3. The audience will understand the clinical requirements and process for USAF aeromedical waiver approval for neurological DCS.

[134] OPERATIONAL TO EDUCATIONAL, SME TO SGP

Angelica Fullerton
U.S. Air Force, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This presentation discusses the varying roles junior flight surgeons find themselves in, and some tips for success. **BACKGROUND:** Junior flight surgeons, including those straight out of training and without a residency, find themselves in a variety of assignments. This can be overseas, involve a variety of special duties, and involve every possible mission. With only months of training, these flight surgeons often struggle to succeed, resulting in burnout, suboptimal care, and detriments to the mission and flying safety. **CASE PRESENTATION:** My first assignments out of my flight surgeon training were a short tour with a fighter squadron in Kunsan, South Korea, and then as SGP of the Air Force Undergraduate Combat System Officer training program. The first assignment was very mission focused, with a strong historical culture, and small patient population. The second assignment is a large training group, with significant MAJCOM level visibility and a young population without experience on flying status. Both assignments required significant learning and adaptation to deal with unique populations and requirements. **DISCUSSION:** While every assignment will be unique, there are common themes for what young flight surgeons can do to grow and what more senior flight surgeons can do to help them succeed. Seeking out (or being) mentors, humility, and adaptability are essential to the success of junior flight surgeons. Finally, there are some key opportunities when dealing with young flyers, especially the opportunity to build a healthy trust and relationship with flight medicine, that are not to be missed in any assignment.

Learning Objectives

1. Appreciate the variety of assignments and responsibilities that junior flight surgeons undertake.
2. Understand some keys to success for junior flight surgeons, both universally and in a training environment, and how senior flight surgeons can aid in their growth.

TUESDAY, MAY 23, 2023

Tuesday, 05/23/2023 ***8:30 AM***
Grand Ballroom A-B-C

9TH REINARTZ LECTURE

Ansa Jordaan, M.B.Ch.B., B.Sc.(Hons.)
Aerospace Medicine, DOMH

"Civil Aviation in the Future: Key Issues to be Addressed"

Tuesday, 05/23/2023 ***10:30 AM***
Grand Ballroom A-B-C

[S-25]: PANEL: CLINICAL AND RESEARCH INSIGHTS INTO SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Chair: Tyson Brunstetter
Co-Chair: Mary Van Baalen

PANEL OVERVIEW: *First discovered in 2005, Spaceflight Associated Neuro-ocular Syndrome (SANS; formerly known as "VIIP") is a condition unique to long-duration spaceflight. SANS is associated with a multitude of signs such as optic disc edema and retinal nerve fiber layer thickening; globe flattening; shifts in refractive error; and chorioretinal folds. Other potential signs include brain anatomical changes, retinal cysts, retinal pigment epithelial detachments (PEDs), and optic nerve sheath distention; however, it is unclear whether these signs are truly associated with SANS. While the pathogenesis and pathophysiology of SANS remain elusive, several theories exist. This panel will explore the latest technologies in detecting, diagnosing, and monitoring SANS; present recent SANS/neuro-ocular clinical surveillance and research findings from long-duration crewmembers and terrestrial subjects; and explore potential physiological factors that may contribute to the generation of additional neuro-ocular risk during exploratory spaceflight.*

[135] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS): 2023 CLINICAL UPDATE

Tyson Brunstetter[1], Sara Mason[2], Wafa Taiym[3], C. Robert Gibson[4], Mary Van Baalen[1], Ann Tsung[3], William Tarver[1]
[1]*NASA JSC, Houston, TX, United States;* [2]*Aegis Aerospace, Inc., Houston, TX, United States;* [3]*KBR, Houston, TX, United States;* [4]*South Shore Eye Center, League City, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) is unique to long-duration spaceflight (LDSF). Two-thirds of LDSF astronauts present with the earliest indication(s) of SANS, defined as development of any of the following in ≥1 eye during or immediately following spaceflight (SF): 1) optic disc edema (ODE; ≥20 micron increase in peripapillary total retinal thickness [Delta TRT]); 2) chorioretinal folds; 3) globe flattening; and 4) refractive error shift (≥+0.75D). Each presents risk to a crewmember's vision and mission effectiveness; however, it is not yet known what severity and/or duration might lead to acute or permanent impacts to ocular anatomy or visual performance. Brain anatomical changes also occur during LDSF and are being monitored; however, these changes have not yet been associated with functional decrements or with SANS. **METHODS:** Data were obtained from clinical records and subject matter experts. Areas of interest include: 1) prevalence of SANS, 2) ongoing SANS clinical efforts, and 3) SANS clinical thresholds. **RESULTS:** Prevalence of SANS findings in USOS LDSF crewmembers is: 64% for ODE, 15% for chorioretinal folds, 26% for globe flattening, and 14% for hyperopic shifts (≥+0.75D). **DISCUSSION:** All SANS diagnostic hardware are performing nominally onboard the International Space Station (ISS). The Goggle-Based Visual Field (GBVF) device has completed clinical validation testing at Ohio State University and is planned for parabolic flight testing (2022-23) and an ISS technology demo (2024). Four SANS Clinical Thresholds are now established: 1) "Earliest Indication of SANS" – Introduced in 2020, see definition, above; 2) "Clinically Concerning SANS" – Development of any of the following during or immediately following SF: a) ODE (≥55-micron Delta TRT and/or Frisèn grade ≥1), b) sharp chorioretinal folds in/near the macula, or c) moderate globe flattening; 3) "Pathological SANS with Acute Functional Impact" – Development of any of the following during or immediately following SF: a) visual field (VF) loss, b) distorted central vision, or c) shift in refractive error beyond power of available optical correction; 4) "Pathological SANS affecting Long-Term Health" – Development of any of the following during or following SF: a) permanent VF loss, b) reduced retinal nerve fiber layer thickness, c) permanently distorted central vision, d) atrophy of retinal pigment epithelium or photoreceptors, or e) choroidal neovascularization.

Learning Objectives

1. Understand the new and previously established clinical thresholds of Spaceflight Associated Neuro-ocular Syndrome (SANS), their rationale.
2. Understand the risk of SANS to the eyes, vision, and mission of astronauts during long- and extended-duration spaceflight missions.

[136] INTRAOCULAR PRESSURE DYNAMICS IN MICROGRAVITY AND TERRESTRIAL ANALOGUES: A SYSTEMATIC REVIEW AND QUALITATIVE ANALYSIS

Wiaam Elkhatib[1], Kristen Shafer[2], Sara Mason[3], Tyson Brunstetter[4]
[1]*Mayo Clinic Florida, Jacksonville, FL, United States;* [2]*Naval Medical Center, Portsmouth, VA, United States;* [3]*MEI Technologies, Houston, TX, United States;* [4]*NASA JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight-Associated Neuro-ocular Syndrome (SANS) presents risk to expeditionary spaceflight. Related ocular findings carry poorly understood pathophysiology, including relationship to intraocular pressure (IOP) dynamics in microgravity. The study objectives were to conduct a systematic literature review and pool available IOP data from terrestrial microgravity analogs plus published spaceflight measures for comparison and qualitative analysis. **METHODS:** Manuscripts were retrieved through October 2, 2022, from the Scopus, PubMed, Google Scholar, Web of Science electronic databases and NASA document repository. References were citation-mined. Search terms limited to English language included IOP, microgravity, spaceflight, head down tilt, and bedrest. Inclusion criteria required the presence of original quantitative IOP data, human subjects aged 18 to 65 years, and subjects ≥ 3 for analogues. Exclusion criteria were pre-existing intraocular pathology, non-peer-reviewed sources, use of IOP-altering medications, recent ocular surgery, and head down tilt angles beyond -15°. Two individuals independently reviewed literature with a third-party resolving any conflicts. Retrieved manuscripts underwent CEBM clinical appraisal with PRISMA 2020 checklist application. Literature summaries and IOP data were qualitatively synthesized tabularly and graphically. Bias risk assessment and statistical analysis were limited by study heterogeneity and cohort sizes. **RESULTS:** After duplicates removal, 796 studies were screened, and 35 eligible studies identified with their characteristics summarized. Cohorts varied from one to 65 subjects with a total number of 520 participants, age range of 18 to 65 years, and male sex majority. IOP changes between baseline and microgravity/analogues were found to generally trend from an initial, significant increase followed by stabilization at a value above baseline with gradual return to baseline (or slightly below) mostly maintained within nominal IOP ranges (8mmHg - 21mmHg). **DISCUSSION:** IOP microgravity dynamics suggest physiologic adaptation rather than ocular pathology with analogue data correlating to spaceflight. Margins of instrument and operator error often confounded statistical significance within studies, and variable experimental protocols impeded complex statistical analysis for comparison. This assessment factors evidence from thousands of IOP measurements to help elucidate the theoretical mechanisms in SANS.

Learning Objectives

1. Understand the current status of literature regarding IOP dynamics in microgravity.
2. Discuss the potential role of IOP in SANS, and the limitations of IOP measuring devices on-orbit with implications towards future research.

[137] THE PRECISION STUDY: A ONE-YEAR LONGITUDINAL QUANTITATIVE MRI STUDY OF HEALTHY CONTROLS NOT EXPOSED TO MICROGRAVITY

Larry Kramer[1], Khader Hasan[1], Xu Zhang[1], Brandon Macias[2], Steven Laurie[3]
[1]*McGovern Medical School UTHealth, Houston, TX, United States;* [2]*NASA, Houston, TX, United States;* [3]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Quantitative MRI has been utilized to study the intracranial effects of long-duration spaceflight using serial longitudinal measurements for up to one year postflight. There is however lack of control data on how reproducible these quantitative MRI measurements are over a one-year period. **METHODS:** 10 healthy control subjects (5 men, 5 women, Age = 38.3 years (SD=7.80)) volunteered for this study. Subjects were scanned using a subset of sequences obtained from the current astronaut-based MedB MRI protocol on the same dedicated 3-T MRI system using a 32-channel head coil. Each subject underwent a baseline study at 0 months, followed by repeated imaging at 2, 6, and 12 months. Pulse-gated MRI phase-contrast flow imaging was used to quantify peak-to-peak cerebral spinal fluid (CSF) velocity (CSF_{Vp-p}) within the cerebral aqueduct. A 3D T1-MPRAGE sequence was used to quantify total intracranial volume (ICV= brain and intracranial cerebral spinal fluid (CSF) spaces) and lateral ventricular volume using MRI Cloud software and pituitary height measurements. A mixed model was built for each parameter measured over time which included nominal time as the fixed effect factor and subject as the random effect factor. Based on each mixed model, the intraclass correlation coefficient (ICC) was calculated to assess consistency over time. **RESULTS:** All results shown hereby are mean ± standard deviation obtained at 0, 2, 6, and 12 months respectively. CSF_{Vp-p} was 12.2±.3.2, 12.9±4.5, 12.2±3.1, 11.0±4.0 cm/s (ICC = 0.82, 95% CI 0.61-0.94); ICV was 1466±133, 1481±141, 1465±131, 1482±141 mL (ICC = 0.97, 95% CI 0.93-0.99); lateral ventricular volume was 17.8±4.5, 17.9±4.5, 17.7±4.3, 17.8±4.6 mL (ICC = 0.99, 95% CI 0.98-1.00); and pituitary height was 6.6 ±.1.3, 6.7±1.4, 6.8±1.4, 6.6±1.6 mm (ICC = 0.98, 95% CI 0.95-0.99). The heart rate obtained at the time of the CSF flow measurements was 62.6±5.8, 61.5±6.1, 61.3±7.4, 59.3±11.3 bpm (ICC = 0.65, 95% CI 0.36-0.88). **DISCUSSION:** Mean longitudinal quantitative MRI measurements of intracranial anatomy and physiology showed excellent reproducibility over the one-year observation period. Further work is underway to identify thresholds representing normal change over this period of time to aid in the interpretation of spaceflight effects.

Learning Objectives

1. The participant will understand how quantitative MRI is used to study intracranial changes in anatomy and physiology relative to long-duration spaceflight and how the parameters are altered over a one-year period.
2. The participant will learn how intracranial anatomy and physiology using quantitative MRI is altered over a one-year period in healthy controls not exposed to spaceflight.

[138] LONGTERM VISUAL OUTCOMES IN A TERRESTRIAL MODEL OF SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME

Susan Mollan[1], Mark Thaller[2], Victoria Homer[2], Yousef Hyder[2], Alex Sinclair[2]
[1]*University Hospitals Birmingham NHS Trust, Birmingham, United Kingdom;* [2]*University of Birmingham, Birmingham, United Kingdom*

(Original Research)

INTRODUCTION: Only limited data can be gained from astronaut populations, and lifelong follow-up outcomes are not yet a reality for those who develop spaceflight associated neuro-ocular syndrome (SANS). Terrestrial analogues, such as Idiopathic Intracranial Hypertension (IIH), can help provide insights that may help guide flight surgeons and agencies. The aim was to evaluate long term visual outcomes in IIH in those with a normal body mass index (BMI) and those who are asymptomatic, which may best represent an astronaut population. **METHODS:** A longitudinal prospective cohort study (IIH:LIFE) was conducted between 2012 to 2021. The study was ethically approved by National Health Service National Research Ethics Committee (14/LO/1208). Data included demographics and disease status. Visual outcomes included acuity, visual field and optical coherence tomography (OCT) measurements including total retinal thickness (TRT). To assess longitudinal visual outcomes, the effects of body mass index (BMI), presence or absence of symptoms, and categorization of TRT informed models. LOESS (locally weighted scatterplot smoothing) graphs were constructed in order to ascertain the relationship between variables and emergent trends. **RESULTS:** The cohort contained 490 confirmed IIH patients. 98% were female with a mean body mass index (BMI) of 38kg/m^2. TRT did not alter with BMI at baseline. Those with the highest TRT had the worst visual outcomes. Those with a BMI <30kg/m^2 had a

more rapid improvement in papilledema over the first 6 months from baseline visit, with an additional improvement of the retinal nerve fibre layer of 10.79µm/month (95% CI: -26.51, +4.92) and TRT of 5.90µm/month (95% CI: -36.29, +24.48). Those who were asymptomatic had a lower BMI. Patients with a BMI <30kg/m^2 and those who were asymptomatic did not have a different long term trajectory for mean deviation of the visual field and OCT ganglion cell layer measures as compared to typical IIH patients when trends over time were demonstrated on LOESS graphs. **DISCUSSION:** The long-term visual outcomes were not significantly different between BMI groups nor were they determined by presence or absence of symptoms. Amount of papilledema as measured by TRT determines long term visual outcomes. These data enable potential cut-off levels of OCT measures, such as TRT, that could be used to inform clinical decision making in SANS.

Learning Objectives

1. The audience will understand the different measures that can be taken from an optical coherence tomography scan of the eye that can identify optic nerve head swelling.
2. The audience will be able to summarize the similarities and differences between idiopathic intracranial hypertension and Space Flight Associated Neuro-Ocular Syndrome.
3. The audience will be able to consider the challenges in making management decisions in Space Flight Associated Neuro-Ocular Syndrome and apply knowledge from terrestrial analogues based on well characterized clinical cohorts.

[139] UPDATED PERSPECTIVE ON INTRACRANIAL PRESSURE IN ASTRONAUTS DURING SPACEFLIGHT

Steve Laurie[1], Connor Ferguson[2], Patrick Sibony[3], Brandon Macias[4]

[1]KBR, NASA JSC, Houston, TX, United States; [2]Aegis Aerospace, Houston, TX, United States; [3]Stony Brook Medicine, Stony Brook, NY, United States; [4]NASA, Houston, TX, United States

(Original Research)

INTRODUCTION: Crewmembers flying ~6-month missions to the International Space Station (ISS) show signs of optic disc edema (ODE), chorioretinal folds, globe flattening, and/or hyperopic shifts in refractive error, along with increases in ventricular volume; collectively these findings are known as spaceflight associated neuro-ocular syndrome (SANS). No direct measures of intracranial pressure (ICP) have been collected during long-duration spaceflight. Mild elevations in ICP have been recorded after spaceflight in some, but not all astronauts with signs of ODE, but preflight measures of ICP are lacking. No ICP measurements have been obtained in astronauts without optic disc edema. This presentation will provide an update on our understanding of SANS in astronauts during spaceflight. **METHODS:** Noninvasive indicators of ICP (nICP) were collected in 13 ISS crewmembers before and after long-duration spaceflight in multiple postures, and during spaceflight. Optical coherence tomography (OCT) images collected before and during spaceflight were assessed to quantify morphological changes at the optic nerve head and the development of SANS findings in 21 crewmembers. **RESULTS:** Early signs of optic disc edema were observed in 69% of crewmembers. During long-duration spaceflight mean nICP measures were similar to the seated upright posture and did not exceed the supine posture. OCT images revealed a 24% incidence of choroidal folds and 10% incidence of retinal folds in crew with early signs of ODE. Choroidal fold progression worsened with flight duration. **DISCUSSION:** The lack of elevated nICP indicators during spaceflight, along with different presentation of optic nerve head changes and chorioretinal fold incidence than occurs in patients with pathologically elevated ICP, argue against pathologically elevated ICP developing during spaceflight. Further research is needed to better understand the chronic, unremitting headward fluid shift that occurs during spaceflight and whether it contributes to pathologic ocular findings in some, but not all astronauts. The long-term health of astronauts may depend on identifying who is most at risk for developing SANS findings and tracking the severity and duration of optic disc edema, especially since future missions to Mars will be longer than current ~6-month mission duration.

Learning Objectives

1. The audience will understand the limitations to our understanding of ICP during spaceflight.
2. The audience will learn about differences between the presentation of SANS findings in astronauts and signs and symptoms in individuals with pathologically elevated ICP.

Tuesday, 05/23/2023 ***10:30 AM***
Grand Ballroom D-E

[S-26]: PANEL: EVOLVING SCIENCE SURROUNDING PILOT HEALTHCARE SEEKING BEHAVIOR, DISCLOSURE AND AVOIDANCE IN THE US AND ABROAD

Chair: William Hoffman
Co-Chair: Quay Snyder

PANEL OVERVIEW: *Aircraft pilots are required to meet certain medical standards in order to maintain an active flying status. If a pilot develops a new symptom or condition and discloses during aeromedical screening, the pilot runs the risk of temporary or sometimes permanent loss of their aeromedical certificate. For this reason, it has been proposed that some aircraft pilots participate in healthcare avoidance behavior due to fear for aeromedical certificate loss. Several recent studies have demonstrated that a proportion of aircraft pilots participate in healthcare avoidance behavior due to fear for certificate loss both in the US and abroad. These findings have been hypothesized to have broad implications to (1) aeromedical screening, (2) pilot health, and potentially (3) aviation safety. Importantly, pilot healthcare seeking behavior and avoidance is anticipated to become more complicated as aerospace science advances and the pilot population becomes more diverse. The current panel aims to present the evolving data surrounding pilot healthcare seeking and avoidance behavior in the US and abroad. The panel will begin with a patient case followed by five abstracts addressing pilot healthcare seeking behavior and avoidance over the course of a pilot's career. Topics include: (1) a cross sectional descriptive study of pilot healthcare avoidance in US and Canadian pilots due to fear for aeromedical certificate loss, (2) cross sectional descriptive study of underreporting during aeromedical screening in Norwegian pilots, (3) qualitative study of factors that influence healthcare seeking behavior, information disclosure, and wellness in a sample of USAF undergraduate pilot training students and civilian university student pilots, (4) pilot mentality (the "Right Stuff"), peer support programs and mental healthcare seeking, and (5) pilot medical certification and healthcare avoidance from a safety management system framework.*

[140] HIDING IN PLAIN SIGHT: HEALTHCARE AVOIDANCE DUE TO FEAR FOR AEROMEDICAL CERTIFICATE LOSS IN US AND CANADIAN PILOTS

William Hoffman

Brooke Army Medical Center, San Antonio, TX, United States

(Original Research)

BACKGROUND: Aircraft pilots are required to meet certain medical standards in order to maintain an active flying status. If a pilot develops a new symptom or condition and discloses during aeromedical screening, the pilot runs the risk of temporary or sometimes permanent loss of their aeromedical certificate. For this reason, it has been proposed that some aircraft pilots participate in healthcare avoidance behavior due to fear for aeromedical certificate loss, but the degree of healthcare avoidance in US and Canadian pilots and subgroups remains uncertain. **METHODS:** We conducted a cross sectional population-based anonymous survey of pilots in the United States and Canada.

RESULTS: There were 3,763 U.S. pilots and 1,405 Canadian pilots (72.8% v. 26.7%) included in the analysis. The respondents included 491 female pilots (9.5%), 1,679 paid civilian pilots (34.2%) and 280 military pilots (5.7%). There were 55.9% of respondents admitted to at least one type of healthcare avoidance behavior due to fear of medical certificate loss (56.1% of US pilots v. 55.2% Canadian pilots, p=0.58). There were 67.9% of Canadian pilots who reported ever seeking informal medical advice due to fear of medical certificate loss compared to 52.7% of US pilots ($p \leq 0.01$). When asked if they had ever withheld information during an aeromedical examination, there were 39.9% of Canadian pilots and 28.7% of US pilots who affirmed ($p<0.001$). Pilot types associated with compensation were more likely to report a history of healthcare avoidance than pilot types not associated with compensation. Statistical significance was found between select pilot subgroups. **DISCUSSION:** Pilot healthcare avoidance due to fear of medical certificate loss may be present in US and Canadian pilots and select behaviors may have higher prevalence in certain jurisdictions due to factors unique to the local aeromedical system. Open questions center around the impact of pilot healthcare avoidance to aviation safety and pilot health.

Learning Objectives

1. The learner will define pilot healthcare avoidance and factors that might influence healthcare avoidance behavior.
2. The learner will describe the rate of self reported healthcare avoidance due to fear for aeromedical certificate loss in US and Canadian aircraft pilots.
3. The learner will describe demographic factors associated with higher rates of self reported healthcare avoidance due to fear for aeromedical certificate loss.

[141] UNDER-REPORTING OF SELF-REPORTED MEDICAL CONDITIONS IN AVIATION: A CROSS-SECTIONAL SURVEY

Trond-Eirik Strand
Own, Oslo, Norway

(Original Research)

INTRODUCTION: The applicants' self-declaration of aeromedical history (during aeromedical certification) and healthcare avoidance is crucial for flight safety. In a civil aircrew population (Norway) 12% admitted having ever under-reported any medical conditions. **METHODS:** We conducted a survey among all civilian aircrew in Norway and 1 616 responded the electronic questionnaire about the aeromedical certification process. Main results have been published in AMHP, April 2022 (doi: 10.3357/AMHP.5823.2022). A total of 726 of the respondents were commercial pilots and further analyses were performed to investigate this subgroup more in depth. **RESULTS:** Among commercial pilots 5.6% had (ever) underreported /withheld information for an aeromedical examiner (AME) about his or her physical health. And for same questions regarding mental health, use of medications and drug use including alcohol the proportion of pilots confirming underreporting was 4.7%, 2,2% and 7,0% respectively. The corresponding numbers for other classes combined were 2,9%, 2,2%, 1,2% and 5,4 respectively. A total of 70,6% pilots believed medical certification to a large extent contribute to increased flight safety. The corresponding number for non-pilots was 58,0%. **DISCUSSION:** Pilots in general believe aeromedical certification to a higher degree contribute to increased flight safety compared to non-pilots. On the contrary, pilots have increased drive to underreport in all four categories questioned (physical and mental health, use of medication and drug use including alcohol) compared to non-pilots. Strategies for underreporting should be implemented and we might assume this could contribute to reduce health care avoidance among air crew as well.

Learning Objectives

1. The audience will learn about the frequency of self-reported underreporting among different aircrew classes in civil aviation.
2. The audience will learn that pilots have different reported proportion of undererreporting compared to other aircrew classes.

[142] PILOT MENTALITY (THE "RIGHT STUFF"), PEER SUPPORT PROGRAMS AND MENTAL HEALTHCARE SEEKING

Dave Fielding
BALPA and British Airways, London, United Kingdom

(Education - Program/Process Review)

TITLE: Pilot mentality (the "Right Stuff"), peer support programs and mental healthcare seeking. **OVERVIEW:** Other speakers have identified under-reporting of aeromedical issues by pilots. Reasons behind this are necessarily complex and inter-related. Whilst the *prima facie* reason is fear of loss of the Class 1 medical, the 'typical' pilot mentality of setting high personal standards, independently solving problems, and demonstrating resilience in unexpected circumstances often leads to pilots attempting to solve their own issues rather than seek professional help. The speaker will argue that these personality characteristics frequently amplify the stigma that is associated with declaration of mental health issues in particular. It is not uncommon for pilots to attempt to use cockpit stress coping mechanisms and problem-solving structures to solve longer-term mental health issues. These are unlikely to be successful, exacerbating the feelings of failure and sinking a small percentage of pilots deeper into depression and further healthcare avoidance. The role of Pilot Peer Support Programs (PPSPs) is critical in addressing this problem. A suitably trained Peer is in a position to assure the pilot that their problems are not uncommon (normalization), to work with them to facilitate those pilot problem-solving skills in a more productive way (roughly 85% of pilot issues are resolved at this stage), and finally to act as a reassuring bridge to professional aeromedical assistance if required. **DISCUSSION:** Many pilots are mistrustful of AMEs. The perception that sometimes-lifelong dreams and ambitions of a flying career could be destroyed by one test or declaration is powerful. For a highly risk-averse population, a surprising number of pilots prefer to risk the consequences of concealing a medical issue from the Regulator rather than declaring it. The challenge facing Regulators and AMEs is to persuade pilots that permanent removal of medical certification for mental health issues is statistically extremely rare. However, direct communication with pilots by the aeromedical community of this fact has had limited effect, hence this Panel. The recent advent of PPSPs into mainstream aviation offers the opportunity for a trained colleague to persuade pilots that they are safe to declare their mental health / aeromedical issues. Partnership with the aeromedical community in this training is paramount.

Learning Objectives

1. To give the audience an understanding of typical pilot psychological characteristics which are relevant to the under-reporting of medical issues.
2. To discuss the importance of Pilot Peer Support Programs in persuading pilots to disclose medical issues.

