraft/owners who fail to meet the FAA-mandated instrument currency, nevertheless, 50% undertake long distance (252 nmi) cross country trips.