[143] PILOT MEDICAL CERTIFICATION AND HEALTHCARE AVOIDANCE FROM A SAFETY MANAGEMENT SYSTEM FRAMEWORK

Anthony Tvaryanas
FAA, Oklahoma City, OK, United States

(Education - Program/Process Review)

BACKGROUND: Safety management systems are the product of a continuing evolution in aviation safety, where safety is viewed from a systemic perspective, encompassing organizational factors in addition to human and technical factors. The Federal Aviation Administration (FAA) chose to implement a SMS as it integrates the management of safety risk into business planning, operations, and decision-making. This presentation reviews pilot medical certification, and the issue of pilot healthcare avoidance, from the perspective of the SMS framework. **OVERVIEW:** Within the SMS framework, the FAA establishes the acceptable level of risk. It then falls to pilots, operators, and manufactures to assess and manage their risk with the goal of compliance and shared interests of

safety. The FAA provides oversight and independent validation of their risk management. This process aligns with the code of federal regulations on pilot medical readiness (14 CFR 61.53) and qualification standards (14 CFR 67). The pilot is responsible for determining their fitness to fly given a medical condition and any associated medications and treatments on any given day between periodic examinations. The FAA conducts independent validations of pilot medical risk management through the periodic medical examination conducted by its designated examiners. When the designee identifies a pilot who does not meet medical standards, the designee refers the case to a FAA medical officer for a safety risk assessment. This safety risk assessment involves a determination of the probability of an aeromedical event during the certification period given pilot health-related hazards and any available mitigations. The goal for these risk assessments is data driven, risk based decision-making, however, when sufficient data is unavailable expert opinion on a case-by-case basis is employed. **DISCUSSION:** The SMS framework emphasizes the primary role of the pilot in managing their medical risk and supporting FAA oversight and validation activities. Given civil pilot medical care occurs in the community healthcare setting, often mediated through health insurance and the workplace, pilot healthcare avoidance is best considered in the context of a safety risk model that incorporates broader organizational and societal factors. Such a model is presented, which incorporates the levels of prevention and health policy factors.

Learning Objectives

1. The audience will learn how pilot medical certification is accomplished with the FAA's safety management system framework.
2. The audience will learn how organizational and societal factors influence pilot healthcare avoidance in the civil aviation setting.

Tuesday, 05/23/2023 ***10:30 AM***
Grand Chenier

[S-27]: PANEL: SAFETY CONSIDERATIONS OF REDUCED CREW OPERATIONS ON LONG-HAUL FLIGHTS

Sponsored by Air Transport Medicine Committee (ATM - AsMA)

Chair: Ries Simons
Co-Chair: Roland Vermeiren

PANEL OVERVIEW: *Safety Considerations of Reduced Crew Operations on long-haul flights Introduction: Several stakeholders in the aviation industry are exploring the possibilities of Reduced Crew Operations of commercial airliners. Concrete developments concern Extended Minimum Crew Operations (eMCO: on long haul flights one Pilot Flying + one Pilot Resting - no augmentation of crew) and Single Pilot Operations (SIPO: one Pilot in cockpit + one supporting Pilot at a ground station). The eMCO concept is supposed to be implemented in the coming years and the SIPO concept is to be rolled out in 2030. The present panel session is geared to discuss safety risks of eMCO and SIPO. Operational, aeromedical, and human factors consequences of these operations will be discussed and main points for risk assessment will be proposed.*

[144] REDUCED CREW OPERATIONS – ADDRESSING THE HUMAN CENTRIC DESIGN OF THE SYSTEM – PILOTS' PERSPECTIVE

Juan Carlos Lozano
IFALPA and European Cockpit Association, Brussels, Belgium

(Original Research)

INTRODUCTION: Airline pilots have a proven track record of maintaining industry's safety record in the day-to-day operations. Despite that, the safety role of a pilot physically present in the flight deck is being questioned by certain parts of the industry. Numerous projects are ongoing to introduce single-pilot or remote-controlled operations to the air transportation system. Some aircraft manufacturers consider the technology aimed at implementing reduced crew configurations "as ready to go". But is it ready to go for all types of real-life scenarios? **CONSIDERATIONS:** Before considering any crew reduction issue, it is necessary to understand today's airline pilots working methods and philosophy. During the last 30 years, pilot training has substantially evolved to tackle the complexities that flight deck automation has brought as well as the increase in air operations. The development and implementation of Cockpit Resource Management (CRM) have proven to be an undeniable factor of the improved global flight safety. In the last 10 to 15 years, we have seen many cases where technology has seriously compromised flight safety and only the coordinated work of two (or more) well-rested, well-trained pilots saved the day. **DISCUSSION AND CONCLUSION:** There are numerous risks associated with the reduction of the number of pilots in the flight deck. Most prominently, these risks stem from the increased workload for the remaining pilot and the elimination of a critical layer of monitoring, cross-checking and operating redundancy provided by a second pilot in the flight deck. This could compromise the safety and security beyond acceptable levels of risk given the many variable emergency situations that may occur during a flight. It has not been demonstrated that automation has matured to the point of enabling operations with only one pilot in the flight deck without compromising safety. Currently, there is a complex interplay of two crewmembers, physically located next to each other on the flight deck, openly communicating with each other. We need to study the probabilities and impact should the pilot 'fail', how loneliness for long periods of time or in critical situations would affect pilot's performance. What are the consequences of pilot incapacitation in a reduced crew operations scenario and how can it be recognized and dealt with?

Learning Objectives

1. Understand the complimentary role of automation to the human in aviation safety.
2. Human limitations (physical and psychological) need to be fully understood before eliminating humans from the flight deck of an aircraft.

[145] WHAT ARE THE AEROMEDICAL CONSIDERATIONS NECESSARY TO FACILITATE REDUCED CREW OPERATIONS WHILST MAINTAINING OR IMPROVING FLIGHT SAFETY?

Declan Maher
European Society of Aerospace Medicine, Dublin, Ireland

(Education - Tutorial/Review)

INTRODUCTION: Reduced Crew Operations (RCO) call for a root and branch analysis of the fundamental aspects of what we take for granted as the fundamentals of Flight Safety. Movement away from the current model will require evidence and expert opinion for the development of a medical standard that applies to those that wish to fly in Extended Minimal Crew Operations (eMCO) or in Single Pilot Operation (SPO). **DISCUSSION:** We have developed Medical Standards that reflect best aviation medicine practice requiring two persons on the Flight Deck at all times. This was reinforced by events in 2015. The mitigation of risk to flight safety through sudden or subtle incapacitation are based on the same concept of two on the flight deck. Our current Medical Standards are based on evidence and expert opinion born from research and experience in Aviation Medicine. This new Medical Standard will need to mitigate against the risk imposed by the absence of the second person on the Flight Deck. How much of the Multi-Crew Operation mitigates risk? What is the impact of Crew Resource Management and does it still have a role? Do we have sufficient evidence that it does, and by how much? Is there evidence to support that it has little or no impact? What are the areas of Commercial Air Transport that are impacted by the concepts of RCO? Do we need to identify and, where possible, quantify the elements that need to be studied when considering the use of RCO?

The Aim of this Presentation is to highlight the elements for research and consideration.

Learning Objectives

1. Explore the changes in Aeromedical Standards required to allow reduced crew operations.
2. Consideration of the risk mitigation achieved by the multi-crew flight deck environment.

[146] REDUCED CREW OPERATIONS ON LONG-HAUL FLIGHTS: SOME FATIGUE CONSIDERATIONS

David Powell
International Air Transport Association, Auckland, New Zealand

(Education - Program/Process Review)

BACKGROUND: Reduced crew operations have been proposed as a possible mechanism to address pilot shortages, operating costs, and other operational challenges in long-haul commercial airline operations. **OVERVIEW:** There are many factors to be considered among the implications of reduced crew operations. For this presentation the focus is the question of pilot fatigue, and the optimal management of on-board rest. How might reduced crew operations impact the rest achieved on board? How might this impact be considered amongst the other factors also addressed in the panel? **DISCUSSION:** To look at this specific question, the presentation will review some research from many studies undertaken as a part of the fatigue risk management system within a long-haul airline. Possible application of the lessons learned will be discussed in the context of airline crew operations.

Learning Objectives

1. Understand the relationship of crew complement to on-board rest in long-haul airline operations.
2. State the typical findings of studies into long-haul fatigue of airline pilots with a range of crew complements, sector durations, and rest patterns.
3. State the possible effect of reduced crew operations on the on-board rest achieved.

[147] REDUCED CREW CONCEPTS (RCC) FOR CIVIL TRANSPORT AIRPLANES – THE FAA PERSPECTIVE

Melchor Antunano
FAA, Oklahoma City, OK, United States

(Education - Program/Process Review)

There is an Increasing interest from airlines and airframers in Reduced Crew Operations (RCC). This is due in part to compensate for existing/expected pilot shortages and to potentially reduce expenses related to crew costs. RCC includes 1) Single Pilot Operations (SPO), 2) Enhanced Minimum Crew Operations (eMCO), 3) Single Pilot – Second Pilot Optional (SPPO), 4) Pilot Optional Operations, and 5) Fully Autonomous Operations. RCC include operating with a single pilot in the flight deck for at least some portion of flight. Single pilot may be supported by additional flight crew for some flight segments, advanced automation on the aircraft flight deck, or ground station operator (remote pilot). Advanced automation implementation would require the retrofit an existing flight deck or to develop a clean-sheet design. This is a paradigm shift in the traditional flight crew design toward reliance on automation to mitigate and manage risk. Applicants for RCC will need to address many issues to establish this. There are a number of significant challenges to implement RCC including: 1) Pilot Incapacitation/Confusion Detection & Mitigation, 2) Pilot Workload & Performance, 3) Control Authority, Priority and Transfer, 4) Flight Deck Design, 5) System Design Philosophy, 6) Flightcrew Roles & Responsibilities, 7) System Safety/Risk Assessment and Contingency Management, 8) Concept of Operations, 9) Ground Station Communication/Signal Integrity and Security, 10) Ground Station Responsibilities/Authority, and 11) Pilot Type Ratings/Qualifications. The FAA Roadmap for RCC for Transport Airplanes mut identify the unique challenges and risks for the eMCO and SPO, assess current rules, guidance and standards and identify gaps and focus areas, develop a plan to fill gaps near-term and long-term, and ensure an equivalent (or higher) level of operational safety to today's transport airplane operations. Such a roadmap must involve Aircraft Certification, Flight Standards, Air Traffic Control, Airports Operations, and Aerospace Medicine.

Learning Objectives

1. The audience will understand the medical and human factors implications of Reduced Crew Concepts (RCC).
2. The audience will understand the challenges and complexity of reducing crew members to operate commercial transports.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon Ballroom C1-C2

[S-28]: PANEL: PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: A NATO WORKING GROUP

Chair: Ryan Mayes

PANEL OVERVIEW: *Tactical aviation has a long history of physiologic events (PEs) associated with flight in challenging environments. However, in the last decade, pilots of multiple high-performance aircraft (fighter/attack jets and trainers) have experienced a higher-than-expected rate of these episodes in multiple services. In order to facilitate dialogue across nations regarding PEs, a North American Treaty Organization (NATO) working group was formed in 2018. With over 20 members from 10 NATO and partner nations, this group seeks to develop a better understanding of the potential causes of PEs, compare PE presentation and experience across nations and airframes, and create international consensus on causes, mitigations, and response where appropriate. This panel will present the NATO working group's progress to date, with particular emphasis on the challenge and group approach, proposing case definition and categorization principles, a presentation of the parameters of interest for physiologic monitoring, a discussion on the best practices for physiologic monitoring in the tactical aviation environment, and an analysis of the knowledge gaps in the current literature.*

[148] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: THE CHALLENGE AND NATO WORKING GROUP APPROACH

Ryan Mayes[1], Adrian Smith[2], Ted Meeuwsen[3], Nicholas Green[4], R. Allen Hoffman[1,9], Erik Frijters[3], Vivienne Lee[5], Oliver Erley[6], Roope Souvelius[7], Laetitia Bertrand[8], Michael Decker[9]
[1]*USAFSAM, Wright-Patterson AFB, OH, United States;* [2]*Institute of Aviation Medicine, RAAF Base Edinburgh, Australia;* [3]*Center for Man in Aviation, Soesterberg, Netherlands;* [4]*RAF Center, Centre of Aviation Medicine, RAF College Cranwell, United Kingdom;* [5]*QinetiQ PLC, Farnborough, United Kingdom;* [6]*Zentrum für Luft- und Raumfahrtmedizin der Luftwaffe, Cologne, Germany;* [7]*Aeromedical Centre, Finnish Defence Forces, Helsinki, Finland;* [8]*Département de Médicine Aéronautique Opérationelle, Mont de Marsan, France;* [9]*Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States*

(Education - Program/Process Review)

BACKGROUND: in-flight physiologic events (PEs) among high-performance aircraft pilots have been attributed hypoxia or g-induced loss of consciousness (GLOC). Accordingly, training, pilot selection, and incident response investigations have been centered around this paradigm. However, as jet life support systems and aircrew flight equipment have improved, it stands to reason that these traditionally-attributed causes of PEs may be incomplete. In the last decade, multiple PEs have been noted among 4th- and 5th-generation fighter pilots in multiple services that do not appear to be connected to hypoxia or GLOC. **OVERVIEW:** In order to facilitate international information

sharing and create a consensus understanding of PEs, a North American Treaty Organization (NATO) working group was formed in 2018. This group has 20+ members representing 10 NATO and partner nations. The group has multiple objectives, but the four primary goals are (1) creating PE classification criteria, (2) generation of a PE case definition, (3) conducting a study of aircrew PE experience across NATO nations and airframes, and (4) creating a matrix of the relevant exposures present in the tactical aviation environment along with the potential outcomes of those exposures. **DISCUSSION:** PE symptom presentation can vary widely, and the cause of PEs are multifactorial and variable. An understanding of the multiple exposures that may lead to symptoms and of the potential outcomes of those exposures, is critical to understanding PEs. PEs require a comprehensive, systematic, and methodical assessment by a specialist. However, not all relevant exposures and outcomes are well-understood, and the multifactorial nature of PEs requires an understanding of the interactions between exposures and physiologic responses. A current understanding of the rapidly evolving state of PE science is critical to assessment of PEs.

Learning Objectives

1. Understand the potential sources of, and challenges posed by, in-flight physiologic events.
2. Understand the objectives of the NATO working group focused on physiologic events.

[149] PRINCIPLES FOR THE EVALUATION, GRADING, AND CLASSIFICATION OF PHYSIOLOGICAL EPISODES.

Adrian Smith[1], Roy Allen Hoffman[2]
[1]*RAAF Institute of Aviation Medicine, Adelaide, Australia;* [2]*Naval Aeromedical Research Lab, Dayton, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Physiological episodes (PHYSEP) remain a significant safety concern for military aircrew, especially those operating high-performance aircraft. Lack of standardized definitions and reporting have made it difficult to compare PHYSEP across platforms and between military forces. NATO RTG HFM 312 has developed a standardized approach to facilitate communication and analyses. **OVERVIEW:** Evaluation is based on establishing a symptoms-based probabilistic cause for PHYSEP through accurate symptom reporting. Classification is performed based on symptom clusters, their association with an anomaly in an aircraft system, standardized severity rating of symptoms, and physiological explanations with high degrees of confidence. Classification by systematically grouped aircraft system factors and presenting symptoms can be compared across different platforms and between military. The evidence underpinning different potential causes is weighted based on three questions: Is the symptomology consistent with the proposed mechanism? Is the timeline, evolution, and response to treatment or mitigation consistent with the proposed mechanism? Are the environmental conditions necessary for the proposed mechanism present? Grading is performed according to severity of the symptomatic event and adequacy of defenses. The severity of PHYSEP can be described in terms of the extent to which the symptoms degrade physiological margin and human performance or jeopardize flight safety. Reporting will have host nation variation but include the evaluation, classification and grading, of PHYSEP by aviation medicine specialists' consensus panel review, with timely release of preliminary information to support the engineering and safety investigations following a PHYSEP. **DISCUSSION:** The principles outlined in this presentation provide a structured approach to evaluating and assessing the most-credible explanations for the associated symptoms experienced in PHYSEP flights and serve as the basis to communicate relevant evidence-based information to assist the safety investigators and engineering-support team in developing their response and construct solutions. The standardized framework will allow PHYSEP experience to be shared between platforms and military forces.

Learning Objectives

1. The audience will learn about the framework proposed by NATO RTG HFM 312 for the assessment and classification of PHYSEPs.
2. The audience will learn about the benefits of adopting a standardized approach to PHYSEPs when comparing trends across different systems.

[150] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: A NATO WORKING GROUP

Erik Frijters[1], Ryan Mayes[2], Ted Meeuwsen[1]
[1]*Center for Man in Aviation, Royal Netherlands Air Force, Soesterberg, Netherlands;* [2]*USAFSAM, Dayton, OH, United States*

(Original Research)

INTRODUCTION: Military flying is very demanding on the human operator, especially in high performance jet aircraft. High Gz forces, onboard oxygen systems, fluctuating cabin pressures and pilot flight equipment can all impact pilot physiology. Physiological events are sometimes reported by pilots who "just don't feel right". Physiological symptoms may be vague, non-specific, or ambiguous, and may not clearly be attributed to a single root cause. There is currently no objective measure that a pilot can use to assess signs and symptoms in-flight. **METHODS:** For effective application of a physiological monitoring system, the design principles to be considered include: fit for purpose in the flight test environment; a passive datalogger for forensic use post-event; active monitoring and display of relevant information in a format for aircrew to use to assess wellbeing in flight, including in the presence of symptoms; an alerting system to warn aircrew of degrading physiological conditions requiring action. Because physiologic events are multifactorial with wide-ranging symptoms and presentations, generalized parameters are the most useful to study. **RESULTS:** Cardiopulmonary measures (ECG, heart rate, minute ventilation, respiratory rate) are relevant and achievable. The "smart flight suit" has such capabilities. It is a cooperation effort between the Royal Netherlands Air Force and U.S. Air Force Research Laboratory and is an example of a product that is specifically designed for the cockpit environment. An overview of parameters of potential interest for the future will be discussed in the presentation. **DISCUSSION:** Parameters that are specific to a particular exposure or casual pathway (such as blood oxygen level) are of more limited utility. Looking to the future, electroencephalograpy (EEG) and eye tracking may provide valuable insight into aircrew state, but are more complex to measure. As technology progresses more ways to measure physiological responses may become available. Application in the cockpit environment depends on usability and robustness and requires thorough testing and certification. **BACKGROUND:** In 2021 a 3 year collaborative working group called 'Unexplained Physiological Events' (HFM RTG-312) was formed. The team consists of experts from 20 different NATO countries and is working on creating an exposure matrix to identify which factors are most relevant to the operator and ways to mitigate their effects.

Learning Objectives

1. The audience will learn about how measuring in-flight physiological parameters can be relevant to increase operator effectiveness and mission succes. Current and future potential will be discussed.
2. The audience will learn about the challenges that come with designing a reliable and robust way of measuring physiological parameters in the cockpit environment.

[151] MONITORING: BEST PRACTICES FOR MEASUREMENT IN THE TACTICAL AVIATION ENVIRONMENT

Nicholas Green[1], Erik Frijters[2], Oliver Erley[3], Roy Hoffman[4], Vivienne Lee[5], Ted Meeuwsen[2], Adrian Smith[6], Roope Sovelius[7], Michael Decker[8], Ryan Mayes[9]
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(Education - Program/Process Review)

BACKGROUND: The aerospace environment presents significant challenges to the acquisition of accurate biomedical data, even in the controlled environment of a hypobaric chamber or centrifuge. The presence of environmentally generated artefacts or other confounding variables has an important influence on the interpretation of any changes observed. This presentation outlines some guiding principles to optimize biomedical measurements in the tactical aviation environment. **DESCRIPTION:** At the outset, target variables should have been previously demonstrated to show meaningful changes in the flight setting. We need to be confident that data collected can be used to prompt changes in pilot behavior or equipment operation during flight, so that aircrew performance is increased or risk is reduced in a timely manner. If no meaningful intervention can be made, there is no value in monitoring (except sometimes for post-flight investigation). It is essential to monitor the most reliable and reproducible data source. For many variables, this source may not be directly from the human. For example, breathing rate and depth can be more readily measured in the gas supply to the pilot rather than by detecting movement of the pilot's chest. Measures must have appropriate sensitivity and specificity in the flight environment, and caution should be exercised when reading across the performance of proprietary algorithms to flight. If real-time data analysis is being conducted, data must be artefact free or must be amenable to real-time artefact stripping. Artefacts may be reduced by careful location of sensors, but these must be compatible with flight gear. Ideally, the variable chosen for monitoring should have clear threshold values for action, but often meaningful changes in flight physiology data are trend-based, which makes reliable real-time analysis more challenging. **DISCUSSION:** The occurrence of Physiological Events is rare per flight hour. Therefore, when considering monitoring in the tactical flight environment, it is important to consider Bayes' theorem. Without measures that have high specificity, there is a risk that monitoring in tactical aviation will generate an unacceptable number of false positive reports. Appropriate choice of target variable, measurement site and data handling may optimise utility.

Learning Objectives

1. Understand the challenge of physiological monitoring in the flight environment.
2. Understand the principles that may improve the chance of success when monitoring in the flight environment.

[152] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: WHAT DON'T WE KNOW AND WHAT DO WE NEED TO KNOW?

Vivienne Lee[1], Roope Sovelius[2], Michael Decker[3], Nicholas Green[4], Adrian Smith[5], Erik Frijters[6], Ted Meeuwsen[6], Oliver Erley[7], Ryan Mayes[8]

[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*Centre of Military Medicine, Satakunta, Air Command Health Clinic, Helsinki, Finland;* [3]*Naval Medical Research Lab, Dayton, OH, United States;* [4]*RAF Centre of Aviation Medicine, Henlow, United Kingdom;* [5]*Institute of Aviation Medicine, RAAF, Adelaide, Australia;* [6]*Centre for Man in Aviation, Soesterberg, Netherlands;* [7]*Zentrum fur Luft und Raumfahrtmedizin der Luftwaffe, Furstenfeldbruck, Germany;* [8]*U.S. Air Force Research Lab, Dayton, OH, United States*

(Education - Tutorial/Review)

INTRODUCTION: Pilots of high-performance aircraft from a number of nations have reported in-flight physiologic events (PEs) over recent years. As part of its remit, the NATO HFM RTG-312 group has identified areas where knowledge is lacking and where effort is required to promote an international understanding of the factors influencing PEs, their mitigations and to inform aircrew education. **TOPIC:** The HFM RTG-312 has developed a matrix of exposures containing factors relevant to PE occurrence. As part of the process, knowledge gaps associated with these factors are being identified and key areas for research are being considered. The process has already highlighted knowledge gaps including: the implications of the operational environment on inflammatory processes and the significance of these with respect to aircrew performance and PEs; the implications of delivered gas mixture, dehydration, nutrition, smoking and external stressors on PEs; the effect of exercise and sleep quality prior to flight; the effects of circadian disruption and fatigue on flight performance and susceptibility to PEs. Additionally, a review of current knowledge has highlighted the need for further research into breathing system resistance to improve standards; with increasing capability to undertake long duration missions, cockpit ergonomics and other factors associated with extended periods of flight need consideration with respect to susceptibility to PEs, and their effect on cognitive performance. In many areas, research has been undertaken on individual stressors associated with the flight environment but knowledge is lacking on the potential synergistic effects of combined stressors. Importantly, there is a need to understand implications of age, anthropometry and sex; going forward, there is a need for research to include female participants as these data are currently lacking. **APPLICATION:** Research into the knowledge gaps identified will inform international understanding of the factors influencing the development of a PE, which in turn can underpin development of robust mitigations. A broad, robust knowledge base should support best practice for aircrew education, leading to optimal management of PEs by operators and aircrew.

Learning Objectives

1. The audience will learn what NATO RTG 312 consider the key knowledge gaps relevant to physiologic events.
2. The audience will learn what NATO RTG 312 consider to be research priorities relevant to physiologic events.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon Ballroom D1-D2

[S-29]: SLIDES: COVID AND HEALTHCARE INTEGRATION

Chair: Benisse Lester
Co-Chair: Tamara Averett-Brauer

[153] EATC CROSS-NATIONAL STRAT AE FLIGHTS DURING COVID-19 AND UKRAINIAN CRISIS

Alessandro Fiorini, Martin Gascon Hove, Erwan Dulaurent, Ralph Vermeltfoort, Henning von Perbandt, Mathias Borsch
European Air Transport Command, Eindhoven, Netherlands

(Education - Program/Process Review)

INTRODUCTION: European Air Transport Command (EATC) is integrated command of 7 nations and among its core capabilities is that of Strategic Aeromedical Evacuation (Strat AE). During the global COVID-19 pandemic and Ukrainian crisis, EATC has proven that only acting in concert leads to success. This is achieved by pooling and sharing aircraft and personnel, thus having privileged access to a diverse fleet and pool of experts. It is based on a common set of rules and regulations. This ensures that EATC is able to address any problem with innovation and expertise. **MATERIAL AND METHODS:** Impact of novel coronavirus and the recent Ukrainian crisis were analyzed based on numbers and characteristics of patients and executed missions within EATC during the biennium 2020-2022. **RESULTS:** 1060 COVID-19 patients were transported in 186 missions. Neither death nor disease contagion were reported during those Strat AE flights. Military cases transferred were 986, mostly routine priority (91,4 %). The other 74 cases were civilians, who were transported in 17 missions, 81,1 % of which

were categorized as urgent. 251 patients were transported during the Ukrainian crisis, 112 of which were military and 139 were civilians, including 30 children. Among the recorded injuries were cerebrocranial, abdominal and chest injuries, as well fractures of extremities (180) and amputations (48). **CONCLUSIONS:** EATC is recognized as a centre of expertise in the aeromedical evacuation domain, where interoperability and harmonization of concepts are keys for success and safety. Cross-national missions, where a patient is evacuated by an aircraft and medical crew provided by another nation, offer a maximum of flexibility. Complex situations, such as the COVID-19 pandemic and the Ukrainian crisis, have shown that multinational cooperation is the best way forward.

Learning Objectives

1. The audience will learn about the nature and participants of EATC and its core task of Strat AE.
2. The audience will learn about the challenges and advantages of cross-national Strat AE flights during the COVID-19 pandemic and Ukrainian Crisis.

[154] ENROUTE CARE PROVIDER POSTURE STUDY

Amy Lloyd[1], Rachel Kinsler[2], Kerri Caruso[1], Laura Kroening[1], Joshua Dupuy[1], Jeffery Molles[1]
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(Original Research)

INTRODUCTION: The confined space of common medical evacuation (MEDEVAC) platforms requires strenuous positions and painful postures of Critical Care Flight Paramedics (CCFPs) during patient loading and unloading. The goal of this study was to characterize the postures used to load and unload patients and compare them to known acceptable limits for preventing musculosketal disorders (MSD). **METHODS:** Subjects performed patient loading and unloading on a simulated MEDEVAC interior while motion data was collected through a reflective marker-based motion capture system. A total of ten trials were taken for each subject (five loading and five unloading). Six trials were completed on the Basic Medical Interior (BMI), and the other four trials were completed on the Interim MEDEVAC Mission Support System (IMMSS). The subject's postures were investigated to identify potentially dangerous postures that are known to lead to injury or MSD. A questionnaire was given following each loading and unloading pairing, allowing subjects to describe which factors caused the most difficult postures and document their general experience. **RESULTS:** The data from the litter pan position evaluations document was examined to identify movements or postures that cause pain or discomfort. The lower back was consistently mentioned as negatively affected by the lifting for each litter pan position; 77% of subjects reported lower back discomfort. From the motion tracking software average joint angles were found for the back, hip, and knee. Using these average angles, the compressive force was estimated for the vertebral disk between the fifth lumbar and first sacrum vertebrae for two subject load scenarios: half the manikin weight and one quarter of the manikin weight. All the values for both cases were over the safe lifting limit of 770 pounds force. **DISCUSSION:** En route care providers are reporting injuries from the painful postures resulting from loading and unloading patients in the MEDEVAC environment. All subjects mentioned at least one posture and one area of the body negatively affected. If it was assumed the subject only lifted a quarter of the manikin weight versus half, there was a reduction in the compressive force on the back by an average of 40%.

Learning Objectives

1. Understand the postures and positions that cause discomfort or pain when loading or unloading patients.
2. Understand the MEDEVAC features that can negatively affect loading and unloading of the patient.
3. Understand the areas of the medic's body that are negatively affected by loading and unloading patients.

[155] GLOBAL HEALTH INNOVATION GAP ANALYSIS: AVOIDING THE NEXT PANDEMIC

Diego M. Garcia[1], Charles A. DeJohn[2], Kris Belland[3]
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(Education - Program/Process Review)

BACKGROUND: The Public Health Public Health Emergency of International Concern (PHEIC) triggered by COVID-19 posed a heavy burden on the aerospace industry. International passenger transport played a key role in rapid virus translocation, raising questions about the effectiveness of global health security countermeasures implemented by authorities and stakeholders. A systematic review of the policies, strategies, and technology developed for the COVID-19 crisis, reflecting on the opportunities for improvement, paradigm shifts, and new technological advancements for the prevention of transmissible diseases in commercial air transport is in need. **OVERVIEW:** Although travel restrictions and border closures were enacted early in the COVID-19 crisis, a rather quick international spread of the disease was observed, followed by uncoordinated efforts by mostly unprepared states that delayed the full onset of the initial waves of the outbreak, but were insufficient for stopping its eventual global dissemination and ubiquitous presence. Unfruitful travel restrictions remained in place even after full-scale local transmission was ongoing in almost every country of the world. Then, when further improvement in diagnosis, disease treatment and immunizations concurred with the predominance of virus variants with enhanced morbidity potential (Delta and Omicron), air travel was back close to pre-pandemic numbers with record occupancy in the summer of 2022, right before a new PHEIC made appearance: Monkeypox. At risk of repeating this dystopian scenario, the policies, strategies, tools, and procedures related to global health security must be reassessed in the wake of persistent, debutant or re-emerging infectious diseases with pandemic potential. **DISCUSSION:** Observational and some scarce experimental data on the transmission dynamics of pathogens with high-reproduction number will inform a gap analysis on how to enhance existing capacities and how to bond key stakeholders around new collaborative platforms and leading-edge technology with the aim of innovating in our defense strategy against the next pandemic.

Learning Objectives

1. The audience will review the lessons learnt related to COVID-9 travel restrictions and aerospace industry policies in order to identify room for improvement and the need for collaborative and innovative approaches.
2. Attendants will learn about new technology and collaborative platforms for intersectoral participation in Public Health Emergencies of international Concern (PHEIC).

[156] INTEGRATING CIVILIAN AND MILITARY MEDICAL RESOURCES – COST-EFFECTIVE HEALTHCARE IMPROVEMENT

Russell Andrews
World Federation of Neurosurgical Societies, Los Gatos, CA, United States

(Education - Program/Process Review)

BACKGROUND: Improving global healthcare – both routine day-to-day care and mass-casualty disaster response – depends upon cost-effective programs. One-third of deaths worldwide are due to conditions requiring surgery; nearly one-half of deaths in the USA among those less than 50 years old are due to trauma, a condition requiring surgical resources. Cost-effective programs to expand surgical care are essential to improve global healthcare. In many countries military medical resources are better developed than the public civilian resources – yet the military resources are frequently underutilized. Over the past several decades in the USA there have been efforts to integrate civilian and military medical resources – primarily to improve trauma care nationwide. **OVERVIEW:** The trauma center

model addresses the need not only for surgical resources 24/7/365 but also for ancillary services such as radiology, blood bank, and laboratory that are necessary for non-surgical conditions. A trauma center closely resembles the most extensive emergency medical team facility (Type 3 Specialized Care) specified by the World Health Organization (WHO). WHO has also noted that effective response to both natural disasters and man-made mass casualty situations requires a robust and resilient local medical infrastructure: external resources (e.g. the Red Cross) that arrive days to a week or more after the event are not effective for acute surgical conditions. A prime example of civilian-military integration comes from Israel. The Israeli Defense Forces Field Hospital, combined with civilian sector healthcare resources, optimizes injury prevention, prehospital transport and care, acute care, and rehabilitation. Other examples of integration of civilian and military medical resources in Australia and Chile are considered. Civilian-military integration of technology — e.g. electronic records, telemedicine, drones — is another cost-effective way to expand healthcare. **DISCUSSION:** By combining the advanced resilient resources of the military for emergency response with the breadth and depth of the civilian healthcare system for day-to-day care, the trauma center model can be expanded into the mass casualty center model that cost-effectively augments both emergency mass casualty care and routine day-to-day care for large segments of the population.

Learning Objectives

1. The audience will learn the primary role of surgical resources for improvement in global healthcare.
2. The audience will learn the advantages of integrating civilian and military medical/surgical resources for optimizing both day-to-day and emergency mass casualty healthcare capabilities.
3. The audience will learn about technological advances that improve healthcare from both effectiveness and cost aspects.

[157] THE ROLE OF NURSE PRACTITIONERS AND PHYSICIAN ASSISTANTS IN AEROSPACE MEDICINE

Jessica Knizel[1], William Gressier[2], Scott Rhodes[3]
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(Education - Program/Process Review)

BACKGROUND: Since 2014, the AF has experienced its steepest manpower cuts in two decades resulting in marked vacancies, yet mission demands and requirements have continued to expand. This has increased and stretched the Flight Surgeon's (FS) role beyond the historical scope. Many FS vacancies are being filled by Aeromedical Physician Assistants (APA) and Aeromedical Nurse Practitioners (ANP) whose scope of practice is being limited by the Federal Aviation Administration (FAA) and AF. These limitations decrease aviator access to care for readiness and suitability examinations. **OVERVIEW:** Preparing for future conflict and facing ever-changing readiness demands require a second look at our approach to aerospace medicine. **DISCUSSION:** We will outline several peer reviewed articles with a focus on innovative remolding of the primary care team by utilizing autonomous Nurse Practitioners (NPs) and Physician Assistants (PAs). Following a True Care Team Model, with multiple providers functioning independently, improves access to care, care coordination, and enhanced communication (Chaney et al., 2022). A study of state regulations and outcomes found that restricting scope of practice did not improve quality of care (Perloff et al., 2019). Less restrictive states had 40% increased access to care for its beneficiaries (Graves et al., 2016). Over three decades of research have shown that NPs are equally as safe and effective as their physician counterparts (Geller & Swann, 2021). NPs have consistently demonstrated quality, safe, and cost effect health care in many settings (Lowery et al., 2016; RAND, 2009). The utilization of full scope NPs increases access to cost effective care (Liu et al., 2020; RAND, 2009). NP and PA visits are often 35% less expensive than their physician counterparts (RAND, 2009). The current FAA aeromedical certification process has positively shown a reduction in odds of death while holding a medical certificate. Aviators with a waiver have lower odds of an accident compared to aviators with a regular issuance (Mills & Greenhaw, 2019). Modification to the current FAA regulations and updating the AF Medical Standards Directory will allow aeromedical-trained NPs and PAs to work at their full scope of practice within the multidisciplinary team. Facilitating a change and allowing a collaborative co-sign agreement has the potential to increase access to care, improve readiness, and yield cost savings for the DoD.

Learning Objectives

1. The learner will be able to provide two examples of benefits to increasing ANP and APA autonomy in Team Aerospace.
2. The learner will be able to name the three regulating bodies discussed in the presentation.
3. The learner will be able to list three of the AF Aeromedical Provider training requirements.

[158] FACIAL BAROPARESIS MIMICS A STROKE IN A COMMERCIAL AIRLINE PASSENGER: A CASE REPORT

Azeem Ali
Emirates Group, Dubai, United Arab Emirates

(Education - Case Study)

INTRODUCTION: This case report describes a previously healthy 31-year-old male passenger on a commercial aircraft that experienced an acute unilateral facial muscle paralysis at cruising altitude with a complete resolution of symptoms shortly after the descent. **BACKGROUND:** Neurological symptoms account for up to 30% of all in-flight medical events that require ground-based medical support (GMS) services. Strokes and other suspected neurological emergencies are time-sensitive with a limited window for potential reperfusion therapies; hence they account for approximately 10-30% of all medical diversions in commercial aviation. Non-specific neurological symptoms in a previously healthy passenger require a detailed review by a GMS service before making impactful recommendations like an aircraft diversion. **CASE PRESENTATION:** The passenger was a 31-year-old male travelling from the Maldives to Dubai with no recent diving but had a sinus problem during the vacation. Our in-house GMS service managed this case with an acute and evolving right facial numbness that also involved his tongue and buccal area. This started approximately 2 hours before landing at a cruising altitude of 39,000 feet. A physician medical volunteer on board assisted and found that he had non-specific neurological symptoms with a suspected stroke or bell's palsy. With continuous observation and no medication, he had a complete resolution of symptoms with a decrease in altitude during landing. Further medical evaluation at the airport medical services found no signs/symptoms of a neurological emergency, with a likely diagnosis of facial baroparesis. No follow-up was required. **DISCUSSION:** Facial baroparesis is a seventh cranial nerve palsy caused by transient hypoxemia of the facial nerve due to increased pressure in the middle ear cavity. Symptoms mimic a stroke, Bell's palsy, air embolism, or Type II decompression sickness. It is under-reported because of its transient nature and single episodes despite recurrent exposure to similar flight or diving conditions. This case highlights the awareness of the physicians involved that resulted in no unnecessary recommendations to divert the aircraft or the requirement for inappropriate investigations by the medical services on the ground. Eliciting an accurate history together with symptoms that resolved shortly after equalization of the middle ear and ambient pressure will lend itself to an accurate diagnosis.

Learning Objectives

1. Participants will be more aware of facial baroparesis as a differential diagnosis for transient unilateral facial numbness. This awareness may prevent unnecessary aircraft diversion recommendations, inappropriate investigations at hospitals or revocation of diving/aviation medical certification.
2. The audience will learn that facial baroparesis is an under-recognised condition that can mimic a stroke, Bell's palsy and other neurological medical conditions.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon C3

[S-30]: PANEL: DOES AEROMEDICAL SCIENCE SUPPORTS THE USE OF UV-C LIGHTING TO REDUCE DISEASE TRANSMISSION / TRANSLOCATION ABOARD AIRCRAFT

Chair: Charles DeJohn

PANEL OVERVIEW: *Ultraviolet Germicidal Irradiation (UVGI) air disinfection is nearly 100 years old. UVGI was widely uised in hospitals and public places to reduce infections by inactivating airborne pathenogens in the 1930's through the 1950's. The SARS-Cov-2 pandemic has led to a resurgence of interest in the research and development of UVGI air disinfection, leading to the development of practical Light Emitting Diode (LED) systems showing promise for use in aircraft. Although questions of efficacy and safety of UVGI as a control measure have been raised, the use of far-UV-C wavelength has led to a reexamination of UV technology and Threshold Limit Values (TLV's) have been revised. Innovative designs and improved procedures have been implemented to improve the safety and efficacy of today's UVGI systems. This panel will examine the safey and efficacy of using direct, continuous UV-C irradiation of occupied cabins of commercial aircraft cabins inflight.*

[159] EMERGING AVIATION MULTI-LAYERED DISEASE DEFENSE STRATEGY (AMLDDS), ULTRAVIOLET (UV-C)

Kris Belland
Aerospace Medical Association, Alexandria, VA, United States

(Education - Program/Process Review)

BACKGROUND: Worldwide aviation has been greatly and negatively impacted by the COVID-19 pandemic. Right from the outset, organizations, businesses, and individuals within the aviation industries have faced unique and complex challenges. As the pandemic evolved, so did knowledge, attitudes, and expectations. Controversy has not been rare, especially around the relative weight of preventive measures, creating unique opportunities for learning. In this presentation, the author will provide an Systematic Review / Meta analysis overview and update to the Aviation Multi-Layered Disease Defense Strategy (AMLDDS) and discuss Emerging risk-mitigations (application of Reason Swiss Cheese Theory to inflight disease transmission / translocation). Strategies will include current and emerging technologies to include use of airborne Ultraviolet (UV-C) irradiation. **OVERVIEW:** The author served as the AsMA representative to the International Civil Aviation Organization (ICAO) and Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) during the last three years of the COVID-19 pandemic and has formed a unique perspective and best business practices. Contingency planning has had to adapt constantly. Procedures have been assessed, reassessed, implemented and made more robust, which may serve the aviation community well in years to come. Emerging layers of disease risk mitigation protection including the use of UV-C at safe levels and how they can reduce translocation and transmission of disease in flight will be discussed. **DISCUSSION:** After a thorough systematic review of subject publications and in anticipation of publishing a systematic review / meta analysis in the AsMA Blue Journal, the author will discuss existing and emerging infectious diseases risk mitigation strategies critical to aviation - COVID-19 and beyond, and will provide an overview and update to the AMLDDS and discuss Emerging risk-mitigation (evolutionary application of James Reason, Swiss Cheese Model / Theory which was successfully adapted to international COVID-19 pandemic response by ICAO and CAPSCA. Lessons learned and emerging technologies will continue reduce inflight disease transmission / translocation of disease and enhance future pandemic responses. New advanced technology strategies including airborne use of Ultraviolet (UV-C) will be discussed.

Learning Objectives

1. Understand Reason Swiss Cheese Model of risk mitigation and risk reduction in order to mitigate disease transmission and translocation in flight.
2. Ultraviolet - "C" utilization in flight, commercial, military and space to reduce disease burden, translocation and transmission.

[160] SAFETY ASPECTS OF GERMICIDAL ULTRAVIOLET RADIATION

David Sliney
Johns Hopkins University Bloomberg School of Public Health, Fallston, MD, United States

(Education - Program/Process Review)

Germicidal UV (GUV) – or ultraviolet germicidal irradiation (UVGI) – dates back more than a century and was widely used in hospitals and public places to reduce infections by inactivating airborne parthenogens in the 1930s – 1950s. With the outbreak of COVID-19, questions of efficacy and safety of UVGI as a control measure appeared and optical safety experts were questioned on this. At that time, most experience with UVGI had largely been limited to TB clinics – particularly in some developing countries where some expertise on this technology had been retained. Sadly, misconceptions about GUV, such as a perceived skin cancer risks remained and a lack of understanding of proper safety precautions continue to slow the wide acceptance of UVGI in North America and Europe. The COVID-19 pandemic greatly accelerated development of traditional UV-C lamps and new lamp types such as UV LEDs the krypton-chloride (222-nm) lamp to augment the traditional use of low-pressure mercury (254 nm) lamps. Accidental exposure of skin and eyes if GUV is poorly installed GUV had resulted in transient effects of the skin and eyes leading to real safety concern. The cornea is the most sensitive tissue to UV-C irritation: this is a transient injury – photokeratitis ("welder's flash," or "snow-blindness") – with symptoms of "sand in the eyes." Erythema – reddening of the skin– is mild from the very superficially penetrating UV-C. The delayed effects, such as skin cancer raise the greatest concern, but it is the UV-B in sunlight that penetrates to the basal (germinative) layer of the epidermis and is the recognized cause of most skin cancer. The "far UV-C" wavelengths (e.g., 222 nm) are even more heavily absorbed in the superficial epidermis & stratum corneum than longer UV-C wavelengths greater than ~ 230 nm, with the result that guidelines for human exposure can be much less restrictive below 230-240 nm. For this reason, whole-room, far-UV-C GUV became practicable. The use of the new, far-UV-C wavelengths led to a reexamination of UV TLVs and these have now been revised. Instead of shifting wavelength, manipulation of the geometry of exposure has been shown particularly effective with UV LEDs.

Learning Objectives

1. The audience will learn about the potential for acute-injury hazards to the eye (photokeratitis) and skin (erythema) from inappropriately installed germicidal ultraviolet UV-C lamps.
2. The audience will learn that not all ultraviolet exposures pose a real risk of skin cancer, the actual spectral band is critically important. Because UV-C (100 - 280 nm) has very shallow penetration the photocarcinogenic risk is less than 1 % of that from UV-B (280-315 nm) wavelengths in sunlight.
3. The participants will learn to distinguish between the levels of safety afforded by newer germicidal lamp systems that emit at shorter UV-C wavelengths compared to the traditional mercury-lamp systems when requested to provide judgements on the choice of differing germicidal ultraviolet systems.

[162] THE SAFE AND EFFECTIVE APPLICATION OF GERMICIDAL UV AIR DISINFECTION – A 40 YEAR EXPERIENCE

Edward Nardell
Harvard Medical School and Harvard TH Chan School of Public Health, Boston, MA, United States

(Education - Tutorial/Review)

Germicidal UV (GUV) air disinfection technology is nearly 100 years old. In the 1930s It was proven to reduce measles transmission in schools in suburban Philadelphia. Early public health practitioners envisioned making indoor free from seasonal airborne infections just as water treatment virtually eliminated water-borne infections. But indoor air cannot be centrally disinfected like water, and the advent of antibiotics and vaccines promised to eradicate respiratory infections, eliminating the need to further develop the technology. Until a resurgence of TB in the US from 1985-1992 upper room UV was uncommonly used, but TB transmission in homeless shelters, hospitals, AIDS treatment facilities resulted in a resurgence of interest and research. In 2009, NIOSH published guidelines for safe and effective upper room UV air disinfection. As the TB officer for Boston and Massachusetts, I was instrumental in an installation of upper room UV to prevent TB transmission in homeless shelters, jails, prisons, hospitals, and other congregate setting around the US. A controlled nationwide study in homeless shelters demonstrated no more eye or skin complaints when active fixtures were in use than in the same shelters under placebo conditions. A published personal UV dose monitoring study showed that room occupants receive a fraction of threshold limit value dose. An experimental hospital in South Africa demonstrated that 80% less airborne infection was transmitted from infectious TB patients to highly susceptible Guinea Pigs breathing ward air on days when upper room UV fixtures were on in their rooms. The dose specifications used in those experiments is the basis for upper room UV air disinfection dosing recommendations about to be issued by ASHRAE. Numerous published bioaerosol chamber studies using a variety of surrogate test organisms have further refined the scientific basis for the safety and efficacy of upper room GUV. The SARS-CoV-2 pandemic has again led to a resurgence of interest, development, and research on GUV air disinfection, leading to the development of practical LED and 222 nm excimer lamps, with advantages and disadvantages compared to conventional mercury based 254 nm GUV sources.

Learning Objectives

1. The participant will understand the history and current safe and effective use of germicidal ultraviolet (GUV) air disinfection, and recent technical developments such as LED-UV and FAR-UV in its application against SARS-CoV-2 and future airborne pathogens.
2. The participant will understand why germicidal UV is the most effective and cost-effective method of air disinfection for many applications compared to mechanical ventilation and air filtration.
3. Participants will understand that GUV efficacy and safety are based on the ability of UVC to penetrate airborne microbes whereas penetration of the exposed human cornea and skin is limited by confining energy to the upper room in the case of upper room GUV, and by the use of low-penetration 222 nm UV in the case of FAR-UV.

[163] CONTINUOUS DISINFECTION OF CABIN AIR USING SAFE AND CONTROLLED LEVELS OF ULTRAVIOLET LIGHT

Gary Allen
Princeton University, Euclid, OH, United States

(Education - Program/Process Review)

BACKGROUND: Ventilation in commercial aircraft is very good, but not good enough to prevent airborne transmission of disease in a cabin densely packed with passengers. Additional risk mitigation is required, such as wearing masks, which is not popular. Disinfection of the air with safe levels of ultraviolet (UV) light augments, or may surpass, the air disinfection efficacy of aircraft ventilation. **DESCRIPTION:** Using safe levels of UV can contribute significantly to a multi-layered risk mitigation strategy to reduce transmission of airborne diseases in aircraft. Transmission of SARS-CoV-2, Influenza, and other airborne pathogens appears to be primarily via aerosols, not droplets or surface contamination. Air disinfection can be accomplished either by replacing contaminated air with fresh air (ventilation) or by inactivating airborne pathogens in the air without replacing the air (e.g., UV). The air disinfection rate is quantified in Air Changes per Hour (ACH). Typical ventilation rates in aircraft are 10-35 ACH, compared to 1-10 ACH in terrestrial settings. UV disinfection rates in aircraft are expected to be 20-50 ACH_{eq}. The risk of infection is proportional to the density of passengers (pax/m^3) divided by ACH. The extremely high pax density in aircraft cabins drives the risk of infection to exceed that in most other settings, so that aircraft ventilation should be augmented by other risk mitigants, e.g., UV. UV levels safe for human occupancy inactivate 90% of SARS-CoV-2, Influenza, Colds, pneumonia, etc., in 10-30 minutes. Rapid improvements in UV technology will soon provide 100-200 ACH_{eq} at safe levels, and inactivation times of 2-6 minutes. We will explain the allowed Exposure Limit vs. wavelength of light for skin and eyes, demonstrating that UV exposure to pax on an 8-hour flight is equivalent to less than 5 minutes of sunshine. **DISCUSSION:** UV disinfection of air in the cabin of military and civilian aircraft may increase the confidence and wellness of passengers, may reduce crew absences due to illness, and may help to mitigate outbreaks of coronavirus, Influenza, colds, TB, and other airborne diseases in military and general populations.

Learning Objectives

1. The audience will be introduced to a new technology for disinfection of air in an aircraft cabin using levels of ultraviolet light that are safe in occupied spaces, and several reasons why existing aircraft ventilation systems are insufficient and should be augmented by UV disinfection.
2. The participant will learn how to quantify the efficacy of ventilation and UV systems for mitigating the risk of infection by airborne pathogens such as SARS-CoV-2, Influenza, colds, pneumonia, and how ventilation and UV additively contribute to a multi-layer disease defense strategy in aircraft.
3. The participant will learn how the rapidly emerging technology of UV-C LEDs promises to enhance the efficacy of UV air disinfection by about 10x over the next few years, such that UV disinfection may soon become the dominant risk mitigant for airborne disease transmission in aircraft.

[161] OPTIMIZING DESTRUCTION OF AEROSOLIZED-PATHOGENS USING MODERN ELECTRONIC TECHNIQUES

Stephen Glaudel
Syracuse University, Syracuse NY, United States; St. Joseph's University, Philadelphia, PA, United States

(Education - Program/Process Review)

BACKGROUND: The recent Covid-19 pandemic (more prior, will be more to come) impacted virtually all aspects of our lives. We have seen over 1m lives lost (just in USA), many more hospitalized, and countless more impacted more subtly. Fear and Restrictions have severely impacted many livelihoods, especially in places where people aggregate. Businesses have suffered in many ways: customers & employees lost, sick-time, resignations, work-patterns permanently changed (e.g. telecommuting), etc. When we look more closely, epidemics have been here all along: E.g. Influenza typically kills 'only' 40k people annually in USA alone (we become 'numb' to this); Young children with RSV hit the news; Measles rebounds; ad-nauseum. We in USA, and around the world, need to deal with disease-prevention more diligently, utilizing ALL Tools provided by modern Science & Technology. **OVERVIEW:** The author has educational background in Engineering, Biology, and Business, with 48+ years experience in development & applications of Electronic Control-Systems in multiple Industries (Semiconductor-Fabs/Tools, BioTech/Pharma, Power-Gen, Water-Treatment, Metals, Oil&Gas, ...) and has managed teams globally (traveling to over 100 countries). Air travel has been sorely impacted by the above Epidemiological / Societal issues. We herein discuss emerging layers of disease risk mitigation in aircraft, including use of Ultraviolet-light at safe Irradiance levels, with 'Intelligent' dosing & direction, and how that can reduce transmission of disease in flight. **DISCUSSION:** Aerosolized Pathogens pose a large & growing risk: Epidemics have become Pandemics. Difficulties in prevention arise from the simple fact that infected Humans exhale those aerosols in close proximity to Humans inhaling those aerosols. Thus, episodic-cleaning is ineffective; preventive treatments must be provided continually & safely, where & while Humans are present for hours.

"Swiss-Cheese" models (multiple protection layers) include: Vaccines, Masks, HVAC, and now Ultraviolet Irradiance. Advanced technology & control-strategies are available (versus large/older ?fluorescent tubes?), to provide broad-spectrum disinfection (viricidal/bactericidal), including rapidly growing availability of UV-C LEDs (Light-Emitting Diodes: low-power, small-size, low-cost) controlled by simple Electronics that deal with adjusting & directing that Irradiance to where these pathogens can best be eliminated: the Air in-between the passengers.

Learning Objectives

1. The audience will learn more of the practical applications of Ultraviolet light to Disinfection: its benefits, limitations, and the selection of auxiliary componentry to ensure Safety and Efficacy in an Aircraft application.
2. The audience will learn about Safety & Efficacy different wavelengths of light.
3. The audience will learn about selection of different sources of Ultraviolet light.

Tuesday, 05/23/2023 ***10:30 AM***
Nottoway & Oak Alley

[S-31]: PANEL: GERMANY'S HOT TOPICS IN AEROSPACE MEDICINE

Sponsored by German Society of Aerospace Medicine (DGLRM)

Chair: Jens Jordan
Co-Chair: Torsten Pippig

PANEL OVERVIEW*: This session provides different hot topics of the last year in Aerospace Medicine. The session language is Germa; slides are presented in English.*

[164] CARDIOVASCULAR TOLERANCE TO GRAVITATIONAL STRESS FOM ASTRONAUTS TO PATIENTS WITH ORTHOSTATIC INTOLERANCE

Jens Jordan
German Aerospace Center (DLR) and University of Cologne, Cologne, Germany

(Education - Program/Process Review)

The ability of the cardiovascular system to cope with gravitational stress is crucial for astronauts returning to Earth or setting foot on another celestial body, for fighter pilots, and for patients with orthostatic intolerance. Ultimately, tolerance to gravitational stress is determined by the magnitude of the hemodynamic stress and counterregulatory mechanisms, particularly baroreflex-mediated changes in autonomic nervous system activity. I will introduce novel methodologies to assess these mechanisms in human beings. Combining lower body negative pressure with physiological monitoring and cardiac real-time magnetic resonance imaging provides unobtrusive insight in hemodynamic responses to simulated standing. High-resolution functional resonance imaging combined with physiological or pharmacological challenges can be applied to elucidate baroreflex mechanisms at the level of the brainstem. Previously, brainstem mechanisms have only been accessible in animal studies. Finally, I will present findings from recent head-down bedrest studies testing artificial gravity through short-arm centrifugation and prolonged daily lower body negative pressure as potential countermeasures for spaceflight. In addition to enabling human spaceflight, such studies may have applications for patients prone to orthostatic intolerance on Earth.

Learning Objectives

1. Novel technologies to assess mechanisms affecting cardiovascular tolerance to gravitational stress.
2. The talk introduces currently tested countermeasures for astronauts, such as artificial gravity.

[165] PREDICTION OF FATAL OUTCOMES IN GERMAN GA ACCIDENTS BY USING A SCORING SYSTEM TO FACILITATE ADEQUATE RESPONSE OF EMERGENCY CONTROL CENTRES

Felix Liebold, Katharina Hippler, Jochen Hinkelbein, Jan Schmitz, Volker Schick, Markus Rothschild
University Hospital-Cologne, Cologne, Germany

(Original Research)

BACKGROUND: Whereas only few accidents are documented for large aircrafts, numerous accidents occur with small aircrafts every year. However, prediction of survival or death is impossible so far. The current study aims to identify significant factors elementary to predict survival or death of occupants after General Aviation aircraft accidents using a scoring system which can then be implemented in emergency control centres for improving future aviation safety. **MATERIAL AND METHODS:** Data of flight accidents over a 20-year period (extracted from the German Federal Bureau of Aircraft Accident Investigation [BFU] webpage) was analysed for fixed-wing motorized small aircrafts. Various factors of interest were analysed. Correlation tests were performed using Chi^2- and Mann-Whitney-U-Tests. Logistic regression was used to create a score to calculate the probability of a fatal outcome after an aircraft accident. **RESULTS:** The BFU lists 1,595 aircraft accidents between 2000 and 2019. The influencing factors "Last quarter of the year" ($p=0.002$), "fire" ($p<0.0001$), "distance away from airport > 10 km" ($p<0.0001$), "landing" ($p<0.0001$) and "cruise" ($p<0.0001$), significantly correlated with a fatal outcome. "Take-off", "approach", "month", "day of the week", "persons on bord above three", "night-time" and "icing conditions" showed no significant correlation. Using logistic regression "cruise" was excluded when using the B-STEP Method. Including the four significant parameters, the score showed a strong effect with $f^2=0.709$. **DISCUSSION:** The implementation of a score in the rescue coordination centre in the context of digital development and artificial intelligence can contribute to provide the best possible emergency aid in the event of a small aircraft crash.

Learning Objectives

1. The audience will learn about how the development of a scoring system to predict the outcome of aircraft accidents can improve the EMS response chain and thus ensure better emergency management for aviation accident victims.
2. The participant will be able to understand the distribution of severity and outcome of small aircraft accidents in Germany.

[166] UNFIT TO FLY. WHAT'S NEXT? AEROMEDICAL WAIVER.

Torsten Pippig
Zentrum Luft- und Raumfahrtmedizin der Luftwaffe, Koeln, Germany

(Original Research)

INTRODUCTION: Military pilots and crew, as well as the entire Air Force personnel involved in flight operations, are exposed to high physical stress. Therefore, for all personnel an initial aeromedical examination is performed, and regular follow-up examinations of the musculo-skeletal system are conducted. Any congenital or acquired changes to the musculo-skeletal system that limit operability and mission capability, preclude service as a pilot, crew member or air traffic controller. As a consequence, it may happen that highly experienced personnel are rejected from service due to minor physical conditions. Within the framework of an aeromedical waiver, it can be evaluated and decided on a case-by-case basis whether service can be permitted with or without restriction. **METHODS:** Between 1.1.2012 and 31.12.2021, approx 3,000 per anum people were examined and assessed annually in the Dept of Orthopaedics and Anthropometry. During this period, 369 applicants and active military personnel applied for an aeromedical waiver. At a young age, congenital changes in the musculoskeletal system (scoliosis, spondylolysis/spondylolisthesis, Scheuermann's disease, transition vertebrae) are the most common reasons, in middle age (up to the age of 50), trauma and consequences, rheumatic diseases, soft

disc diseases, and in old age osteoarthritis, spinal stenosis, spondylodesis, artificial joints, and gout. The medical reasons, gender, age, use, waiver, and potential restrictions are evaluated. Important, are the function and load capacity of the joint and the spine, the prognosis of the disease, the requirements and hazards in the aircraft, the flight order. The decision-making process is explained with several examples (jet pilot after hip endoprosthesis, helicopter pilot after cervical spondylodesis, helicopter pilot with psoriasis arthropathy). **RESULTS:** A total 369 cases that applied for an aeromedical waiver were included. These consisted of 227 aircrew (138 recruit applicants, 30 pilots, 47 crew members) and 142 ground staff. The average age was 29.3 years. In 28 cases, an aeromedical waiver was refused. Of the 227 air crews examined, 162 were subject to service restrictions. **SUMMARY:** An aeromedical waiver is valuable to maintain operational capability. It is always a case-by-case decision considering arguments in favor an against it. In many cases, a restriction in the waiver allows personnel to stay mission capable, despite minor physical limitations.

Learning Objectives

1. The audience will learn about aeromedical waiver decision in case of disorders of musculoskeletal system.
2. The audience will learn about significant musculo-skeletal disorders and military flying fitness.
3. Waiver and aeromedical limitations.

[167] WAIVER RESULTS (REFERRALS) FOR CLASS 3 MEDICALS IN GERMANY 2017 - 2021

Ulrich Werner
German Military Aviation Authority, Cologne, Germany

(Education - Program/Process Review)

BACKGROUND: Within the European Union (EU) aviation has a single regulatory framework. Aviation Medicine is documented in Commission Regulation (EU) No 1178/2011. Additionally, specifics for Class 3 Medicals (Air Traffic Controllers) are documented in Commission Regulation (EU) 2015/340. If an applicant does not fulfill the medical requirements, the Aeromedical Examiner (AME) must forward the case for referral (Class 1 and 3) or consultation (Class 2) to the Competent Authority of the EU member state. The technical term waiver is not used in EU legislation, but referral. The Competent Authority (CA) has a medical department and employs Medical Assessors (MA). With regard to air traffic controllers, the German competent authority is the Federal Supervisory Authority for Air Navigation Services (BAF). The CA and it´s MA are the waiver authority for aeromedical decision making. This presentation depicts the German competent authority's experience and results of referrals for Class 3 medicals over the 5-year period from 2017 to 2021. **OVERVIEW:** There are about 1700 Class 3 medical examinations in Germany every year. On average 30 referrals were forwarded to the CA by the AMEs annually, which correlates to 1.8% of each year's examinations. 88% of all referrals ended with a positive aeromedical decision. The 3 most affected medical domains for referrals were visual system incl. colour vision (29%), cardiovascular (17%) and, with equal magnitude, psychiatry and neurology (10% each). The 3 most affected medical domains with negative decisions were neurology (28%), visual system (22%) and otorhinolaryngology (17%). Of those negative decisions, no case was disputed by the applicant. **DISCUSSION:** Waiver decisions or referrals represent a high-level discipline in aviation medicine decision making. With regard to the low number of cases, it requires a relatively high amount of working capacity. Medical Assessors themselves take specialist advice for sound decisions. Notwithstanding the required responsibility and difficulties for those decisions, it represents an interesting focal point of aeromedical work.

Learning Objectives

1. The audience will learn about the waiver results of Class 3 aeromedical examinations.
2. The participant will be able to assess the impact of the waiver process to the workload of a medical department of an aviation authority.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Ballroom A-B-C

[S-32]: PANEL: NASA EXPLORATION ATMOSPHERE - THE PATH TO THE MOON AND MARS

Chair: Alejandro Garbino

PANEL OVERVIEW: NASA's Moon to Mars exploration architecture, as well as the emerging commercial LEO market that NASA is helping foster, will involve multiple different crew capsules, orbital habitats, transit habitats, landers, surface habitats, pressurized rovers, IVA spacesuits and EVA spacesuits. The selection of atmospheres (i.e., operating pressures and constituent gases) for each of these elements is a complex trade between hypoxia, flammability, crew time, crew workload/fatigue, consumables, ECLSS efficiency, vehicle inter-operability, and decompression sickness risk. NASA has been trading various 'Exploration Atmospheres' - pressure/O2 combinations that maximize EVA operations. In 2022, NASA performed a series of chamber tests at 56.kPa (8.2psi) and 34% O2 atmosphere, culminating in an 8-crew, 11-day chamber run testing the effectiveness in controlling DCS, as well as characterizing the hypoxic stress of living in a low-pressure environment.

[168] HABITABILITY ASSESSMENTS AND LESSONS-LEARNED FROM 3-DAY AND 11-DAY ENRICHED OXYGEN HYPOBARIC CHAMBER TESTS AT NASA JOHNSON SPACE CENTER

Andrew Abercromby[1], Lichar Dillon[2], Monica Hew[3], Patrick Estep[4], Karina Marshall-Goebel[5], Alejandro Garbino[4]
[1]*NASA Ames Research Center, Houston, TX, United States;* [2]*NASA and UTMB, Houston, TX, United States;* [3]*NASA and KBR, Houston, TX, United States;* [4]*NASA/GeoControl Systems, Houston, TX, United States;* [5]*NASA JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Decompression sickness (DCS) is a risk to the health and performance of astronauts and high-altitude aircrew. Tolerance to flammability, hypoxia, prebreathe duration, and DCS risk varies across different organizations, vehicles, suits, and destinations, necessitating a variety of DCS risk mitigation approaches. Existing models of altitude DCS risk are often insufficient to enable accurate risk-informed decisions during hardware development, mission planning, and flight operations. **METHODS:** NASA completed outfitting of a dedicated facility at Johnson Space Center to support testing of up to eight human subjects for multiple days in hypobaric and enriched oxygen atmospheres. The primary purpose of the testing capability is validation of DCS risk mitigation protocols for Artemis missions to the Moon; however, it will also support development and validation of a generalizable altitude DCS risk estimation tool. A 3-day and an 11-day prebreathe validation test were completed in 2022, each with 8 human subjects living at 56.5 kPa (8.2 psia), 34% O2, 66% N2, with 6 simulated EVAs performed on masks at 29.6 kPa (4.3 psi), 85% O2, 15% N2. Facility and organizational lessons-learned and process improvements were recorded during and following the tests, and subjective habitability ratings were recorded daily during the 11-day test. Hypoxia and DCS-related physiological and cognitive outcome measures were recorded during both tests and are reported in companion presentations.

RESULTS & DISCUSSION: All subjects completed each of the tests. Primary habitability issues related to mask discomfort during simulated EVAs and poor sleep quality due to thin mattresses. Polybenzimidazole (PBI) clothing was worn by all subjects due to the increased fire risk and may be required for Artemis missions; clothing was found to be acceptable overall with the worst ratings being due to poor fit and inelasticity. Chamber O2 and CO2 sensor inconsistency was observed that did not result in test termination but required post-test follow-up. Forward

plans include additional hypobaric testing and integration of existing and future physiological outcome data into an open-source Aerospace Estimation Tool for Hypobaric Exposure Risk (AETHER). NASA is also working to make the testing capability available to commercial companies.

Learning Objectives

1. The audience will learn about NASA's recent altitude chamber testing operations, including multi-day high altitude chamber tests.
2. The audience will learn about NASA's plans to develop and operationalize DCS and hypoxia models to support spaceflight and high-altitude operations.

[169] EVALUATION OF PLANETARY EXTRAVEHICULAR ACTIVITY PREBREATHE PROTOCOLS USING A 56.5 KPA/34% O2 CABIN ATMOSPHERE IN AN 11-DAY HYPOBARIC HYPOXIA STUDY

Alejandro Garbino[1], Lichar Dillon[2], Patrick Estep[1], Monica Hew[3], Karina Marshall-Goebel[4], Jason Norcross[3], Kadambari Suri[3], Andrew Abercromby[5]

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(Original Research)

INTRODUCTION: Apollo missions used 100% O2 cabin atmospheres which effectively eliminated the risk of decompression sickness (DCS) during Lunar extravehicular activities (EVAs, 'spacewalks'); however, this atmosphere presented a flammability risk that is no longer acceptable to NASA. Denitrogenation prebreathe protocols used to mitigate DCS risk for Space Shuttle and International Space Station EVAs are validated for the microgravity environment, but the significantly increased risk of DCS during equivalent ambulatory surface EVAs make these protocols inapplicable to planetary/Lunar missions. A cabin/vehicle "Exploration Atmosphere" of 56.5 kPa (8.2 psia), 34% O2, 66% N2 has been recommended by NASA for future Moon and Mars missions as a compromise that balances subsequent pre-EVA prebreathe duration, hypoxia, and flammability risk, assuming a 29.6 kPa (4.3 psi) spacesuit. Prebreathe validation studies were initiated utilizing a three-story 6m diameter hypobaric chamber at NASA's Johnson Space Center. Here, we report the results of a 11-day human-in-the-loop system checkout. **METHODS:** Six volunteers lived in a hyboparic chamber for 11 days with an 'exploration atmosphere' of 56.6kPa/34% O2 66% N2. Subjects acclimated to the exploration atmosphere for 48 hrs and thereafter participated in five 6-hour simulated EVAs at 34kPa/85% O2 / 15% N2 over the course of 11 days. Prior to each simulated EVA, subjects underwent a 20-minute prebreathe at 85% O2. The EVA simulation was designed to include tasks that are physically and ergonomically representative of future planetary EVAs, proportionate to the subject's VO2max. Decompression stress was evaluated during the simulated EVA by serial doppler and echocardiographs alternating every 15 min, as well as clinical monitoring for DCS signs/symptoms. **RESULTS AND DISCUSSION:** Venous gas emboli (VGE) were present in 3 of 6 subjects during EVAs, with peak Grade II VGE as evaluated by Doppler and a peak Eftedal-Brubakk score of 5 by cardiac ultrasonography. Two cases of DCS were diagnosed during the 11-day test chamber. No acute hypoxic symptoms were noted. Musculoskeletal and gastrointestinal complaints were noted, likely associated with the exercise load and the food system. Two cases of DCS (8%) does not cross either accept or reject pre-test criterion, so an additional study is planned for 2023 to meet our pre-test thresholds.

Learning Objectives

1. The audience will learn about the NASA Decompression algorithms and their applicability to EVA operations on Artemis/Moon
2. The audience will learn about decompression diagnosis and treatment methods available for crew and for ground testing operations.

[170] IMPACTS OF A NOVEL EVA PREBREATHE PROTOCOL ON BEHAVIORAL HEALTH AND PERFORMANCE OUTCOMES AMONG ASTRONAUT SURROGATES

Steven Anderson[1], Alexa Doerr[1], Sheena Dev[1], Bruce Keller[2], Alaa Khader[2], Jennifer Miller[2], Suzanne Bell[3]

[1]*KBR Inc., Houston, TX, United States;* [2]*JES Tech, Houston, TX, United States;* [3]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: Decompression Sickness (DCS) is a risk during spaceflight extravehicular activities (EVAs). The current study aimed to validate modeling efforts for a short (15-20 minute) prebreathe protocol while adequately mitigating risk of DCS. We examined effects of exposure to the hypobaric hypoxic environment on behavioral health and performance. **METHODS:** 8 astronaut surrogates (mean age: 35.70, SD = 4.27, 50% female) spent 11 days in a chamber at NASA Johnson Space Center (JSC) where they were exposed to an atmosphere consisting of lower pressure (8.2 psia) and higher O2 (34%), controlling physiologic levels of N2. Data were collected on participants' cognitive performance, operational performance, and self-reported behavioral health. Cognitive performance was collected via a computerized battery of 10 cognitive tasks. Operational performance was measured by ROBoT-r (robotics onboard trainer for research), a task that simulates capture and grappling maneuvers required for astronauts operating the Canadarm2 robotic arm on the ISS. Demographics, fatigue, energy, and mood were collected via self-report surveys. **RESULTS:** Cognition results were consistent with data collected in previous analog studies without the exposure to the hypobaric hypoxic environment. There were small improvements or stabilization in speed and accuracy over time for most subtests. Performance on many Cognition subtests showed greater consistency during the 11-day test compared to pre- or post-test phases. Similar to findings in previous analog studies, ROBoT-r results suggested improved performance across the 11-day test for accuracy and overall performance. However, unlike previous analog studies, ROBoT-r response times remained stable (i.e, no improvement). Survey results indicated that participants reported less energy on the days that they conducted EVAs. Fluctuations in mood were reported by some participants early in the 11-day test, possibly due to a conflict between crew members. **DISCUSSION:** Results were consistent with trends observed from data in other NASA spaceflight analog environments (e.g., HERA) except for response times on the ROBoT-r task. Limitations include the small sample size and no control group. However, initial findings suggest that the tested short-term prebreathe protocol and hypobaric hypoxic environment is unlikely to negatively affect behavioral health and performance.

Learning Objectives

1. [The audience will learn about...] the effects of a prebreathe protocol and hypobaric hypoxic environment on behavioral health and performance.
2. [The participant will be able to…] understand how the effects of a hypobaric and hypoxic environment impact cognitive and operational performance in astronaut surrogates.

[171] APPETITE AND FOOD INTAKE DURING 11 DAYS OF MILD HYPOBARIC HYPOXIA

Lichar Dillon[1,4], Grace Douglas[2], Holly Dlouhy[1], Patrick Estep[3], Patti Gillman[1], Monica Hew[1], Robert Howard[2], Thomas Oswald[1], Susan Rapley[1], Sara Zwart[4], Alex Garbino[3]

[1]*KBR, Houston, TX, United States;* [2]*NASA, Houston, TX, United States;* [3]*GeoControl Systems, Houston, TX, United States;* [4]*UTMB, Galveston, TX, United States*

(Original Research)

INTRODUCTION: Reduced food consumption and loss of body mass have been observed during spaceflight. Hypoxic conditions that

astronauts may encounter on exploration missions may further implicate satiety signals and dietary intake. Appetite, food intake, and satiety hormones were investigated under conditions of mild hypoxia and simulated extravehicular activity (EVA). **METHODS:** Artemis-like food was packed for each subject based on estimated energy requirements for the 11-day test. Only room temperature water was available to rehydrate food and beverages in-mission. Measures included food records; fasted body weight; Dual-energy X-ray absorptiometry (DXA); crew feedback; and fasted blood levels of ghrelin and leptin. **RESULTS:** On average, subjects consumed 341 calories less on EVA days compared to non-EVA days in-mission (p=0.0511). Total weight loss from weight measurements (-1.1 kg, p=0.0028) is consistent with underconsumption and supported by DXA measurements (-1.3 kg total body mass, p=0.0123 and -1.6 kg fat mass, p=0.0016). Most foods that were consumed were given acceptable scores. Comments indicated that the most acceptable foods were those not intended to be heated. Comments also indicated that subjects found their favorite foods early in the mission and avoided the foods that they did not like throughout the mission. Habitability scores indicated that overall aspects of the food system were considered borderline or unacceptable over the length of this mission. Foods that caused gas were avoided pre-EVA to prevent discomfort during pressure changes. Average fruit and vegetable intake decreased from 4.8 servings/d pre-mission to 3.4 servings/d on non-EVA days (p=0.0872) and 2.3 servings on EVA days (p=0.0020). Fasting ghrelin was lower pre-EVA and on non-EVA days when exposed to mild hypoxia compared to normoxic conditions pre-mission and post-EVA (p=0.0136). Fasting levels of leptin did not change. **DISCUSSION:** Food intake declined in-mission, resulting in a caloric deficit and weight loss for most subjects. Appetite ratings and crew comments indicated this was due to a combination of limitations in food choices, preparation capability, time, and physiological challenges with the changing pressure. The regulation of appetite stimulating hormone ghrelin, but not the appetite suppressor leptin, appeared to be sensitive to hypoxic conditions. Results demonstrate the importance of scheduling ample recovery time between EVA days.

Learning Objectives

1. The audience will learn about the effects of mild hypoxia on appetite and food intake.
2. The audience will learn about the effects of mild hypoxia on hormonal regulators of appetite.

[172] MEDICAL LESSONS LEARNED FROM THE EXPLORATION ATMOSPHERES STUDY

Robert Sanders[1], Kristi Ray[2], Jennifer Law[2]
[1]*NASA JSC, Houston, TX, United States;* [2]*UTMB, Galveston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The National Aeronautics and Space Administration's (NASA) Exploration Atmospheres study (EA) was done to evaluate alternative cabin atmospheres for future spacecraft designs and planetary surface exploration of the Moon, Mars, and beyond. Deep space exploration involves creating habitats and environments safe for human occupancy and the means to explore the outside environment (extravehicular activities, EVA). In order to validate alternative atmospheres and pre-spacewalk procedures, the EA study was conducted to evaluate factors such as hypoxia risks, denitrogenation protocols, food limitations, medications, and the impact of other factors on human performance. **OVERVIEW:** Space travel is constrained by mass, volume, power, and the cost of vehicle development, which creates tradeoffs in various capabilities, including breathing gasses. Higher atmospheric pressure in a vehicle means more gas and a stronger containment vessel/habitat; while lower pressure requires higher oxygen partial pressure, which may increase fire risk. NASA's EA study evaluated a proposed alternative cabin environment (8.2 psia, 34% Oxygen), for future spacecraft habitat and planetary EVAs. EA included both a 3-day and a 11-day trial. These trials included a depressurization and saturation to 8.2psi at 34% O2 with additional depresses to 4.3 psia at 85% O2 for simulated EVAs (1 EVA during the 3-day and 5 during the 11-day trials). **DISCUSSION:** Planning for and executing the medical monitoring and response plan for a trial of this scope was a huge undertaking with no prior practice to fall back on. Food obstacles, sleeping issues, medications, joint injury, equipment limitations, medical privacy, multiple cases of decompression sickness, and even a COVID outbreak among the support team proved challenging. Testing of this nature is an essential part NASA's preparation for the upcoming Lunar Artemis missions. As spaceflight transitions beyond low earth orbit, to planetary, even more trials of this nature will be required to learn what are the optimal atmospheric and associated operational constraints to maintain the optimal health of the crew and achieve mission objectives.

Learning Objectives

1. The audience will learn about the lessons learned from NASA's Exploration Atmosphere.
2. The audience will learn about medical monitoring and response of NASA's Exploration Atmosphere.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Ballroom D-E

[S-33]: PANEL: AEROSPACE TOXICOLOGY

Chair: David Mattie
Co-Chair: Richard Pleus

PANEL OVERVIEW: *Aerospace Toxicology is the multi-disciplinary approach to understanding and managing the effects and impacts of chemical and biological agent exposures, while in flight or on the ground preparing and servicing vehicles for flight, to keep humans healthy and safe. Exposures to chemicals associated with all aspects of flight need to be understood and managed to ensure everyone associated with aerospace operations are protected. The Aerospace Toxicology Association is a new organization that is in the process of becoming an AsMA affiliate. The abstracts in the session while having diverse topics all address issues related to toxicology associated with flight or maintenance operations.*

[173] THE STATE-OF-THE-SCIENCE REGARDING HEALTH IMPACTS OF CHEMICALS IN THE CABIN AIR OF COMMERCIAL AIRCRAFT

Richard Pleus, Gretchen Bruce, Lisa Corey, Kelli Hackney, Cameron Bellamoroso
Intertox, Seattle, WA, United States

(Original Research)

Studies demonstrate that small amounts of jet engine oil or hydraulic fluid can enter the environmental systems of commercial aircraft and the aircraft cabin air. These occurrences are called fume air events. Often during a fume event, only an odor is detected; even more rarely, a haze is present. The chemical class that has gained the most interest is organophosphates, a broad class that includes tricresyl phosphate and its isomers (TCP). Some aviation community members single out TCP as a causative agent of neurotoxicity in crew members. We review the neurotoxicology of chemicals in jet engine oil and hydrolytic fluid. We evaluate the byproducts of jet oil and hydraulic fluid combustion. The toxicology literature for many chemical agents is sufficient to evaluate toxicity, and doses of detected chemicals can be estimated. For example, TCP produces distinctive delayed neurotoxicity known as organophosphate-induced delayed peripheral neuropathy (OPIDN). After exposure of sufficient magnitude, OPIDN develops after a period of from ten days to a few weeks. Except for instances where the doses of TCP are very high (e.g., Ginger Jake syndrome during Prohibition), the effects of OPIDN are reversible. TCP has not been demonstrated to cause cognitive effects, whole-body injury, loss of smell and taste, coughing, or breathing problems. Most

organophosphates affect the enzyme acetylcholinesterase (AChE) and cause a distinct collection of associated symptoms, including constriction of the pupils, sweating, urination, defecation, salivation, nausea, vomiting, and diarrhea immediately after exposure. TCP is a weak inhibitor of AChE. We summarize the literature on the health effects of exposure to jet engine oils, hydraulic fluids, by-products of combustion, and mixtures. We conclude that chemicals are detected in commercial aircraft cabins at different phases of operation and, in some cases, may cause temporary or reversible irritation of mucus membranes but that the exposure levels, duration of exposure, and subsequent doses are not sufficient to cause neurotoxicity.

Learning Objectives

1. How toxicologists conduct a chemical toxicity assessment in aerospace toxicology.
2. The method toxicologists use to determine acceptable levels of human chemical exposure in aerospace toxicology.

[174] TOXICOLOGICAL ASSESSMENT OF PHYSIOLOGIC EPISODES IN F/A-18A-F AND ES-18G AIRCREW

Michael Kosnett[1], Richard Pleus[2]

[1]*Colorado School of Public Health, Aurora, CO, United States;* [2]*Intertox, Seattle, WA, United States*

(Original Research)

In 2010 the number of F/A-18A-F and EA-18G hazard reports (HAZREP) related to unexpected aviator(s)/operator(s) physiologic episodes (PEs) began to increase. A Root Cause Corrective Action (RCCA) started on March 10, 2017. A team of Aeromedicine, Physiology, and Toxicology experts investigated these PEs. The Aerospace Medical Team consisted of a multidisciplinary group of clinicians and scientists. We focus on the toxicological work conducted in this effort through 2018. In some PEs, pilots reported neurological and constitutional symptoms that included dizziness, cognitive impairment, tingling in extremities, headache, nausea, vision disturbances, and fatigue. Collectively these symptoms suggested potential impairment of the central nervous system via direct or indirect modes of action. The question posed to toxicologists was whether chemical contaminants in breathing air caused or contributed to these symptoms. The toxicology team assessed over 400 chemicals that were measured and evaluated. Air samples were taken in various locations, including on the tarmac, flight deck, cabin, and inlet and outlet of the On-Board Oxygen Generating System (OBOGS). Measurements were compared to toxicological reference values, and hazard quotients and indices were calculated. The overall toxicological assessment, based on maximum measured concentrations, potential sustained doses, and the nature and temporal pattern of the episodes was that direct or indirect neurotoxic effects of chemical contaminants in breathing air were unlikely to account for almost all reported PEs, although their possible role in a handful of isolated events could not be excluded. As part of its work, the team independently developed a comprehensive list of chemical agents considered capable of causing overt neurotoxic or irritant effects after low-dose, short-duration exposure. To the extent that industrial hygiene, chemistry, or engineering assessments indicated that any of these compounds could conceivably be present in the aircraft environmental control system by their presence in native aircraft fluids or components or their thermal degradation or reaction products, expansion of future analytical techniques to measure those agents not detectable using current investigative regimes was recommended. Revised approaches for augmenting the collection and recording of clinical toxicology findings in future incident investigations were also presented.

Learning Objectives

1. Understand the approach toxicologist use to assess possible chemical exposures.
2. Understand the type of data that is needed to conduct a toxicological assessment.

[175] COMPARISON OF OPERATIONAL JET FUEL AND NOISE EXPOSURES

David Mattie[1], Satoshi Maruyama[2], Nobuhiro Ohrui[2], Takahiro Imamura[2], Kunio Takada[2], Asao Kobayashi[3], Kerrine LeGuin LeGuin[4], Dirk Yamamoto[1]

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(Original Research)

INTRODUCTION: Personnel who work around aircraft on the flight line are potentially at risk for developing hearing loss. A study that is part of an international agreement with Japan was designed to address gaps in data for flight line personnel with combined exposure to jet fuel and noise. **METHODS:** Subjects from JASDF and USAF air bases in Japan (Hyakuri, Matsushima, Hamamatsu, Kadena, and Misawa, ABs) were sampled during a single shift on the flight line. Control subjects from Hyakuri, Yokota, Kadena, Misawa and Iruma ABs were sampled during a single shift in an administrative area or at a base hospital or clinic. All subjects were recruited under approved Japanese and AFRL human subject research (IRB) protocols. A previous study showed the importance of sampling control subjects to obtain data for comparison between working on an air base versus working on a flight line. During their work shift, subjects wore a personal vapor pump to sample for jet fuel components and a noise dosimeter to assess their personal noise exposures. After their shift, each subject was asked questions concerning exposures during the shift and audiological history. In addition, blood was drawn, urine was collected, and a complete audiometric test battery was conducted. **RESULTS:** The noise dosimetry data showed an average actual TWA for time of sampling was 94.5 dB for flight line personnel versus 68.2 dB for controls in clinics or offices. Audiological histories showed a trend for tinnitus in flight line personnel but was also identified in some controls. The post-shift questions confirmed exposure to jet fuel and exhaust as well as engine oils and hydraulic fluids. **DISCUSSION:** The chemicals in air, blood and urine will be in another presentation in the Aerospace Toxicology Panel. Exposure to higher noise and jet fuel supports a potential for jet fuel as an ototoxicant although studies suggest it may be a synergist effect. Audiometric test results are not available yet. (Disclaimer: No DoD endorsement implied.)

Learning Objectives

1. Attendees will learn about the combined exposure of jet fuel and noise on USAF and JASDF flight lines in Japan.
2. Attendees will learn about the audiological history of subjects and the potential for Jet fuel to be an ototoxicant.

[176] COMPARISON OF OPERATIONAL JET FUEL AND NOISE EXPOSURES: FUEL EXPOSURE RESULTS

Nobuhiro Ohrui[1], Satoshi Maruyam[1], Chisato Takazawa[1], Atsushi Torihata[1], Yasutami Otsuka[1], Takahiro Imamura[1], Asao Kobayashi[2], David Mattie[3], Dirk Yamamoto[3], Kunio Takada[1], Tetsuya Tsujimoto[1]

[1]*Aeromedical Lab, Japan Air Self-Defense Force, Sayama, Japan;* [2]*Air Development and Test Command, Japan Air Self-Defense Force, Fuchu, Japan;* [3]*U.S. Air Force Research Lab, 711th Human Performance Wing, Airmen Systems Directorate, Wright-Patterson AFB, Dayton, OH, United States*

(Original Research)

INTRODUCTION: Noise is pervasive in the living environment and can cause hearing loss. The noise and chemical exposures have long been crucial issues in flight or maintenance operations. Recent studies suggested jet fuel in combination with noise are more associated with hearing

loss than with noise exposure alone. Flight line personnel working in and around aircraft, who are constantly exposed to noise and exhaust fumes, may be more likely to developing hearing loss. This study was a collaborative research effort between the Japan Air Self-Defense Force (JASDF) and the US Air Force (USAF) to examine the effects on hearing in flight line personnel with combined exposure to jet fuel and noise. The JASDF measured jet fuel components as personal exposure of 15 volatile organic compounds (VOCs) in blood, urine and within flight line air environment (personal air samples) at air bases in Japan. **METHODS:** There were 152 subjects. The subjects were divided into eight groups: CJ, Non-exposed control subjects in JASDF; CK, Non-exposed control subjects in Kadena; CM, Non-exposed control subjects in Misawa; T-4, JetA1 (T-4) exposed subjects in Matsushima and Hamamatsu; F-2, JetA1 (F-2) exposed subjects in Matsushima; F-4, JP-4 (F-4) exposed subjects in Hyakuri; F-15, JP-8 (F-15) exposed subjects in Kadena; F-16, JP-8 (F-16) exposed subjects in Misawa. Personal air samples were collected during a work shift. The subjects also had their blood drawn post shift and their urine collected prior to shift (early morning urine) and post shift. **RESULTS:** Total VOCs concentrations in personal air sample, blood and urine in each group were extremely low. Total VOCs concentrations in personal air samples were higher in the jet fuel exposure groups, except for F-2, than in CJ and CK. The total VOCs concentrations in blood sample was significantly higher in F-4 compared to in CJ, CK and CM. Total VOCs concentration in urine sample was significantly higher post shift than prior to shift in T-4. **DISCUSSION:** There were no significant correlation between total VOCs concentrations in personal air sample and in blood sample. The effects of jet fuel exposure on auditory function will be analyzed in along with results of noise dosimetry and audiometric test conducted by the USAF.

Learning Objectives

1. The participant will learn about exposure levels of volatile organic compounds in air, blood and urine under flight line environment.
2. The participant will learn about the differences of jet fuel exposure effects by jet fuel type or aircraft type.

[177] NON-INVASIVE BIOMARKERS FOR AEROSPACE TOXICOLOGY ASSESSMENTS

Nesrine Ramadan
University of Oxford, Oxford, United Kingdom

(Education - Program/Process Review)

BACKGROUND: Various non-invasive biomarkers such as microRNAs (miRNAs), proteins, and antibodies can serve as informative markers to examine physiological alterations or toxic effects on tissues and organs. Their presence in biological fluids (e.g. saliva, urine, sweat, plasma) provides the opportunity to utilize them as potential novel monitoring tools to investigate how spaceflight stressors affect human health. This presentation will be part of the Aerospace Toxicology Panel and will review how biomarkers used in terrestrial risk assessments, clinical studies, diagnosis, and therapeutic monitoring can be envisaged as novel toxicological and monitoring biomarkers in aerospace fields. This is relevant for biomedical, scientific, educational, and regulatory audiences. **OVERVIEW:** This work focuses on the growing potential of miRNAs and deciphers 2 overarching strands: 1) Space: this section provides an explanation of how established studies investigating the impact of environmental and occupational toxicants on miRNAs can be exploited for aircraft toxicology studies and risk assessments. 2) Outer space: this segment highlights miRNA's roles in a plethora of terrestrial physiological, biological, and psychiatric phenomena which are also identified as responses to microgravity and spaceflights such as muscle wasting, osteoporosis, depression, and PTSD (post-traumatic stress disorder) in civilians and veterans. Overall, understanding the wide potential of miRNAs in aerospace allows to propose novel solutions and pipelines. This will be discussed through 3 primary recommendations also aimed at developing consensus for the use of these molecules: 1) generating repertoires to evaluate the significance of miRNAs signatures in combination with other proteins, metabolic or biochemical biomarkers; 2) integrating non-invasive biomarkers in systems monitoring stress, fatigue, and depression in spaceflights; 3) generating inclusive data for the development of both universal and personalized solutions. **DISCUSSION:** Non-invasive biomarkers will emerge as tools for health and mental health surveillance. They can facilitate the development of promising medical and technological innovations and solutions aimed at maximizing human performance and operational health capability in both civilians and military spheres. MiRNAs specifically hold promising potential in the aerospace toxicology arena and open new perspectives for aerospace precision and personalised medicine.

Learning Objectives

1. Understanding the potential of non-invasive biomarkers with emphasis on the roles of microRNAs in the aerospace toxicology sector and beyond.
2. Learning how terrestrial biomedicine advances can support aerospace precision and personalized medicine.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Chenier

[S-34]: SLIDES: SAFETY & SURVIVABILITY: WHAT CAUSED THAT

Chair: Albert Lee
Co-Chair: Erik Johnson

[178] IN-FLIGHT INCAPACITATION/IMPAIRMENT IN AIRCREW- AN ANALYSIS OF UK CAA MANDATORY OCCURRENCE REPORTS

Ryan Anderton, Jonathon Walter
UK Civil Aviation Authority, Gatwick, United Kingdom

(Original Research)

INTRODUCTION: The incapacitation of aircrew presents a clear flight safety risk. Mandatory Occurrence Reports (MORs) have been a part of UK aviation operations since 1976, with regulation mandating the reporting of safety related occurrences, including aircrew medical incapacitation/impairment. Understanding trends in the causes may lead to an improvement in flight safety through review of medical policy, guidance material and approach to aeromedical fitness decisions. An analysis of the data from 2006 to 2021 was undertaken to identify MORs with medical causes of incapacitation. **METHODS:** The UK Civil Aviation Authority database of MORs was analyzed for incapacitation/impairment events with a suspected medical cause. Categorization of the events into type of condition was undertaken through a review of free-text entries. Data on whether crewmembers recovered for landing, the flight origin, flight distance (short, medium and long haul) and the affected crew members position was also collected. Collection and use of data was retrospective, anonymized and considered exempt from research ethic committee approval. **RESULTS:** Between 2006 and 2021, there were 659 MORs reports with a suspected medical cause for aircrew incapacitation/impairment. The reports in order of most frequent were gastrointestinal, 'unknown/unwell', hypoxia/fume events, injuries/pain, syncope/LOC, disorientation/dizziness, sinus/ear pain, vision impairment, cold/flu symptoms, epistaxis, fatigue, seizure, allergy, choking, renal colic, migraine/headache, psychological, myocardial infarction/chest pain and death. 36.2% of reports involved the First Officer, 24.1% the Captain and 6.6% involved both members of aircrew. 39% of events occurred on short haul flights, 39% on long haul and 21% on medium haul. In 42.3% of cases the crewmember recovered for landing, 37.1% did not, and in 19.4% of events they were replaced by additional crew. 41.4% of flights in the reports departed from the UK and 58.5% departed from overseas. **DISCUSSION:** Gastrointestinal illness is the leading cause of incapacitation. Whilst difficult to predict and prevent, improved crew education/training may have a significant impact on total incapacitations. This data provides an opportunity for

regulators and airlines to review medical policy and guidance material to target reductions in incapacitation risk where possible. Future research may identify impacts of any policy/guidance material development on incapciation numbers.

Learning Objectives

1. The audience will gain an understanding of the leading causes of in-flight incapacitation in aircrew.
2. The audience will gain an understanding of how data collected about in-flight incapacitations might influence medical policy and guidance material to improve flight safety.

[179] THE MORE THINGS CHANGE, THE MORE THEY REMAIN THE SAME: WEATHER-RELATED ACCIDENTS IN HELICOPTER EMERGENCY MEDICAL SERVICES

Paige Lawton, Gabriela Rosado, McKenna Tooker, Albert Boquet
Embry Riddle Aeronautical University, Daytona Beach, FL, United States

(Original Research)

INTRODUCTION: Historically, investigations of accidents within aviation have placed attention primarily on errors committed by the pilot. This analysis aims to examine the theater of operation within which Helicopter Emergency Medical Services (HEMS) pilots fly and the factors associated with accidents in HEMS operations. **METHODS:** Researchers collected FAR Part 91 and Part 135 HEMS accident and incident reports occurring between [blank to blank] from the National Transportation and Safety Board (NTSB) database. In total, sixty accidents were analyzed using the HFACS and consensus coded by a three-person panel trained in the Human Factors Analysis and Classification System. Coding was further validated through collaboration with an HFACS expert. **RESULTS:** Analysis of 60 accident reports yielded a total of 211 causal factors, primarily within the Unsafe Acts (77) and Preconditions for Unsafe Acts (123) tiers. Within the Preconditions for Unsafe Acts tier, 57% of contributing factors were attributed to physical environment, in particular instrument meteorological conditions (IMC) (30%) and dark night conditions (40%). Accidents that occurred in dark night conditions contributed 87% of all fatalities. Additionally, 78% of accidents involving flight into IMC resulted in fatalities while only 27% of non-IMC accidents resulted in fatalities. **DISCUSSION:** An HFACS analysis of HEMS accidents demonstrates the extent to which factors within HEMS pilots' operational environment contribute to safety outcomes. As no pilot operates within a vacuum, taking a closer look at personal and environmental factors that lead to unsafe acts lends itself to the development of data-driven interventions. Despite improvements in on-board weather identification technologies and reporting, preliminary findings suggest that causal factors associated with inadvertent flight into instrument meteorological conditions and dark night remain a persistent threat to helicopter emergency medical services (HEMS) crews and their patients. These results present a monumental safety concern in HEMS with little to no policy change to support safe operations. Thus, future researchers should focus on identifying system components including behaviors, technologies, and policies and procedures that serve to arrest failures and prevent accidents and behaviors associated with these factors.

Learning Objectives

1. The audience will learn more about the theater of operation within which HEMS pilots perform to mitigate the factors that contribute to pilot error and develop data-driven interventions.
2. The audience will be able to better understand the preconditions that contribute to the occurrence of unsafe acts that result in HEMS accidents characterized by flight into IMC and dark night conditions.

[180] MENTAL HEALTH IN AVIATION: A REVIEW OF ACCIDENT REPORTS

Clare McNerlin[1], Riley Ferguson[2], Matthew Wilson[1]
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(Education - Program/Process Review)

BACKGROUND: The Federal Aviation Administration (FAA) requires a certified Aviation Medical Examiner (AME) to issue at least a third-class medical certificate to all civilian pilots currently flying. This certification requires full disclosure of all medical history and prescription records of the pilot. According to FAA standards, pilots with psychiatric diagnoses must seek a special issuance of this medical certificate, and are often grounded for at least six months, incurring significant healthcare costs and an inability to work. Depression is one of the most commonly diagnosed mental health disorders, and despite its high prevalence in the general population, it is often not discussed among aviators due to the fear of no longer being able to fly. **OVERVIEW:** The National Transportation Safety Board (NTSB) compiled and provided a database of all aviation accidents from 1/1/2002-12/31/2021 which resulted in 29,904 accident reports, of which 5,527 were fatal. Each fatal report was analyzed and the prevalence of mental health diagnoses and use of psychoactive pharmaceutical medication determined by toxicology reports, autopsy reports, and witness and family statements were assessed. On review of fatal accident reports, intentional suicides were identified as a specific subsection of fatal accidents. Additionally, some of these reports documented that the pilot had a history of a mental health disorder that was not disclosed to their AME and the FAA during their initial or subsequent medical evaluations. Toxicology reports showed multiple fatal accidents where psychotropic medication was considered to be a factor. Of significance, there is evidence of selective serotonin reuptake inhibitor (SSRI) use both before and after FAA approved their use in 2010. Pilot mental health needs to be adequately addressed and treated to ensure safety. **DISCUSSION:** In this presentation, the prevalence of psychiatric diagnoses in relation to fatal aircraft crashes is discussed, as well as current avenues of treatment accessible to the aviation community. Ultimately, pilot reluctance to seek mental healthcare and the current FAA regulations around psychiatric treatment must be considered as these mental health associated intentional suicides continue to take place.

Learning Objectives

1. Discuss the current state of mental health care and barriers to access for pilots.
2. Understand the impact of the Federal Aviation Administration's changes to selective serotonin reuptake inhibitor use among pilots.

[181] CHANGING MISHAP REPORTING SYSTEMS CHANGED HUMAN FACTORS TRENDS IN U.S. NAVAL AVIATION MISHAPS

Jefferson Grubb
U.S. Naval Safety Command, Norfolk, VA, United States

(Original Research)

INTRODUCTION: A 2005 memorandum of agreement mandates that all branches of the U.S. military use the Department of Defense Human Factors Analysis and Classification System (DoD HFACS) to record human factors contribution to mishaps. In principle, this commonality permits comparison of human factors trends both longitudinally and between services. Although the DoD specifies the use of DoD HFACS, it does not mandate a common overarching mishap reporting system. How the reporting system handles HFACS data entry may influence which codes investigators assign for a given mishap. If so, HFACS codes recorded under different reporting systems may not be comparable. In 2020, the Department of the Navy switched reporting systems from the Web Enabled Safety System (WESS) to Risk Management Information (RMI). This study compared HFACS coding trends in U.S Naval Aviation mishap reports entered using WESS with those entered using RMI. **METHOD:** The author examined 878 Class A-D Naval Aviation mishaps entered under WESS between FY17 and FY20 and 584 such mishaps entered under RMI between FY20 and FY22. Empirical Bayes estimation was used to compare the percentage of mishaps in which each DoD HFACS 7.0 code was cited in the two mishap data sets. **RESULTS:** Of 109 possible codes,

29 showed significant changes in citation rate after the reporting system change. Investigators cited more codes for unsafe acts, environmental preconditions, teamwork preconditions, and supervisory planning issues. In contrast, investigators cited fewer codes for mental awareness preconditions, state of mind preconditions, and supervisory violations. **DISCUSSION:** Policy makers and researchers must use caution when interpreting DoD HFACS data. In particular, these results indicate that HFACS codes entered using different reporting systems are not directly comparable. HFACS data are subjective. A change in an HFACS code's reporting rate may reflect a real safety trend, a change of investigator perception of existing safety conditions, or simply a change in the mechanics of how investigators assign HFACS codes.

Learning Objectives

1. Examine factors that limit the interpretability of DoD HFACS data.
2. Explore factors influencing investigators' classification of human factors contributions to mishaps.
3. U.S. Department of Defense reporting requirements for human factors contributions to mishaps.

[182] GENERAL AVIATION ACCIDENTS RELATED TO DEFICIENT AERONAUTICAL DECISION-MAKING (1991-2019)

Douglas Boyd, Mark Scharf
Embry-Riddle Aeronautical University, Daytona Beach, Florida, United States

(Original Research)

INTRODUCTION: The ~60X higher general aviation (GA) accident rate (c.f. air carriers) partly reflects less rigorous operational regulations for the former (14CFR 91 vs. 121). Accordingly, since 1991, aeronautical decision-making (ADM), in context of go/no-go, has been emphasized in *ab initio* and recurrent GA training. However, no research has address whether ADM-related mishaps have declined thereafter or identified the most frequent subcategories. Herein, we determined the (i) temporal change in ADM-related fatal accidents (1991-2019) involving private pilots (PPLs) operating single piston engine airplanes and (ii) the most prevalent categories of such ADM-related mishaps per the Pilot-Aircraft-enVironment-External Pressure (PAVE) model. **METHODS:** Fatal mishaps were per the National Transportation Safety Board database. GA fleet time was used to determine accident rates. Statistical testing employed Poisson Distribution, Fisher Exact and Mann Whitney U-tests. **RESULTS:** Of 1,437 fatal accidents, 846 were ADM-related. Although the ADM-related accident rate declined ($p<0.001$) from 6.6 to 3.6/million flight hours (1991-2005), no further decrease was evident thereafter ($p=0.446$). Using the PAVE model, half of mishaps involving poor go/no-go decision-making were environment-related with adverse weather representing the largest sub-category. Regarding the latter, non-instrument-rated PPLs were over-represented for accidents involving departures into forecasted/known enroute degraded visibility (IMC). Conversely, a disproportionate count of mishaps was observed for IFR-PPLs electing to depart with forecasted thunderstorms ($p=0.012$) or icing enroute ($p<0.001$). Interestingly, external pressure to undertake a flight was evident only for 10% of ADM-related accidents. No difference ($p=0.444$) in PPL total flight experience was evident for ADM-related and un-related accidents. **DISCUSSION:** Notwithstanding substantial gains made over 3 decades in educating pilots as to the importance of pre-flight ADM, new educational approaches are needed to further decrease a stagnated rate. Finally, for the IFR-rated and non-rated PPL, selective emphasis needs to be placed on go/no-go decision-making for flights with forecasted thunderstorm/icing and IMC respectfully.

Learning Objectives

1. Audience will learn that approximately half of general aviation accidents are due poor decision-making prior to the flight being undertaken.
2. Audience will learn about the widely-used PAVE model for aeronautical decision-making introduced to general aviation in 1991.
3. The audience will learn that the type of adverse weather leading to deficient aeronautical decision-making varies between the IFR-rated and non-IFR rated pilot.

[183] FOLLOW UP OF THE BOEING 737 MAX MISHAPS, WHO WENT WRONG, AND THE FIXES AND REMARKS ABOUT THEM

Carlos Salicrup
Colegio Mexicano de Medicina Aeroespacial, Mexico City, Mexico

(Education - Case Study)

INTRODUCTION: There is nothing more thrilling than trying to take manual control of the airplane during a critical situation and an erratic computer overtaking your commands. Along with manual skills getting blurred by automation and the startle and surprise effect. **BACKGROUND:** For those already flying the Boeing 737 NG, the training for the 737 MAX consisted of a few hours watching videos and reading material online. It was not required to fly, at least for the first flight, with a flight instructor. The Flight Crew Operation Manual only stated in a single paragraph the existence of an MCAS, the Maneuver Characteristics Augmentation System. Nowadays we take a full Return to Service (RTS) Training, consisting of several hours on computer-based training, ground school and a full simulator session that involves training in the MAX systems, containing full scenarios involving new automation, how it works and how to recover or manage its failures. **CASE PRESENTATION:** Automation means a machine that partially or fully covers the task of a human being, when a new automation is introduced, the user (pilot) along with being aware of the new "system" capability, and functions, should be trained about the failure modes and how to overcome them. The Boeing 737-MAX mishaps lead to an investigation that resulted in pointing out interesting factors like human-systems integration, automation training, and the economic-administrative factors. These days, due to the past events and the RTS obligations, the B737MAX may be the most surveilled and safe airliner, pilots feel more comfortable with the specific training and automation was limited so the pilot may overtake control at any time, not letting systems like the MCAS put the airplane in an upset situation. On the other side, we are not only training pilots to be proficient, but also to develop and maintain their competencies, some compromised by automation. **DISCUSSION:** A hard lesson was learned, indeed automation has lowered the rate of mishaps, but when one occurs it is disastrous. We must be careful introducing new automation and to train pilots in its functions, failure modes and recovery, along with continuously train and develop pilot competencies that are identified to be blurred by automation, like manual flying skills, upset recovery and situational awareness.

Learning Objectives

1. The attendee will learn about the overcome of the 737MAX investigations.
2. The attendee will learn about levels of automation and pilot competencies.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon Ballroom C1-C2

[S-35]: SLIDES: HOW TO TRAIN FOR FLIGHT

Chair: Jeffrey Harris
Co-Chair: David Gregory

[184] EFFICACY OF ADAPTIVE ALGORITHMS FOR TRAINING IN VIRTUAL REALITY

Alessandro Verniani, Esther Putman, Abhishektha Boppana, Benjamin Peterson, Ellery Galvin, Sandra Tredinnick, Eric Vance, Torin Clark, Allison Anderson
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Virtual reality (VR) has been increasingly used for training over the last three decades for its immersiveness and practicality.

However, training is often facilitated by an operator or automated rather than personalized to individual needs. This research investigates the effect of training algorithm adaptivity, which alters task difficulty as a function of subject performance across a range of disparate but interconnected subtasks, and its effect on skill acquisition and performance. We hypothesize that more adaptive training algorithms lead to improved outcomes in learning retention between trials, increased skill transfer between the virtual and physical environments, and improved performance in a physical cockpit mock-up. **METHODS:** A virtual training simulator was developed to emulate landing a spacecraft on Mars, with VR immersion being conducted through a head-mounted display for three subtasks. Given IRB approval, we used human subjects to study three degrees of adaptivity in algorithms, including fixed linear response, dynamic linear response, and non-linear response. Difficulty was modulated linearly to a set paradigm, modulated dynamically to consecutive increases in performance, or modulated proportionately to performance, respectively. These were compared to non-individualized fixed progression, which coarsely mimics the adaptive paradigm, and non-adaptive algorithms which fix difficulty. Subjects (n=8 per algorithm, 4M/4F) aged 18-60 were screened for colorblindness and motion sickness susceptibility, grouped randomly, and baseline information was taken by means of a demographic survey, Affect Grid questionnaire, and reaction time test. Data was collected on joystick and keyboard inputs and associated performance grades across subtasks and sessions were analyzed using non-parametric regression and both paired and non-paired tests. **RESULTS AND DISCUSSION:** We analyzed the effect of training personalization on learning outcomes across several algorithms compared to a control and determined the extent to which different algorithms had similar outcomes. We evaluated learning retention between trials and skill transfer between the virtual and physical environments. Our results inform the required algorithmic complexity to attain optimal training results. Future research should explore the use of Bayesian estimation and machine learning models to scale difficulty by predicting performance for more optimally individualized training.

Learning Objectives

1. The audience will learn about the effect of training algorithm adaptivity on skill acquisition, learning retention, and performance.
2. The audience will learn about the required algorithmic complexity to attain optimal training results.

[185] GALVANIC VESTIBULAR STIMULATION AS AN ANALOGUE DEVICE FOR SPATIAL DISORIENTATION TRAINING IN MILITARY AVIATION

Amanda Lippert[1], Aaron Allred[2], Scott Wood[3]
[1]*U.S. Navy, Patuxent River, MD, United States;* [2]*University of Colorado-Boulder, Boulder, CO, United States;* [3]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The number one cause of fatalities in military aviation continues to be Spatial Disorientation (SD). For decades, there has been a multifaceted approach to lowering this statistic, including developing automated systems within aircraft and training aircrew to recognize and recover from a disorienting scenario in flight. Current SD training for military aircrew consists of regularly occurring didactic training on topics such as human sensory systems (capabilities and limitations), environmental conditions that may induce SD, and widely accepted theory on the types of SD. This lecture-style training is sometimes coupled with using devices such as flight simulators (both motion-based and static), the Multi-Station Disorientation Device (MSDD), Underwater Egress Training Devices, and Barany Chairs. However, the experiential training that the various devices offer is infrequent, with the most common device being a static flight simulator. Static flight simulators offer no vestibular stimulation to the brain of the crew, often relying solely on visual and audible inputs when simulating a disorienting scenario. **OVERVIEW:** Galvanic Vestibular Stimulation (GVS) offers an opportunity to create a perception of disorientation by providing supra-threshold bilateral bipolar electrical current to the vestibular system in a safe and reliable manner. GVS has been used on humans for decades in the laboratory environment, to research topics such as balance, neurological functions of healthy and diseased populations, detrained vestibular systems in spaceflight crew, and recently in virtual reality scenarios to simulate a variety of commonly experienced somatogravic and somatogyral illusions in flight. **DISCUSSION:** The ability to disorient aircrew in the safe training environment of a static flight simulator would allow for aircrew to experience the sensations of sensory mismatch while demonstrating typical flight-related tasks. Additionally, this would serve as an opportunity to practice the life-saving checklist items to recover from Spatial Disorientation while actually experiencing a disorienting event. In this presentation, the authors discuss using targeted waveforms of GVS that will elicit the sensations felt during common sensory illusions in flight, creating a training profile that could be worn by military aircrew in a static flight simulator, offering a low-cost training solution to the number one cause of fatalities in military aviation.

Learning Objectives

1. Explain the basic workings of a typical Galvanic Vestibular Stimulation (GVS) device.
2. Describe how GVS will function as a training analogue for Spatial Disorientation (SD).

[186] PRELIMINARY EVALUATION OF AN OSTEOPATHIC MANIPULATIVE TREATMENT (OMT) TO PREVENT MOTION SICKNESS SYMPTOMS

Virginia Thomas[1], Amanda Kelley[2], Albert Lee[3], Thomas Fotopoulos[1], Jason Boggs[2], John Campbell[2]
[1]*Alabama College of Osteopathic Medicine, Dothan, AL, United States;* [2]*U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States;* [3]*U.S. Army Medical Center of Excellence, Fort Rucker, AL, United States*

(Original Research)

INTRODUCTION: Unmanaged motion sickness can lead to pilot or aircrew impairment during flight, and if severe enough, disqualification from flight duty. Advancements in the next fleet of rotary-wing aircraft anticipate increased maneuverability and speeds which may lend towards increased incidence of motion sickness. While many medications currently exist in the marketplace, they vary dramatically in reported effectiveness and side effects, and are allowed only on a limited basis for military flight teams. This study aimed to demonstrate the use of osteopathic manipulative treatment (OMT) to alleviate the neuromuscular components of the impacted systems related to motion sickness. **METHODS:** A novel OMT protocol for the reduction of motion sickness symptoms and severity was evaluated using a sham-controlled, counter-balanced, between-subjects study design. The independent variable was OMT treatment administered prior to the motion sickness inducing procedure (target treatment vs. sham treatment). The primary dependent measures were total and sub-scale scores from the Motion Sickness Assessment Questionnaire (MSAQ) and heart rate. **RESULTS:** The findings suggest the novel treatment shows promise for this purpose. Specifically, the results suggest that the treatment may reduce gastrointestinal (nausea) and sopite-related symptoms (sleepiness). The OMT target treatment group experienced significantly less gastrointestinal symptoms than the sham group whilst controlling for motion sickness susceptibility. Heart rate data patterns were consistent across groups supporting the validity of the manipulation (procedure) for inducing motion sickness. **DISCUSSION:** While our findings did not result in specific, implementable recommendations, they did provide a more-focused direction for future investigations. A more precise evaluation of the mechanism of action is needed. In terms of practicality and applicability, the treatment needs to be tested with a variety of providers, using a variety of motion sickness inducing stimuli. Also, the duration of the effect needs to be established. Further investigation will be invaluable in determining the validity of OMT to alleviate motion sickness symptoms.

Learning Objectives
1. Participants will learn about a non-pharmaceutical approach to motion sickness symptom prevention.
2. We will consider the mechanisms of action which resulted in greater reduction of some symptoms over others.

[187] CERVICAL RANGE OF MOTION ASSESSMENT- A NOVEL APPROACH USING VIRTUAL REALITY

Aya Ekshtein[1], Yuval Kozlov[2], Miriam Peri[1], Shachar Shapira[1], Oded Ben-Ari[1]
[1]*Israeli Air Force, Ramat Gan, Israel;* [2]*Faculty of Medicine, Hebrew University of Jerusalem, Jerusalem, Israel*

(Original Research)

INTRODUCTION: Neck pain (NP) in military aviators is a significant problem associated with cervical injury and impaired flight safety and operational performance. There is evidence of a link between decreased cervical range of motion (CROM) and NP in aviators and the general population. Our goal was to evaluate whether CROM assessment in aviators using a Virtual Reality (VR) device can predict NP. **METHODS:** The study was a cross-sectional study. Clinical, demographic, and military data was collected from the electronic medical records system. **RESULTS:** A total of 1,187 active Israeli Air Force (IAF) aviators underwent CROM assessment by the unit's physical therapist using the XRHealth™ Oculus Quest VIVE HTC VR™ system between January 2020 and July 2021. Of 1,187 IAF aviators, 30% reported neck pain. NP was significantly correlated ($p<0.001$) with reduced neck flexion. A significant decrease in CROM was found in subjects 50 and over years of age ($p<0.0001$). **DISCUSSION:** Our findings suggest that the VR system may be a valuable tool for assessing aviators CROM and their risk of developing NP. The most significant factor associated with a decline in CROM was increased age. Reduced flexion was associated with NP.

Learning Objectives
1. Implementation of a virtual reality device to assess cervical range of motion.
2. Cervical range of motion as a mandatory examination during yearly routine checkup.
3. Adding the possibility of grounding aircrew due to neck pain.

[188] MILLER FISHER SYNDROME IN A JORDANIAN FIGHTER PILOT

Rafat Rahayfeh[1], Vasileios Pastamentzas[2]
[1]*Royal Jordanian Air Force Medical Facility, Amman, Jordan;* [2]*Hellenic Air Force, Athens, Greece*

(Education - Case Study)

Introduction: In this case report we will describe a military F16 pilot who was infected with mild acute respiratory syndrome coronavirus 2 (SARS- CoV-2) and develop Miller Fisher syndrome (MFS). **Background:** MFS is a rare variant of Guillain-Barré syndrome (GBS), It is an autoimmune response that typically follows an upper respiratory or diarrheal illness. It is characterized by the acute development of ataxia, weakness, ophthalmoparesis and areflexia. The muscle weakness can progress to cause respiratory failure. MFS occurs in approximately 5-10% in the US and 20% in Asia of GBS cases. Serum anti-GQ1b IgG antibody is indicative of syndrome. Treatment could include supportive respiratory care, intravenous immunoglobulin therapy (IVIG), or plasmapheresis. **Case Presentation:** The pilot is a 25-year-old fighter pilot, who was infected with SARS-CoV-2. He was previously vaccinated, but still experienced mild to moderate viral symptoms. After 3 days of symptoms, he started to have severe headache, unsteady gait, dysarthria and blurry vision. He was seen by his flight surgeon and transferred to King Hussein Medical Center for inpatient neurology evaluation and ophthalmology consultation. MRI and lab work were normal despite his persistent symptoms. He was diagnosed with Miller Fisher Syndrome. Treatment included a course of IVIG over his 5-day hospital stay. Symptoms resolved day by day but complete recovery took six months. He was evaluated 1 year after recovery and recommended to have training flights to evaluate his ability in the jet and G-tolerance. He had no problems and was returned to full duty. **Discussion:** Even though Miller Fisher syndrome is a rare form GBS, it should be included in the differential diagnosis of a patient with neurologic and ophthalmologic symptoms and a recent illness. With the large number of SARS-CoV-2 infections flight surgeons should be aware of this potential complication. This report highlights the importance of early diagnosis and treatment of the syndrome especially on a pilot whose vision, balance and situation awareness are crucial to safe operation of an aircraft. The decision to return to flying duties should consider the low likelihood of recurrence and include a sufficient time interval to assure full resolution of symptoms.

Learning Objectives:
1. Recognize and understand how to diagnose Miller Fisher syndrome and identify treatment options.
2. Review the aeromedical policies of the US Department of Defense, Federal Aviation Authority, and international aviation standards for Guillain Barre and Miller Fisher syndrome.

[189] AAMIMO GRAND ROUNDS PRESENTATIONS

AAMIMO Physician
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

The Advanced Aerospace Medicine for International Medical Officers (AAMIMO) program is a 6-month workshop hosted by the US Air Force School of Aerospace Medicine (USAFSAM). Experienced Aerospace Medicine physicians from militaries outside of the US complete rotations with each US Dept of Defense Agency, as well as with the FAA and NASA. The workshop is meant to increase understanding and interoperability between Aerospace Medicine practitioners from all over the world. Each participant will prepare and present a clinical case, either from their country or from their experiences at USAFSAM, that will highlight similarities and differences in clinical care between the US and their home country. The participants do not begin the program until Jan 2023, they will have their case abstracts completed for submission in mid-February.

Learning Objectives
1. The audience will learn about the clinical care of the condition chosen.
2. The audience will learn about care of the aviator in US and International military environments.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon Ballroom D1-D2

[S-36]: PANEL: NEUROTICISM IN AVIATORS: SHOULD WE BE WORRIED?

Chair: Joe Wood
Co-Chairs: Monica Malcein, Justin Bunn, John Heaton, Kevin Heacock

PANEL OVERVIEW: *This panel presents original research from clinicians at the Neuropsychiatry Branch of the Aeromedical Consultation Service (ACS). The first presentation describes the concept of personality in general and neuroticism in particular and provides an overview of the literature regarding neuroticism and aviators. The second presentation examines differences in personality characteristics across three generations of pilots (Generation X, Millennials, and Generation Z), focusing on similarities and differences in the domain of neuroticism for 33,074 pilots. Next will be a presentation describing changes in pilot personality over time comparing 98 baseline neuroticism scores with results obtained during subsequent psychological evaluations at the ACS. The fourth presentation discusses the use of the NEO-PI-3 personality measure as a clinical tool for evaluating aviators*

and compares neuroticism scores for 198 pilots evaluated at the ACS who did and did not receive a recommendation for a flying waiver. The final speaker will provide two case presentations and highlight the benefits of utilizing personality measures when conducting clinical assessments.

[190] NEUROTICISM IN AVIATORS: SHOULD WE BE WORRIED?

Joe Wood
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The ability to compartmentalize and perform under pressure is a hallmark attribute of the prototypical aviator. The personality characteristic of neuroticism provides a framework with which to examine these traits. **TOPIC:** As one of the domains from the Five-Factor model of personality, neuroticism assesses emotional stability, proneness to psychological distress, and use of maladaptive coping strategies. Persons low in neuroticism are often described as calm, resilient, and secure. High scorers on neuroticism are associated with increased likelihood of developing psychiatric disorders. Thus, selecting aviators with lower levels of neuroticism can be beneficial in multiple ways. First, they would be expected to perform more proficiently during high-stress periods. Second, they would be less susceptible to developing clinical distress or disorders that would degrade their performance or cause extended periods of non-flying while treated for psychiatric conditions. Though there are some special duty programs that specifically assess for neuroticism using psychological measures, such as the NEO-PI-3, most are not. An attempt is made to screen out highly neurotic applicants indirectly through review of their medical record, with a history of diagnosis and treatment for psychiatric conditions disqualifying for most aviation positions. For those with a psychiatric history requesting a waiver to pursue an aviation-related field, use of psychological measures to help determine neurotic tendencies can be helpful in determining relative risk of recurrence of psychological distress. Personality measures have been utilized fruitfully for many decades at the Aeromedical Consultation Service as part of the intensive evaluation process. **APPLICATION:** Assessing for neuroticism can provide career fields with individuals who are more resilient and better able to handle the stressors inherent in the aviation environment. Utilizing clinical personality measures is beneficial as part of a robust clinical evaluation of aviators.

Learning Objectives

1. The audience will learn about the importance of the personality domain of neuroticism in aviators.
2. The audience will learn how personality tests that measure neuroticism can provide useful when assessing aviators for flying duties.

[191] NEUROTICISM IN AVIATORS: A CROSS-GENERATIONAL STUDY OF USAF AVIATORS FROM GENERATIONS X, Y, AND Z

John Heaton, Joe Wood III, Kevin Heacock, Jared Haynes
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Neuroticism is the tendency to experience negative emotions like anxiety, depression, and anger. Low scorers on this scale tend to have more self-confidence, are slow to become frustrated, worry little, and are able to calm themselves down effectively. People high in neuroticism are more emotionally reactive and easily stressed, thus making them more susceptible to anxiety and depressive disorders. Generational research shows that Generation Xers, Millennials, and Gen Zers view the world, work ethic, and priorities differently, and these differences can present different strengths and challenges for military service, occupational demands of aviation, and interpersonal relationships. The aim of this study is to examine similarities and differences in the domain of neuroticism of USAF aviators across three generations (X, Millennials, and Z). **METHODS:** The authors analyzed data of 33,074 pilot applicants who completed comprehensive computer-based personality (NEO-PI) testing prior to pilot selection. Those categorized as Generation X (n=2060) have birth years between 1964 and 1979 (mean age 27.53). Millennials (n=23,896) have birth years between 1980 and 1994 (mean age 23.56). Generation Z (n=7118) have birth years between 1995 and 2001 (mean age 21.26). Sample includes 29,477 (89.12%) male and 3,597 (10.88%) female. Commissioning sources include 63.71% (ROTC, OTS, AMS, other) and 36.29% (USAFA). **RESULTS:** Millennials and Gen Zers endorsed significant differences in anxiety (X: 11.47, Y: 11.50, Z: 12.53) and depression (X: 9.06, Y: 9.37, Z: 10.43) compared to their Generation X counterparts. Gen Zers endorsed significantly higher levels of vulnerability to stress (X: 6.17, Y: 6.64, Z: 7.09) compared to Gen X counterparts. Millennials showed significantly lower levels of anger hostility (X: 11.18, Y: 10.48, Z: 10.25) and impulsiveness (X: 14.29, Y: 13.57, Z: 13.11) compared to Generation X individuals. **DISCUSSION:** Differences in personality scores for pilots versus the general population illustrate the need for using pilot-specific norms and support the use of both sets of data for clinical evaluation. Personality differences found between generations are consistent with other literature based on intergenerational variability. Future research on the implications on training and retention should be of focus.

Learning Objectives

1. The audience will better understand generational differences in pilot applicants concerning susceptibility to psychological distress.
2. The audience will better understand how USAF pilots differ from the general population.

[192] THE PERSONALITY TRAIT OF NEUROTICISM IN A CLINICAL SAMPLE OF USAF PILOTS

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: The personality dimension of neuroticism, the tendency to experience negative emotions, has been shown to predict the development of anxiety and depression in the general population. Within the USAF, the assessment of personality traits on the NEO-PI has been studied in student pilots, with a consistent finding of lower neuroticism compared to the general population. Few studies have focused on NEO-PI in clinical evaluation of trained pilots and little is known about neuroticism scores in a population of pilots referred for clinical evaluation. **METHODS:** 98 USAF pilots with mental health diagnoses were evaluated at the ACS for waiver recommendation. All pilots underwent cognitive and psychological assessment, including the NEO-PI-R or NEO-PI-3. The neuroticism factor and facet scores were compared to the general population. Additionally, differences were explored on the neuroticism factor and facet scores for those that received recommendation for waiver versus those that were not. **RESULTS:** Compared to general population on the NEO-PI, trained pilots with a history of mental health diagnosis exhibited overall lower levels of neuroticism ($p < 0.5$). All neuroticism facet scores were lower than the general population, with the vulnerability to stress facet score producing the largest effect size (d=.89). Those recommended for waiver (n=156) exhibited lower levels of anxiety, anger/hostility, depression, and vulnerability to stress than those not recommended for waiver (n=33), although these findings were not significant. While there were differences between the two groups (waiver vs. disqualified), the average scores for both groups remained lower than the general population. **DISCUSSION:** The overall neuroticism score on the NEO-PI in the clinical population of trained USAF pilots referred for clinical evaluation with history of mental health diagnosis was significantly lower than those in the general population. This was observed across all facets of the N scale, with the clinical pilot population exhibiting lower anxiety, anger, depression, impulsivity, and vulnerability to stress than the general population. Pilots that were not recommended for a waiver due to ongoing clinical symptoms, slightly higher scores on neuroticism facets were seen, but remained considerably lower than the general population. These findings may assist with the interpretation of the neuroticism factor when evaluating trained pilots in a clinical setting.

Learning Objectives
1. The audience will develop a basic understanding of the personality trait of neuroticism in the pilot population.
2. Data related to levels of neuroticism in the clinical population will provide context for interpretation in the clinical context.

[193] COMPARING THE PERSONALITY TRAIT OF NEUROTICISM IN A CLINICAL SAMPLE OF USAF PILOTS FROM INITIAL FLIGHT SCREENING TO FLIGHT WAIVER

Justin Bunn
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The five-factor model describes the structure of normal personality traits, dividing personality into five dimensions, including neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (Costa & McCrae, 1992). Each dimension has identified personality traits or facets utilized to further describe the dimension. For example, the dimension of neuroticism is composed of the facets of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. Individuals who experience these facets at higher levels often describe tendencies to experience more negative emotions, such as fear, sadness, anger, and guilt. Given the potential psychological impact of traits of neuroticism, the USAF administers the NEO-PI to pilot applicants as a baseline measure to assess for the five dimensions of personality. If a trained pilot then develops a mental health diagnosis that requires a flying waiver, the measure can be repeated and compared with the baseline administration. With personality dimensions and traits considered to be fairly stable across the lifespan, changes in dimensions, particularly neuroticism, could aid in providing important information in the clinical evaluation and diagnosis of Air Force pilots. **TOPIC:** 198 USAF pilots with mental health diagnoses were evaluated at the ACS for waiver recommendation. During the medical flight screening (MFS) process, the pilots had completed the NEO-PI-R or NEO-PI-3 and the assessment was re-administered as a part of their evaluation for waiver. This presentation discusses the comparison of baseline MFS scores with those attained during the mental health waiver evaluation, with a particular focus on the neuroticism factor and facet scores. Additional discussion will focus on the differences on the neuroticism factor and facets scores for those who received a waiver recommendation vs. those who did not. **APPLICATION:** This presentation will explore differences in the factor and facet scores of neuroticisms on the NEO-PI for pilot applicants who are then evaluated following the development of a mental health diagnosis. Scores of those who received a waiver recommendation vs. those who did not will also be explored. These comparisons will invite discussion on the potential clinical utility of assessing for changes in the trait of neuroticism and its facets.

Learning Objectives
1. The audience will learn about the potential clinical utility of assessing for changes in the trait of neuroticism and its facets in the pilot population.
2. The participant will be able to identify the specific facets of neuroticism and how they impact the psychological experience of the individual.

[194] EXAMINING THE PERSONALITY TRAIT OF NEUROTICISM IN THE CLINICAL EVALUATIONS OF PILOTS: CASE ILLUSTRATIONS

Kevin Heacock
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The personality dimension of neuroticism, the tendency to experience negative emotions, has been shown to predict the development of anxiety and depression. Within the USAF, baseline assessment of personality traits is accomplished with the NEO-PI and studies have consistently documented lower neuroticism scores in this population compared to the general population. When trained pilots are seen for clinical evaluation following the diagnosis and treatment of a mental health condition, these baseline scores are available for comparison to current scores in the clinical setting. Changes in these scores over time can represent changes in mental health status that would prompt further examination. **TOPIC:** Case presentations incorporating amalgamated information related to pilots' current level of neuroticism, compared to the pilot population, the general population, and the pilots'baseline data will be presented to highlight the usefulness of assessing this trait in the clinical evaluation. Case #1 features a pilot presenting for evaluation with a history of depression and anxiety treated with an antidepressant. Comparison of NEO-PI scores obtained during clinical evaluation revealed significantly higher neuroticism scores than those seen at baseline, consistent with clinical symptomatology. Case #2 describes a pilot seen for several clinical evaluations with variability in symptoms of anxiety across time. NEO-PI obtained at baseline and atsubsequent evaluations mirrored the clinical anxiety symptoms he was experiencing at that time, suggesting the NEO-PI can be useful to track progression of symptoms. **APPLICATION:** The evaluation of the personality trait of neuroticism in the clinical population of trained pilots can be a useful adjunct for assessing current clinical symptomatology. When there is a deviation from baseline scores or from the pilot norm, further exploration of the facets of neuroticism can provide useful information in the clinical setting.

Learning Objectives
1. The participant will be able to see how useful the NEO-PI can be in tracking mental health symptom progression.
2. The audience will learn about the use of the NEO-PI to further explore facets of neuroticism in the clinical setting.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon C3

[S-37]: PANEL: PILOT SPATIAL DISORIENTATION RESEARCH, MODELING, AND MITIGATION

Chair: Richard Arnold
Co-Chair: Brennan Cox

PANEL OVERVIEW: *Pilot spatial disorientation (SD) remains a leading contributory and causal factor in flight mishaps. 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 knowledge, technologies, and research tools are producing better understanding of SD phenomena and should ultimately lead to more effective SD mitigations. This panel will expand upon research featured in our 2022 AsMA panel by highlighting recent and current efforts to understand, characterize, and model sensory, perceptual, and cognitive factors involved in spatial orientation. The panel will discuss research and modeling of vestibular sensation and perception, visual perceptual illusions, sensory integration, and operational contributors to SD. 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.*

[195] RECOMMENDATIONS FOR SPATIAL ORIENTATION MODELING WITH REALISTIC COCKPIT ENVIRONMENTS AND MULTI PHYSIOLOGICAL AND NEUROLOGICAL VARIABLES

Fred Patterson, Richard Folga
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(Education - Program/Process Review)

BACKGROUND: Historically, spatial disorientation (SD) and spatial orientation modeling (SOM) research has focused on vestibular sensory misperceptions as the primary cause of pilot SD. Most SOM investigations concentrated on fixed head vestibular accelerations in dark environments where subjects maintained a strict vertical head alignment with their body and the apparatus. **OVERVIEW:** Aircraft accident statistics and pilot surveys consistently indicate visual misperceptions cause SD episodes at a much higher rate than vestibular anomalies. Additionally, conflicting with the fixed head orientation concept is validated aeromedical research that documents pilots rarely maintain head alignment with the cockpit during VMC roll and pitch maneuvers; instead, during VMC maneuvers visually driven spatial reflexes, such as the opto-kinetic cervical reflex (OKCR) trigger continuous head movement away from the cockpit vertical axis, toward the horizon. Researchers investigating human cognition have also discovered there are at least three types of overlapping spatial cells in mammalian brains - head direction, boundary, and grid cells - which are thought to function similar to a compass rose for orientation in 3D environments. Since spatial cognition is, "understanding through thought, experience, and the senses", variables related to limbic spatial cells should be considered critical components for defining future pilot spatial orientation models. **DISCUSSION:** To improve on the accuracy of SOM to predict pilot SD, an expanded taxonomy of existing pilot human factor variables should be added to the SOM criteria. Recommended variables for inclusion are: sight picture dynamics of visual primary and secondary spatial cues, sensory processing bandwidths, pilot spatial strategies, sensory spatial reflex interactions, and interactions of brain spatial cells. Since pilot vestibular accelerations are directly related to continuous changes in head position relative to the aircraft, in order to create an accurate in-flight dynamic vestibular model, it will be necessary to include OKCR head movement variables. While some SOM research papers mention task saturation as a contributing SD factor, human cognitive processing bandwidth limits were not incorporated into SOM conventions. Since there exists validated information describing functional limits of human sensory, working, and long-term memories, these variables should be included with any pilot SOM taxonomy.

Learning Objectives

1. The participant will be able to recognize that the most prevalent causes of pilot spatial disorientation are visual cognitive processing problems.
2. The Participant will be able to understand pilot spatial awareness and spatial orientation are dependent upon spatial strategies derived from dynamic pilot sight pictures involving primary, secondary, and tertiary visual spatial cues.
3. The participant will be able to understand that accurate Spatial Orientation Modeling (SOM) should prioritize an expanded taxonomy of existing pilot human factor variables that include sight picture dynamics of visual primary and secondary spatial cues, sensory processing bandwidths, pilot spatial strategies, sensory spatial reflex interactions, and interactions of brain spatial cells.

[196] THREE CANDIDATE LAWS THAT GOVERN MUCH OF SENSORY INTEGRATION

Vincent Billock[1], Adam Preston[2]
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(Original Research)

INTRODUCTION: Sensory integration is a discipline that has an abundance of beautiful data and a modicum of theoretical principles, chief among them Stein and Meredith's three Principles of Spatiotemporal Coincidence and Inverse Enhancement. This is inadequate. We need to understand sensory combination and sensory interaction quantitatively, to feed into models of sensory performance and disorientation. **RESULTS:** We extensively mined neural and behavioral data for the simplest theoretically motivated quantitative rules that model sensory integration and other sensory interactions. We found three so far: (1) Gated Amplification: A simple power law beautifully models both modulated multisensory cell firing rates and behavioral data for multisensory perceptual magnitude. The power law has a compressive exponent that agrees with the Principle of Inverse Enhancement. Gated amplification also explains some aspects of color perception and binocular facilitation. (2) Nonlinear Summation: Minkowski's nonlinear summation formula is a good model for facilitatory bimodal neuron firing rates and the cortical neural model matches the psychophysical results. (3) Nonlinear Weighted Averaging: It has always been a mystery what suppressive bimodal neurons are for. We find that most multisensory suppressive neurons seem to compute weighted averages of sensory inputs and thus resemble Bayesian-like reliability-weighted models already used for some psychophysical data. Bayesian averaging is difficult to implement in wetware. Amusingly, the neural data for both multisensory and binocular neurons is better fit by Schrödinger's 1926 nonlinear magnitude-weighted equation, originally used to explain binocular averaging. These nonlinear means may have Bayesian ends. **METHODS:** Theoretical only – nonlinear models of neural and psychophysical data. **DISCUSSION:** Three simple mathematical rules account for virtually all of the neural and psychophysical data modeled so far in three domains: sensory integration, color vision and binocular vision. It is not always obvious in advance which of these three rules will apply. However, the applicability of these rules across sensory domains and the remarkable fits obtained suggest that these rules are generic neural mechanisms broadly available within and across sensory domains. These rules should be considered candidate laws of sensory integration and sensory interaction.

Learning Objectives

1. Understand the difference between faciliatory and suppressive/non-faciliatory interactions in sensory systems.
2. Understand the options that the brain has for combining information.

[197] MODELING VESTIBULAR ADAPTATION TO GRAVITY TRANSITIONS

Victoria Kravets, Aaron Allred, Torin Clark
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(Original Research)

INTRODUCTION: Following a gravity transition, astronauts experience sensorimotor impairment, including spatial orientation misperception, motion sickness, and ataxia. The Central Nervous System (CNS) eventually reinterprets altered sensory cues, but with only a conceptual understanding of this adaptation process, we cannot make the operational decisions (e.g., timing of extravehicular activities) necessary to ensure the safety and performance of the crew. Here, we present a computational model of vestibular adaptation to gravity transitions, enabling the modeling of this impairment mechanism. **METHODS:** The overarching model utilizes several Observers (a well validated model of spatial orientation perception) in parallel, each positing a different magnitude of gravity and generating a distinct sensory conflict signal. From these signals, a posterior probability distribution of the current magnitude of gravity is formulated and updated over time via Bayesian inference in conjunction with a particle filter algorithm. Notably, the model retains a "memory" of past states, allowing the model to consider previously experienced gravity levels (while also dynamically learning new states) when formulating new parallel alternative hypotheses of gravity. From the posterior probability distribution, an estimate (e.g., MMSE) of gravity is produced, driving a central Observer model of spatial orientation perception. **RESULTS:** The model dynamically adapts during gravity transitions without direct input of the true gravity level. Simulating the model with various gravity transitions and self-motions suggests different relative rates of adaptation. For example, more dynamic motion is predicted to increase the adaptation rate. Additionally, the stochastic nature of the gravity "learning" process

generates slightly different paths of adaptation for each simulation. **DISCUSSION:** We present the first computational model of the CNS's adaptation to transitions in the magnitude of gravity. Our model offers quantitative explanations for why astronauts experience different sensations while adapting to the same environment and why repeat flyers adapt to gravity transitions more quickly. Overall, this model generates quantitative predictions that can motivate future experimental work, and with experimental validation, it could also predict the severity and time-course of sensorimotor impairment associated with gravity transitions.

Learning Objectives

1. The audience will learn about sensorimotor impairment associated with space flight.
2. The audience will learn about potential computations involved in the Central Nervous System's adaptation to changing environments.

[198] MODELING ORIENTATION PERCEPTION DURING SUDDEN TRANSITIONS IN VISUAL CUE AVAILABILITY

Jamie Voros, Torin Clark
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(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). We begin by collecting data on angular velocity perception about an Earth vertical axis. We present a modified model of orientation perception that is consistent with our collected data. **METHODS:** Eleven subjects (3 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. Based on the timing of subject reports of rotation, we inferred their perception of angular velocity. **RESULTS:** We found there was a delay on the order of ten seconds in which angular velocity perception transition based upon when visual cues suddenly became available. In the inverse scenario (visual cues suddenly lost), we saw a roughly 30 second period over which angular velocity perception adjusted. Based on the delay time following a visual cue availability transition, we hypothesize low pass filtering may be occurring along the sensory conflict channel of the existing class of observer models of perception. **DISCUSSION:** We present a model of orientation perception that is robust to sudden transitions in visual cue availability. Adding low pass filtering at key stages of the sensory conflict model of orientation perception has allowed model predictions to become more consistent with our human subject data and can help inform potentially disorienting scenarios experienced by pilots.

Learning Objectives

1. The participant will be able to understand how orientation perception changes during a sudden transition in the availably of visual cues.
2. The participant will understand the current state of orientation perception modeling and why the presented model is consistent with our data.
3. The participant will understand what scenarios the model has not been verified for and what open questions still exist.

[199] VESTIBULAR PERCEPTUAL THRESHOLDS ARE INCREASED BY HYPOXIA

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[1]*Ohio State Wexner Medical Center, Columbus, OH, United States;* [2]*University of Dayton, Dayton, OH, United States;* [3]*Naval Aerospace Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Pilots are exposed to a variety of factors that may impact their ability to detect where they are relative to the environment including hypoxia. Despite the potential for hypoxia to impact our ability to detect where we are relative to the environment no prior studies have examined the impact of hypoxia on vestibular function in humans. Given this state of knowledge, we performed a study to begin to investigate how mild hypoxia impacts the vestibular system, specifically vestibular thresholds. **METHODS:** Using a MOOG movement platform in conjunction with a Reduced Oxygen Breathing Device (ROBD) we had 15 participants complete multiple sessions of z translation threshold tests while breathing gases with an oxygen content consistent with 0 feet and 8,000 feet. Thresholds were determined based upon participants responses on a 2 alternate forced choice recognition task which were used to adaptively select the next stimulus. **RESULTS:** We found that 86.7% of the participants' median z translation thresholds were higher when breathing gases with an oxygen content comparable to 8,000 feet than when breathing gases with an oxygen content comparable to 0 feet. The median z translation threshold was 24.1% higher in the hypoxia condition. In other words, larger movements up/down were needed for participants to reliably sense them. Additionally, 46.7% of participants exhibited acclimation effects. **DISCUSSION:** The results of the present study suggest that mild hypoxia (i.e. 8,000 feet; the altitude commercial air lines pressurize at) can impact our ability to reliably sense whether we moved up or down. Specifically, when hypoxic it takes larger movements for us to be able to sense them. Additional research is needed to determine the exact mechanism(s) of this effect and if this generalizes to other types of motions (e.g. roll-tilts). Regardless, the results of this study suggest that it may be beneficial to use supplemental oxygen at altitudes as low as 8,000 feet.

Learning Objectives

1. The participant will understand what vestibular thresholds are and how they relate to flight.
2. The participant will understand the effect of hypoxia on vestibular thresholds.

[200] THE IMPACT OF HYPOXIA AND WORKLOAD TYPE ON SPATIAL DISORIENTATION IN SIMULATED FLIGHT

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Naval Medical Research Unit-Dayton, Dayton, OH, United States

(Original Research)

INTRODUCTION: Spatial disorientation (SD) refers to a pilot's misperception of the attitude, position, or motion of the aircraft with respect to the Earth, gravitational vertical, and/or other objects. SD is a leading cause of fatal mishaps in military and civilian aviation. Another threat to aviation safety is hypoxia, and numerous studies have shown that hypoxia can impair sensory, cognitive, and motor performance. However, hypoxia's impact on the likelihood of SD is still not well understood; the present study was designed to fill that knowledge gap. **METHODS:** This study was approved by the NAMRU-D IRB. Twenty pilots flew simulated formation-flights requiring them to follow and maintain altitude/heading with a lead aircraft in both visual and instrument meteorological conditions (IMC). Participants also performed unusual attitude (UA) recoveries in IMC. Each pilot breathed a normoxic gas mixture in one flight session, and a hypoxic mixture in another session on another day (equivalent altitudes of 277 m [910 ft] MSL and 5334 m [17,500 ft] MSL, respectively). Two different workload conditions were presented on the formation flights: either a verbal Working Memory Task (WMT) or a spatial Variable-Following-Distance Task (VFDT). **RESULTS:** Subjective workload and SD ratings both increased significantly with hypoxia and in IMC. VFDT and altitude error also increased with hypoxia. For UA recoveries, the duration and severity of deviation from straight and level flight increased in the hypoxic condition, but WMT speed and accuracy and number of control reversal errors were not significantly affected. On formation flights, the VFDT, but not the WMT, led to more time spent banked past 60° in IMC.

DISCUSSION: Hypoxia had significant detrimental effects on four of the five dependent measures that were spatial in nature (SD ratings, VFDT error, altitude error, and UA recovery). The non-spatial WMT was not significantly impacted. This pattern of results suggests that hypoxia negatively affects spatial resources/processing and may increase a pilot's SD susceptibility. Regarding workload type, the VFDT (but not the WMT) led to more severe bank angles in IMC, suggesting spatial resource competition. Future work should further explore spatial/verbal cognitive resource allocation and any effects on likelihood of SD.

Learning Objectives

1. The audience will understand that spatial disorientation SD is one of the leading causes of fatal mishaps in military and civilian aviation.
2. The audience will understand that hypoxia can increase the likelihood of SD.
3. The audience will understand that it is usually advisable to employ more than one measure of SD to detect an SD event.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Ballroom A-B-C

[S-38]: PANEL: IMPACT-ING EXPLORATION SPACEFLIGHT RISK PREDICTION AND MEDICAL SYSTEM DESIGN

Chair: Benjamin Easter
Co-Chairs: Kris Lehnhardt, Jay Lemery

PANEL OVERVIEW: *Human exploration spaceflight missions to the Moon and Mars present unprecedented challenges for in-mission medical care. Compared with the ISS, the greater distance from Earth will mean increased mission durations, communication delays, limited to no resupply opportunities, and significant limitations on the evacuation of ill or injured crew. Spacecraft mass, volume, and power will be curtailed while higher demands will be placed on the crew's knowledge, skills, and abilities. In this higher risk environment, it is important to: a) quantitatively estimate human system risk attributable to medical conditions, a process known as Probabilistic Risk Analysis, and b) use these estimates to inform medical system design. IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) is a PRA and medical trade space analysis tool developed by NASA to advance exploration mission medical system design. IMPACT improves upon and will soon replace NASA's existing tool, the Integrated Medical Model, with: a novel evidence base baselined to exploration environments; an expanded list of 120 medical conditions; a significant increase in the number of medical resources that can be utilized and in the flexibility of their use; and the modelling of time lost performing mission-specific tasks due to medical conditions. IMPACT provides evidence-based, mission-specific PRA estimates of in-flight medical risk and an initial list of clinical capabilities and medical resources/hardware to be considered. In addition, sophisticated trade space capabilities estimate how human system risk varies with changes to the mission architecture or medical capability set (e.g., if the system mass constraint decreases by 10% or ultrasound is removed). This panel will provide an overview of IMPACT, its intended use cases, and future development plans. The panel will be the first public presentation of IMPACT results, including medical risk estimates for extended duration Artemis missions, the medical conditions most influencing medical risk metrics, and the clinical capabilities that have the largest effect on medical risk.*

[201] INTRODUCTION TO THE IMPACT PROBABILISTIC RISK AND TRADESPACE ANALYSIS TOOL FOR MEDICAL SYSTEM DESIGN

Benjamin Easter[1], Jon Steller[2], Amy Kreykes[2], Jay Lemery[1], Arian Anderson[3], Emily Stratton[2], Ariana Nelson[2], Chris Zahner[2], Eric Kerstman[2], David Hilmers[4], Dana Levin[2]
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(Education - Program/Process Review)

BACKGROUND: Probabilistic risk analysis (PRA) is a method for estimating risk in complex engineered systems that, at a basic level, focuses on what can go wrong and the likelihood and consequences of those occurrences. NASA has used PRA as an integral component of medical system risk estimation and design for spaceflight. IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) is a novel tool to meet these goals for exploration missions. **OVERVIEW:** IMPACT performs hundreds of thousands of Monte Carlo simulations of missions to build aggregate pictures of medical risk. These simulations are based on 120 possible medical conditions (the IMPACT Condition List) selected in a consensus-based process because they are of highest likelihood and/or consequence for exploration spaceflight. The conditions are then tied to clinical capabilities which can be used for management (e.g., inserting an IV) and then to over 600 specific resources needed to deliver a capability (e.g., an angiocath or an ultrasound). Different mission profiles can be simulated with user-specified inputs such as mission duration, destination, number of crew and pre-existing medical conditions, and EVA frequency. While the IMPACT evidence base is designed for exploration environments, these user inputs allow the tool to be used across a broad range of missions. IMPACT's primary outcome metrics include loss of crew life (LOCL, a measure of in-flight mortality due to medical conditions), need for evacuation (RTDC, return to definitive care), and crew disability (TTL, task time lost based on how medical conditions impact the ability to perform over 1000 specific exploration mission crew tasks). In addition to modeling medical risk, IMPACT also accepts user-specified constraints, such as limitations of mass or volume, and will output a recommended clinical capability set and specific medical resources that meet the mission constraints. **DISCUSSION:** This abstract will provide an introduction to IMPACT and describe the nature of the underlying medical evidence. It will also detail potential use cases for how this tool can be utilized by NASA or commercial spaceflight providers.

Learning Objectives

1. The participant will be able to describe how the IMPACT tool models medical risk.
2. The participant will define the primary outcome metrics for IMPACT (loss of crew life, return to definitive care, and task time lost).

[202] IMPACT OUTPUTS FOR A REPRESENTATIVE EXTENDED DURATION ARTEMIS MISSION

Jonathan Steller[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Emily Stratton[1], Arian Nelson[1], Eric Kerstman[1], David Hilmers[4], Kris Lehnhardt[2]
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(Education - Program/Process Review)

BACKGROUND: As NASA and private industry begin preparation for long-duration spaceflight, quantifying the impact that potential human health and performance capabilities have on crew health outcomes is imperative for medical risk mitigation. NASA's Informing Mission Planning via Analysis of Complex Tradespaces tool (IMPACT) applies Probabilistic Risk Assessment (PRA) methodology to estimate these outcomes. **OVERVIEW:** As NASA prepares to return to the Moon, medical system planning has already begun for extended Artemis missions, which will see humans spending months at a time in cis-lunar space and on the surface of the Moon. The Long Duration Lunar Orbital and Lunar Surface (LDLOLS) design reference mission (DRM) lasts 9 months, including 3 months on the lunar surface, and involves 2 male and 2 female crewmembers. LDLOLS assumes no extravehicular activities (EVAs) in orbit, but, while on the lunar surface, involves 2-4 EVAs/month in a pressurized rover and 2-4 EVAs/month in an unpressurized rover or on foot. This DRM assumes a physician level Crew Medical Officer with commensurate knowledge, skills, and abilities. The IMPACT tool was utilized to estimate in-flight medical risk for this mission. More specifically, 100,000 simulations of this DRM were modeled, and overall estimates for loss of

crew life (LOCL), need for evacuation (RTDC; return to definitive care), and crew task time lost (TTL; a measure of disability) were calculated. A recommended medical capability set, with appropriate mass and volume constraints, was also generated. **DISCUSSION:** This abstract reviews the IMPACT-derived risk of these mission outcomes with and without treatment, a macroscopic look at the total mass and volume necessary for full diagnostic and treatment capability, and how these change with input mission parameters.

Learning Objectives

1. The audience will learn about the Long Duration Lunar Orbital and Lunar Surface (LDLOLS) design reference mission (DRM).
2. The audience will learn about mission outcome predictions by IMPACT using the LDLOLS DRM.
3. The audience will have an overview for the medical resourcing predicted by IMPACT using the LDLOLS DRM.

[203] DERIVATION OF THE MOST INFLUENTIAL MEDICAL CONDITIONS FOR AN EXTENDED DURATION ARTEMIS MISSION

Ariana M. Nelson[1], Jon G Steller[1], Kamal Shair[1], Rosemarie Dizon[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Emily Stratton[1], Chris Zahner[1], David Hilmers[4], Kris Lehnhardt[2]

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(Education - Program/Process Review)

BACKGROUND: The risk of loss of mission due to medical conditions may be influenced by loss of crew life (LOCL), need for evacuation (RTDC; return to definitive care), and crew task time lost. Predicting what medical conditions are most likely to lead to crew morbidity and mortality may influence medical system design, clinical capability prioritization, and research strategies. NASA's Informing Mission Planning via Analysis of Complex Tradespaces tool (IMPACT) applies Probabilistic Risk Assessment (PRA) methodology to assess these risks. **OVERVIEW:** A team of subject matter experts (SME) from a variety of medical disciplines developed a consensus-based process to determine 120 of the most clinically relevant medical conditions for long-duration exploration missions (LDEMs). This IMPACT Condition List (ICL) expanded upon previous work done for Integrated Medical Model (IMM). For each condition a best-case and worst-case definition were derived. These definitions were used to identify probability of occurrence, proportion of cases that are best case vs. worst case, clinical phase duration, and risk of outcomes (task time loss [TTL], RTDC, and LOCL) for both treated and untreated states. These data were sources from existing spaceflight databases (e.g. Longitudinal Survey of Astronaut Health), relevant models (e.g. the ISS fire model), and/or terrestrial literature. Each condition was then tied to diagnostic and therapeutic resources and capabilities. IMPACT was then run for the LDLOLS DRM (see Abstract #2 for this panel). **DISCUSSION:** This abstract will present the process for generating the IMPACT condition list, the relevant data for each clinical condition, and present results for the ten most influential conditions impacting LOCL, RTDC, and TTL for a representative extended duration Artemis mission.

Learning Objectives

1. Describe how the Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) Condition List (ICL) was formulated and its importance with respect to probabilistic risk assessment for long duration spaceflight missions.
2. Explain how the incidence, clinical phase duration, and probability outcomes were determined for each medical condition in the IMPACT tool.
3. List the ten most influential medical conditions impacting loss of crew life (LOCL), return to definitive care (RTDC), and task time lost (TTL) for the representative extended duration lunar Artemis mission.

[204] IMPACT IDENTIFIED MEDICAL CAPABILITIES WITH LARGEST EFFECT ON MEDICAL RISK FOR EXPLORATION SPACEFLIGHT

Arian Anderson[1], Steller Glenn[2], Dana Levin[2], Jay Lemery[3], Emily Stratton Emily[2], Ariana Nelson[2], Amy Kreykes[2], Chris Zahner[2], Eric Kerstman[2], David Hilmers[4], Kris Lehnhardt[3]

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(Education - Program/Process Review)

BACKGROUND: Spaceflight medical system design will require a significant change as missions transition from low earth orbit to deep space missions. The risk of a medical event leading to mission failure has been projected to increase while the available resources, and support will decrease due to the constraints inherent to these missions. Thus far, identifying what to include in a medical system been based on prior experience which may be less accurate with changing mission goals. We aim to use the IMPACT software to model lunar missions and identify which capabilities have the largest effect on reducing medical risk to provide evidence-based guidance for medical system design. **OVERVIEW:** NASA previously identified 120 medical conditions with the largest contribution to medical system risk on a deep space mission. We developed an evidence library (EvLib) of medical condition incidence, likelihood of loss of crew life, and medical capabilities required to treat each condition based on best available data. EvLib used as inputs for IMPACT, a trade space analysis tool to perform probable risk assessment on these conditions and capabilities to identify those with the largest effect size. We identified the 10 medical conditions with the largest effect on medical system risk. Among these 10 conditions were respiratory infection, choking on foreign body, abnormal uterine bleeding, etc.… The medical capabilities that had the largest effect on reducing these risks included history taking, performing a physical exam, antibiotics, and pain medication. **DISCUSSION:** By utilizing IMPACT to model 100,000 simulated lunar missions, we were able to identify which conditions contributed to medical risk and which resources most significantly reduced this risk. The capabilities and resources with the largest effect involved a very basic approach to care included performing a history and physical, ultrasound, and treatment with antibiotics or pain medication. Larger and more technical equipment like an AED had a small effect on reducing mission risk. These model-based outputs can help provide an evidence-based approach to medical system design that can be then combined with prior experience in spaceflight to create the optimal medical system for exploration class missions.

Learning Objectives

1. Understand a specific example and application of trade space analysis tools.
2. The conditions with the largest effect on astronaut crew health in deep space long duration spaceflight.
3. The medical resources with the largest reduction in medical risk during deep space long duration spaceflight.

[205] FUTURE IMPROVEMENTS TO IMPACT FOR LONG DURATION EXPLORATION SPACEFLIGHT

Emily Stratton[1], John Steller[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Ariana Nelson[1], Amy Kreykes[1], Eric Kerstman[1], Kris Lehnhardt[2], Benjamin Easter[2]

[1]*KBR, Houston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*University of Colorado Department of Emergency Medicine, Aurora, CO, United States*

(Education - Program/Process Review)

BACKGROUND: While NASA currently uses the Integrated Medical Model (IMM) to model spaceflight medical risk for Low Earth Orbit missions, IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) was created to improve the fidelity of medical risk analysis

for exploration missions involving the Lunar surface and beyond.
OVERVIEW: While completion work continues on the initial version of the IMPACT tool, work has already begun to investigate ways to further enhance the fidelity of the model and its utility to stakeholders.
DISCUSSION: Future additions leveraging the more robust and flexible IMPACT architecture include analyzing mission segments to account for segment-specific environments (ie. Lunar surface or microgravity), clinically tracible outcomes based on partial treatment of conditions, the ability to model mission outcomes based on provider Knowledge, Skills, and Abilities (KSAs), and the ability to affect the incidence of conditions based on the occurrence of related conditions (e.g. UTI progressing to sepsis). IMPACT also enables the addition of new conditions to its database as required to meet future risk assessment needs. Ultimately, the desire is to broaden IMPACT from a tool that models/trades medical risk to one that does so for all crew health and performance relevant systems (e.g., food, exercise, etc.).

Learning Objectives

1. The audience will review more about what IMPACT is and does.
2. The audience will learn about future proposed directions for IMPACT.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Ballroom D-E

[S-39]: PANEL: ALPHA-1 ANTITRYPSIN DEFICIENCY: A HORSE AMONG ZEBRAS

Chair: Mark Ivey

PANEL OVERVIEW: *Alpha-1 Antitrypsin Deficiency (AATD) is an autosomal co-dominant genetic disorder first discovered in 1963. Considered among most providers to be primarily a lung or liver issue, the incomplete penetrance and varied clinical presentations add to the confusion and lack of confidence in screening practices. Most clinicians consider this a rare disorder; however, AATD is implicated in many chronic medical issues and frequently overlooked. Replicated studies have confirmed the average time from symptom onset to diagnosis is just over seven years including referrals to three specialists. Two issues emerge regarding AATD; it is relatively common and frequently under-recognized in the management of chronic disease. Research has shown that poor screening rates from lack of provider knowledge and comfort in the management of genetic disorders are linked to missed opportunities and delayed diagnosis. Since its discovery, persistence in research has led to effective methods of surveillance, treatment protocols and curative options. Despite the publication of the ATS guideline in 2003, only 10% of cases are diagnosed in the US. Increasing provider knowledge in risk stratification and identifying local resources will reduce delays to diagnosis, healthcare resource burden and improve patient QOL.* ***AEROMEDICAL IMPLICATIONS:*** *Civil AME's are often the first point of contact for medical care. In the military, the flight surgeon's team provides both direct and policy-driven care. It is important to note that there are no recommendations for screening asymptomatic members. But AATD must be considered in those with specific risk factors and those members should be tested.*

[206] ALPHA-1 ANTITRYPSIN DEFICIENCY: A SYSTEMIC DISEASE

Cynthia McNerlin
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Tutorial/Review)

In the years of data accumulation since its discovery in 1963, AATD reported rates in the US are still only 10% of expected cases. The majority of the literature published focuses on the anatomic changes and functional impact on the pulmonary and hepatic systems. However, smaller studies and systematic reviews highlight AATD impact on other systemic chronic disease processes. AAT is an important inhibitor of proteolytic enzymes including elastase and collagenase and believed to play a role in maintaining the structural integrity of connective tissues. The balance between proteinases and their inhibitors is important in maintaining the structural integrity of the connective tissues in arterial walls. Studies suggest a correlation between the PiS and PiZ alleles and aneurysmal formation including Cerebral Aneurysms, particularly in those homozygotes. AATD is also implicated in 8% of patients with Primary Spontaneous Pneumothorax (SPTX) and rheumatological disorders including Fibromyalgia Syndrome. Multinational studies have recommended screening for AATD in those with Fibromyalgia. The full extent of the consequences from AATD aren't entirely realized in part due to low reporting rates and poor screening habits. Screening protocols and disease management practices may be reconsidered if AATD is identified in those individuals. Barriers to screening include provider knowledge, comfort in discussing genetic disorders, time commitments and personnel. Lack of screening, delays disease identification, prolongs time to treatment, patient education and counseling and family testing. Statewide and National resources are available for assistance in screening and referrals for patient management and support.

Learning Objectives

1. The participants will be able to identify risk factors of AATD in those patients with non-lung, non-liver related disease.
2. The participants will be able to recognize local and national resources for AATD support for providers and patients.
3. The participants will recognize the barriers to AATD screening and learn methods of implementing screening protocols within their own clinics.

[207] AATD CASE REVIEWS AND AEROMEDICAL IMPLICATIONS

Mark Ivey
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Program/Process Review)

Alpha-1 is a common genetic disorder that presents with common symptoms attributable to other common pathologies. As a consultant to the airlines, the Federal Air Surgeon (FAS) and the DoD, our office is often the first to give consideration to Alpha-1. We will highlight 4 aeromedical cases presented to our office where Alpha-1 was first considered and ultimately found to be relevant. Case 1: Commercial pilot. FAS Consult for a 38 yo commercial pilot with recurrent SPTX. Case 2: USN Aviator with progressive obstructive lung disease and bronchiectasis. Case 3: Student pilot age 56 with new onset 4th CN palsy causing dipoplia and associated with a berry aneurysm. Case 4: "The brothers". Charlie PiMZ, lifelong smoker. FEV1 68%. Michael PiMM. Lifelong never smoker. FEV1 33%. Few patients present as 'text-book' cases of AATD. It is incumbent of each provider using a thorough history to include 3 generations of family history to recognize atypical patterns and use 'outside the box' critical thinking in order to identify the underlying genetic disorder. The main objective of these real patient presentations is to review common and uncommon presentations of AATD, decisions to screen, management decisions and extract take home lessons for other providers. Each case outlines non-standard presentations of AATD with common chief complaints. Not uncommonly, reports from the literature, or their absence, are cited that either directly support or contradict the findings. Outdated guidelines are often used in argument against screening those patients who do not fit into the typical profiles originally cited 20 yr ago.

Learning Objectives

1. Attendees will recognize the variability in the presentations of AATD.
2. Attendees will identify uncommon risk factors for AATD in the aeromedical community.
3. Attendees will learn when screening for AATD is appropriate by policy.

[208] ALPHA-1 ANTITRYPSIN DEFICIENCY: HISTORY AND DISEASE PATHOLOGY

David Mares
Medical Specialists of Madison County, PC, Anderson, IN, United States

(Education - Program/Process Review)

Alpha 1 Antitrypsin Deficiency (AATD) is an autosomal recessive disease with partial penetrance that results in a more rapid decline in lung function compared with nonaffected individuals and the potential for premature onset of chronic obstructive pulmonary disease, emphysema, and bronchiectasis. The gene codes for a protein that protects lung parenchyma from the oxidative damage that we experience daily, some more than others based upon occupation or personal habits. The disease is much more prevalent than other recessive diseases due to a high prevalence of carriers of AATD. This leads to the potential for serial generations to be impacted, otherwise not expected in autosomal recessive diseases. Partial penetrance also results in more persons affected through high level oxidative stress resulting in disease even among carriers. This disease can be devastating to its victims, causing severe morbidity and mortality but can also cause milder symptoms earlier in the process. Also, the symptoms of AATD mimic many other pulmonary processes. Unfortunately, while there are therapies for AATD, often much of the irreversible damage has occurred prior to the referral to a pulmonologist with experience in screening for and treating the disease. Earlier diagnosis is essential but is most effective if it occurs with screening prior to the onset of severe physiologic disturbance. Such screening programs are best suited to primary care offices and the Civil AME visit would be an ideal opportunity to incorporate a program to provide earlier detection of AATD.

Learning Objectives

1. The attendees will be able to identify who is appropriate to screen for AATD.
2. The attendees will recognize that AATD is not rare, but common enough that each of us is overseeing the care of carriers and potentially patients with AATD.
3. The attendees will understand that partial penetrance suggests the need for special care and scrutiny for patients who are carriers.

[209] THE HEPATIC MANIFESTATIONS OF ALPHA-1 ANTITRYPSIN DEFICIENCY

Ben Fiore
U.S. Navy, San Diego, CA, United States

(Education - Program/Process Review)

Alpha-1-Antitrypsin (A1AT), is a hepatically-produced and secreted serine protease inhibitor which prevents tissue destruction by neutrophil elastase. Prevalence is approximately 1:2000 among northern European ancestry with 4 million people carrying a deficient allele. Diagnosis is often delayed until irreversible end organ damage has occurred. Liver dysfunction is a major threat to the health of affected individuals. Under normal conditions, the wild-type protein, "M", is synthesized and secreted from hepatocytes. The most common disease variant, "PiZ", distorts the conformation of the protein causing retention in hepatocytes. This accumulation creates toxic liver injury. The classic presentation of A1ATD is homozygous for the Z allele. Compound heterozygotes with one Z allele have increased risk for liver disease when other processes are present. Current clinical guidelines recommend testing for A1ATD with the gold standard genotype test as part of a comprehensive serologic evaluation for chronic liver disease in patients with persistently elevated ALT > 6 months. Serum testing of A1AT level and liver biopsy are not helpful. Treatment goals are symptom-targeted including avoidance of hepatotoxic agents and treatments. Augmentation of A1AT does not improve liver disease, as it does not reduce accumulation of the Z protein. The only available treatment for decompensated cirrhosis is transplantation. After transplantation, there is no generation of the Z protein and results in an 85% five-year survival. New pharmaceuticals under investigation are poised to transform long term management. It is paramount for the safety of our aviators, crew, and passengers to recognize, diagnose and implement risk mitigation strategies early.

Learning Objectives

1. Attendees will identify the most pathogenic allele associated with liver disease.
2. Attendees will recognize those patients at risk for AATD and appropriate testing methods.
3. Attendees will identify methods to reduce additional stress on functional status of the liver.

[210] ALPHA-1 ANTITRYPSIN DEFICIENCY: A HORSE AMONG ZEBRAS

Mark Ivey
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Program/Process Review)

Alpha-1 Antitrypsin Deficiency (AATD) is an autosomal co-dominant genetic disorder first discovered in 1963. Considered among most providers to be primarily a lung or liver issue, the incomplete penetrance and varied clinical presentations add to the confusion and lack of confidence in screening practices. Most clinicians consider this a rare disorder; however, AATD is implicated in many chronic medical issues and frequently overlooked. Replicated studies have confirmed the average time from symptom onset to diagnosis is just over seven years including referrals to three specialists. Two issues emerge regarding AATD; it is relatively common and frequently under-recognized in the management of chronic disease. Research has shown that poor screening rates from lack of provider knowledge and comfort in the management of genetic disorders are linked to missed opportunities and delayed diagnosis. Since its discovery, persistence in research has led to effective methods of surveillance, treatment protocols and curative options. Despite the publication of the ATS guideline in 2003, only 10% of cases are diagnosed in the US. Increasing provider knowledge in risk stratification and identifying local resources will reduce delays to diagnosis, healthcare resource burden and improve patient QOL. **AEROMEDICAL IMPLICATIONS:** Civil AME's are often the first point of contact for medical care. In the military, the flight surgeon's team provides both direct and policy-driven care. It is important to note that there are no recommendations for screening asymptomatic members. But AATD must be considered in those with specific risk factors and those members should be tested.

Learning Objectives

1. Increase provider knowledge of AATD physiology, common clinical presentations, disease course and surveillance.
2. The audience will become familiar with methods of screening patients and local resources available to assist in management of this disease.
3. The audience will learn about FAA-specific requirements of reporting and monitoring to maintain aeromedical certification and the impact of AATD on military members.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Chenier

[S-40]: PANEL: SAFETY CULTURE IN AVIATION AND MEDICINE: EXPLORING APPROACHES TO ASSESSMENT AND INTERVENTIONS

Sponsored by Aerospace Human Factors Association

Chair: David Schroeder
Co-Chair: Brian Musselman

PANEL OVERVIEW: INTRODUCTION**:** *The Chernobyl nuclear power plant accident, the Challenger and Columbia accidents in space, the two Boeing 737 Max fatal accidents, the former Tennessee nurse who was found guilty of criminally negligent homicide in the death of a patient who was accidentally given the wrong medication, and numerous examples from other industries demonstrate the important role of an organization's safety culture in employee performance and safety.* ***TOPIC:*** *Meta analyses have demonstrated the relationship between measures of*

safety climate, safety knowledge, motivation, engagement, participation, and safety performance (Nahrgang, et al. 2010 and Clark 2006, 2012). Questionnaires are the most common approach to assessing safety culture/climate. The panel includes presentations concerning safety culture in five work environments. ***APPLICATION:*** *Each presenter will describe findings from the scientific literature or experience concerning organizational safety culture assessments, the development of intervention strategies and the overall effectiveness of those interventions. Kylie Key from the FAA Civil Aerospace Medical Institute (CAMI) will describe recent efforts to assess safety culture in aviation maintenance organizations. A representative from NASA will provide an overview of the development of NASA's safety culture program that represents an integration of health and safety. A representative from Delta Airlines will describe efforts to enhance the safety culture as a means of improving the organization's safety management system. A representative from the U.S. Air Force Safety Center will describe their efforts and the impact. Clayton Cowl from Mayo Clinic will provide an overview of safety culture in healthcare. The presentations will provide an up-to-date view of issues and concerns associated with efforts to assess and improve safety culture in space, aviation, and medicine.*

[211] TO ERR IS HUMAN: REVIEWING HEALTHCARE'S SAFETY CULTURE OVER TWO DECADES

Clayton Cowl
Mayo Clinic, Rochester, MN, United States

(Education - Tutorial/Review)

From the release of the groundbreaking book "To Err is Human" in 2000, the culture of safety within the healthcare framework has continued to transform and adapt. Experts estimate that as many as 98,000 people die in any given year from medical errors that occur in hospitals – more than die from motor vehicle accidents, breast cancer, or infectious diseases such as AIDS--three causes that receive far more public attention. The top five medical errors are misdiagnosis, delayed diagnosis, medication error, infection, and harmful medical devices. In the past two decades, there have been marked improvements in the response to critical of errors within the workplace and development of improved communication, team-based safety nets, and a variety of sequelae in response to the need for improved safety cultures within both the inpatient and outpatient healthcare settings yet there remains significant room for improvement. This review will focus on a brief historical outline of transformational improvement efforts, current safety statistics within the medical delivery platform, and efforts for continued improvement in the future.

Learning Objectives

1. To review top causes of error within the healthcare environment.
2. Understand strategies used to reduce error and fatal mistakes in medical delivery.

[212] SAFETY CULTURE IN AVIATION AND MEDICINE: EXPLORING APPROACHES TO ASSESSMENT AND INTERVENTIONS INTRODUCTION

Denise Zona
Air Force Safety Center, Kirtland AFB, NM, United States

(Education - Tutorial/Review)

INTRODUCTION: U.S. Air Force supports an Informed Safety Culture as described in Air Force Instruction 91-202, The US Air Force Mishap Prevention Program. An Informed Safety Culture is comprised of a Just Culture, Reporting Culture, Learning Culture and Flexible Culture. U.S Air Force Commanders and leaders are encouraged to promote the aspects of an Informed Safety Culture. **TOPIC:** The U.S. Air Force Safety Center supports Commanders and leaders assessment of their organization's safety culture through the management and execution of the Air Force Combined Mishap Reduction System (AFCMRS) culture surveys. Surveys are anonymous and confidential to allow members of the Department of the Air Force an opportunity to provide honest feedback about the organization's Informed Safety Culture. The U.S. Air Force Safety Center maintains 15 unique culture surveys to support the various aspects of U.S. Air Force Operations. Commanders and leaders can request a culture survey at any time, and many organizations choose to conduct a culture survey at regular intervals. **APPLICATION:** Commanders and leaders are provided a debrief on their culture survey results by subject matter experts at the U.S. Air Force Safety Center. Culture survey results can be compared across organizations within the same operational area, functional area, or Major Command. Additionally, Commanders and leaders can measure the effects of interventions using pre- and post-intervention safety culture comparisons, or conduct regular culture surveys over a long period of time for longitudinal evolution. Based on survey feedback, recommendations are made to seek to improve Informed Safety Culture. This presentation will provide a general overview of the AFCMRS program and provide examples of culture survey recommendation application. **RESOURCES:** Air Force Chief of Safety. (2022). The US Air Force mishap prevention program (AFI 91-202). Washington, D.C.: United States Department of the Air Force. Retrieved from http://www.e-publishing.af.mil Joint Planning and Development Office (2010). Safety Culture Improvement Resource Guide, v1.6. Retrieved from http://www.rasg-pa.org/RASGPA/SafetyJPDOSC1Gv1.6.pdf. Pantankar, M. S., Brown, J. P., Sabin, E. J., & Bigda-Peyton, T. G. (2012). *Safety culture: Building and sustaining a cultural change in aviation and healthcare*. Burlington, VT: Ashgate Publishing Company. Reason, J. (1997). *Managing the risks of organizational accidents*. England: Taylor and Francis.

Learning Objectives

1. Describe the Air Force Combined Mishap Reduction System (AFCMRS) culture survey.
2. Explain command safety climate culture survey and how it translates into recommendations.

[213] THE ROLE OF JOB DEMANDS AND RESOURCES IN PREDICTING SAFETY CULTURE AND OUTCOMES

Kylie Key[1], Inchul Choi[2], Peter Hu[2], David Schroeder[2]
[1]*FAA, Oklahoma City, OK, United States;* [2]*Cherokee Nation 3-S, Oklahoma City, OK, United States*

(Education - Tutorial/Review)

INTRODUCTION: Employee perceptions of how much the organization values safety (safety culture) is an important foundation of effective safety management in aviation. **TOPIC:** Recent research by Fogarty et al. (2018) demonstrated the utility of a Job Demands and Resources (JD-R) model for explaining safety culture. The model was used to determine the impact of individual factors, organizational factors, and safety culture on performance outcomes (e.g., self-reported errors and violations). We adapted the model for use in an investigation of safety culture in civil aviation. A 200-item questionnaire comprised of 10 job resources (JR) subscales, 6 job demands (JD) subscales, 4 individual outcomes, 3 organizational outcomes, demographics, and a usability subscale was administered to aviation maintenance personnel at five US maintenance organizations; items were tailored to meet the organizational needs of participating companies. Responses were received from 987 individuals. **APPLICATION:** The results provide initial validation evidence for the questionnaire. Structural equation modeling (SEM) revealed that JD-R predicted both individual and organizational outcomes; that the relationship between safety culture; and organizational outcomes are partially mediated through individual outcomes. Further research is needed to increase the small sample size, address the need for objective versus subjective performance measures, and reduce the length of the questionnaire. **RESOURCES:** Fogarty, G. J., Cooper, R. & McMahon, S. (2018). A demands-resources view of safety climate in military aviation. *Aviation Psychology and Applied Human Factors, 8*(2), 76-85. https://doi.org/10.1027/2192-0923/a000141

Learning Objectives

1. The audience will learn about recent efforts to develop a safety culture assessment toolkit for the aviation maintenance industry.

2. The audience will learn about the relationships among job demands, job resources, individual and organizational performance, and safety culture.

[214] THE ROLE OF SAFETY CULTURE IN ENHANCING AN AIRLINE SAFETY MANAGEMENT SYSTEM

Patricia Demasi
Delta Air Lines, Inc., Atlanta, GA, United States

(Education - Tutorial/Review)

INTRODUCTION: Safety Policy and Safety Promotion are two of the components of a Safety Management System, required under 14CFR Part 5 for U.S. commercial air carriers. Key to the success of a positive safety culture is confidential, non-punitive employee safety reporting, a requirement of Safety Policy. Within Safety Promotion, organizations should promote a positive safety culture, and leaders and managers should actively foster a positive safety culture (FAA, 2020). Safety culture has been described as the most important aspect of safety management (ICAO, 2018). **TOPIC:** Researchers have documented that a positive safety culture not only helps the safety management systems work more effectively (French & Steel, 2017; Piers et al., 2009), but also provides the basis for making continuous improvements to safety management systems (Akselsson et al., 2009). Safety culture has been linked to many important safety-related outcomes. These include organizational performance outcomes such as accident/incident rates, compliance, and production/profit; along with employee outcomes such as engagement, morale, strain/burnout, personal injury rates, willingness to report, and turnover intentions. These relationships between a positive safety culture and positive outcomes are stable across safety-critical industries and countries, attesting to their robustness (Zohar, 2014). A cornerstone in the creation of a positive safety culture is the establishment of voluntary, open, non-punitive reporting systems. (IFALPA, 2021). **APPLICATION:** Given the strength of the relationships between a positive safety culture and positive outcomes, it is reasonable to hypothesize that organizations that foster a positive safety culture will see (and benefit from) positive outcomes.

Learning Objectives

1. The participants will understand safety culture as a tenant of the safety management system.
2. The participants will understand the influence of just culture on safety culture.

[215] SAFETY CULTURE INFLUENCE ON SAFETY OUTCOMES

Brian Musselman[1], David Schroeder[2]
[1]*No affiliation, Albuquerque, NM, United States;* [2]*No affiliation, Oklahoma City, OK, United States*

(Education - Tutorial/Review)

INTRODUCTION: Safety Promotion is one of the four aspects of a Safety Management System. Within Safety Promotion, organizations should promote a positive safety culture, and leaders and managers should actively foster a positive safety culture. Safety culture has been described as the most important aspect of safety management. **TOPIC:** Researchers have documented that a positive safety culture not only helps the safety management systems work more effectively, but also provides the basis for making continuous improvements to safety management systems. Safety culture has been linked to many important safety-related outcomes. These include organizational performance outcomes such as accident/incident rates, compliance, and production/profit; along with employee outcomes such as engagement, morale, strain/burnout, personal injury rates, willingness to report, and turnover intentions. These relationships between a positive safety culture and positive outcomes are stable across safety-critical industries and countries, attesting to their robustness. **APPLICATION:** Given the strength of the relationships between a positive safety culture and positive outcomes, it is reasonable to hypothesize that organizations that foster a positive safety culture will see (and benefit from) positive outcomes.

Learning Objectives

1. The participants will understand safety culture as a tenant of the safety management system.
2. The participants will understand the influence of safety culture on safety outcomes.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon Ballroom C1-C2

[S-41]: SLIDES: FATIGUE COUNTERMEASURES - PERFORMANCE

Chair: Jochen Hinkelbein

[216] CAFFEINE GUM (200 MG) ADMINISTERED UPON ABRUPT AWAKENING FROM SLEEP DISRUPTS SUBSEQUENT RECOVERY SLEEP

Rachel Firth[1], Karen Robertson[1], Claire Turner[2], Michael Spencer[2], Victoria Revell[3]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*Affective State, Winchester, United Kingdom;* [3]*University of Surrey, Guildford, United Kingdom*

(Original Research)

INTRODUCTION: Sleep inertia is a transitory reduction in performance and alertness that occurs immediately on waking and is a potential risk for individuals working on-call. Caffeine gum has been proposed as a countermeasure to sleep inertia. However, it is unclear how effective it is in individuals who habitually consume moderate amounts of caffeine, or what is the impact on subsequent sleep quality. **METHODS:** A double-blind randomized crossover study comprising four conditions: control (no gum), placebo gum, 100 milligram (mg) and 200 mg caffeinated gum was completed. Following a one-hour sleep starting at their habitual bedtime, participants were abruptly woken. Gum was administered (if appropriate) upon waking, and chewed for five minutes. Individuals remained awake for two hours, completing a battery of tasks at regular intervals with continuous electroencephalography monitoring, after which they returned to bed and attempted to sleep for seven hours, recorded using polysomnography. Sleep was scored in accordance with the American Academy of Sleep Medicine guidelines. **RESULTS:** Twelve participants (six female, mean age (± standard deviation) 29.6 (2.2) years) completed the study. Sleep structure and duration of the one-hour sleep did not differ between conditions. Sleep structure and duration were not significantly different in the seven-hour sleep opportunity between the control, placebo and 100 mg conditions. Following the 200 mg dose, sleep onset latency (21.4 (4.8) minutes) increased compared with the control (8.2 (1.7)), placebo (10.5 (2.4)) and 100 mg (13.0 (2.9)) conditions ($p<0.05$). Similarly, latency to stage two sleep (32.7 (5.2) minutes) increased compared with control (13.0 (2.0)), placebo (17.4 (1.9)) and 100 mg (20.9 (4.2)) conditions ($p<0.05$). Duration of slow wave sleep was shortest with the 200 mg (75.7 (6.5) minutes) dose (control (105.0 (6.5)), placebo (96.8 (6.5)), 100 mg (93.9 (6.5)), $p<0.05$). Rapid eye movement sleep (75.2 (6.5) minutes) was also reduced compared with control (94.1 (6.5)) and 100 mg (97.4 (6.5)) conditions ($p<0.05$). **DISCUSSION:** The dose-response effect of caffeine gum indicates that, in the event of a return to sleep two hours after administration, 100 mg is unlikely to significantly affect recovery sleep, in contrast to the sleep disruption observed after 200 mg.

Learning Objectives

1. Understand the impact that different doses of caffeine gum has on sleep
2. Understand how caffeine gum can alter the structure of sleep

[217] CAFFEINE GUM REDUCES FATIGUE AND SLEEPINESS, AND IMPROVES MOOD AFTER A ONE-HOUR SLEEP PERIOD

Karen Robertson[1], Claire Turner[2], Rachel Firth[1], Michael Spencer[2], Victoria Revell[3]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*Affective State, Winchester, United Kingdom;* [3]*University of Surrey, Guildford, United Kingdom*

(Original Research)

INTRODUCTION: For personnel on-call, abrupt awaking from sleep can result in sleep inertia, which is associated with poor cognitive performance. Caffeine gum has been proposed as one countermeasure to sleep inertia. However, it is unclear how effective caffeine gum is in individuals who habitually consume moderate amounts of caffeine and what is the duration of any beneficial effects. **METHODS:** A double blind randomised cross-over study was undertaken comprising four conditions: control (no gum), placebo gum, 100 and 200 mg doses of caffeine gum. Participants, habitual caffeine consumers, maintained their normal caffeine consumption throughout the study. They completed a six-minute task battery at half-hour intervals for two hours before retiring to bed at their habitual bedtime and sleeping for one hour. Researchers woke participants and, if appropriate, gum was administered and chewed for five minutes. The task battery was completed two minutes after waking and at regular intervals over the following two hours. It comprised mood assessments, Samn-Perelli fatigue rating, Karolinska Sleepiness Scale, the N-back and Digit Symbol Substitution Tests. **RESULTS:** Twelve individuals (six female), mean age 29.6 years, completed the study. Sleep inertia was evident on the cognitive tasks, with an improvement in performance from two to 23 minutes after waking. However, this was not the case for the subjective measures, with no reduction in fatigue or sleepiness over the same period. Caffeine gum did not reduce sleep inertia associated with cognitive performance tasks. Chewing placebo gum had a positive effect on some subjective mood states (e.g. irritability, calmness, passiveness; all $p<0.05$), with some effects observed from nine minutes after waking. Both doses of caffeine gum improved mood, and reduced sleepiness and fatigue compared to control and placebo ($p<0.05$), with 200 mg caffeine having a more consistent and longer duration of effect. **DISCUSSION:** Caffeine gum was effective in reducing fatigue and sleepiness, and improved mood after waking from a one-hour sleep. It was not possible to establish whether caffeine gum mitigates sleep inertia as most of the recovery of performance occurred from two to nine minutes after waking, which was before the onset of action of caffeine.

Learning Objectives

1. Understand the effects of caffeine gum on cognitive performance over two hours after abrupt awaking.
2. Understand the effects of caffeine gum on subjective measures of mood and fatigue over two hours after abrupt awaking.

[218] EFFECTS OF MODAFINIL ON RECOVERY SLEEP: FIRST RESULTS.

Yara Wingelaar-Jagt[1], Wim Riedel[2], Jan Ramaekers[2]
[1]*Center for Man in Aviation, Soesterberg, Netherlands;* [2]*Maastricht University, Maastricht, Netherlands*

(Original Research)

INTRODUCTION: Fatigue remains an important factor in major aviation accidents. Stimulants may counteract fatigue's adverse effects, with modafinil as a promising option with positive effects on performance. However, the negative effects of modafinil on recovery sleep are not clearly established. **METHODS:** Thirty-two volunteers of the Royal Netherlands Air Force were administered modafinil (200 mg) and placebo on non-consecutive trial days after being awake for a mean 17 h, according to an order-balanced, double-blind, crossover design. Afterwards, the subjects were kept awake for another 8 h, meaning that at the end of the test day subjects had been awake for a mean 25 h. Subjects were instructed to go to sleep and keep a sleep diary on the day and night after each test day. The sleep efficiency (defined as time asleep divided by time in bed x 100%) and Groningen Sleep Quality Scale (GSQS) after modafinil and placebo administration were compared using a Wilcoxon Signed Rank test. **RESULTS:** Median sleep efficiency during the day was 90.3% (IQR 9.7) in the modafinil group, compared to 93.7% (IQR 7.4) in placebo, but this was not statistically significant ($p=0.068$). During the night that followed this was 94.1% (IQR 9.7) and 94.5% (IQR 5.1) respectively, again not statistically significant ($p=0.970$). GSQS scores during daytime sleep was intermediately impaired (GSQS≥3) but did not differ statistically significantly ($p=0.605$) with a median of 4 (IQR 3) in the modafinil group versus 4 (IQR 2.5) in the control group. GSQS scores at night were normal, 2 (IQR 2.75) in the modafinil group versus 2 (IQR 4) in the placebo group respectively, and were not statistically significantly different ($p=0.353$). **DISCUSSION:** In this placebo-controlled study, daytime sleep quality after having been awake for 25 h, was intermediately impaired in both groups. Modafinil did not seem to negatively affect the recovery sleep during daytime compared to the control group. Nighttime sleep afterwards was of normal quality and similar between the two groups. We conclude that the negative effects of modafinil on recovery sleep are limited.

Learning Objectives

1. To determine the (negative) effect of a single dose of modafinil (200 mg) on recovery sleep after extended wakefulness.
2. To assess sleep difficulties in recovery sleep after stimulant use.

[219] SYSTEMATIC REVIEW OF LABORATORY FINDINGS IN EVALUATION OF AIRCREW PERSONNEL

Denis Bron[1], Jonas Mueller[1], Andres Kunz[1], Sibylle Grad[2]
[1]*Aeromedical Centre Swiss Air Force, Duebendorf, Switzerland;* [2]*AO Research Institute Davos, Davos, Switzerland*

(Original Research)

INTRODUCTION: A higher prevalence of back complaints in flying personnel compared to the general population is well documented. Various underlying causes have been described. While standard analysis approaches such as clinical diagnostics, imaging-based evaluation and electrophysiological testing are well established, the role of laboratory analyses is less known. The purpose of this study is to collect information about relevant laboratory parameters, especially bone turnover related angiogenic factors, and to evaluate their potential impact in the analysis of back pain symptoms in flying personnel. **METHODS:** Back complaints status of eighty military pilots and aircrew members have been evaluated during the last two years during their normal health check-ups integrating questionnaires with blood tests aimed at analyzing the following factors: Flt-1, Tie-2, VEGF-C, bFGF. PIGF, VEGF, VEGF-D. The participants were divided in a symptomatic versus an asymptomatic group. **RESULTS:** No significant differences in the values of the assessed factors were found between symptomatic and non-symptomatic air crew members. The values for following factors were however significantly higher [SGRAD1] than the reference values for a normal population: Flt-1, Tie-2, VEGF-C, PIGF, VEGF, VEGF-D. **CONCLUSION:** The results suggest that detection of diseases by analyzing systemic factors may be possible, as the measured values in Aircrew were higher than the reference values. However, the factors do not seem to be related to the symptom presentation. The reason why angiogenic factors are significantly higher in Aircrew compared to the reference values is unclear. Different explanations such as high G loads may play a certain role. What kind of impact this may have in Aircrew is so far unclear. Further analyses are necessary.

Learning Objectives

1. A higher prevalence of back complaints in flying personnel is compared to normal population present.
2. Relevant laboratory parameters, especially bone turnover related angiogenic factors, may have an impact of bone diseases.
3. The study results suggest that detection of diseases by analyzing systemic laboratory factors may be possible.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon Ballroom D1-D2

[S-42]: PANEL: INTERNATIONAL AEROSPACE NEUROSCIENCE CONSORTIUM- TRAUMATIC BRAIN INJURY

Chair: Joseph Connolly

PANEL OVERVIEW: *Traumatic Brain Injury (TBI) is the most common neurologic condition causing aeromedical disqualification and the pursuit of aeromedical waiver or Special Issuance certification. Aeromedical concerns with TBI are different that with TBI in the general population. Much research and media reports focus on disproportionate morbidity, disability and sequalae of TBI. In aerospace medicine, much of the focus is with aviators who have made a near-complete apparent recovery but may have subtle cognitive residua or a significant seizure risk. Pre-pilot training neurocognitive testing and post-TBI cognitive testing of 60 USAF pilots will be reviewed. We will learn about cognitive and exercise aspects of TBI rehabilitation in DoD aviators and special operations personnel. Brain MRI susceptibility-weighted imaging after TBI will be discussed in terms of prediction of post traumatic seizure risk in Aircrew. The utility of prolonged EEG monitoring in aviators with TBI will be explored regarding future seizure risk. Finally, two controversial aeromedical dispositions following head injury will be presented.*

[220] NEUROCOGNITIVE FUNCTIONING IN USAF PILOTS FOLLOWING TRAUMATIC BRAIN INJURY

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Aviation is a cognitively demanding occupation, and any decline in cognitive ability is of significant concern. Following traumatic brain injury (TBI), individuals can experience changes in cognitive functioning that do not always return to baseline. The impact TBI has on cognitive functioning tends to vary across levels of severity of the injury and across individuals. Changes in the areas of attention, concentration, information processing speed, and executive functioning are most commonly seen following TBI. Neuropsychological testing is a required component of the evaluation for return to flying after TBI to determine if functioning has returned to baseline. In highly skilled or highly intelligent and skilled population, identifying subtle changes in cognitive functioning can be difficult. Because pilots represent a unique population with respect to intellectual and cognitive abilities, traditional neuropsychological testing may not reliably detect subtle degradation of these high functioning individuals. For that reason, US Air Force requires medical flight screening (MFS) baseline testing that every pilot completes prior to entry into pilot training. These premorbid measures are useful in the neuropsychological evaluations that occur when pilots are being considered for return to flying duties after medically qualifying diagnosis. **OVERVIEW:** From 2000 to 2022, 61 USAF pilots who had baseline MFS data were seen at the Aeromedical Consultation Service for evaluation of return to flying duties following TBI. They took a measure of intellectual functioning (Multidimensional Aptitude Battery-II,) and a computerized neuropsychological screening exam assessing a number of cognitive domains (MicroCog). Assessment results from these measures completed at clinical evaluation at the ACS following TBI were compared to the baseline testing they completed prior to attending pilot training. **DISCUSSION:** On the MAB, there was no indication of decline across Verbal, Performance or Full-Scale IQ when examining group data for baseline and post-TBI testing. None of the subscales that make up the measure decreased from baseline to post-test. On the MicroCog, there were no significant differences between the baseline scores and those obtained following TBI. When groups were divided into those that sustained a mild, moderate, or severe TBI, no differences in functioning on the MicroCog were seen across severity levels.

Learning Objectives

1. The audience will learn about neurocognitive changes following traumatic brain injury in the aviator population.
2. The audience will understand the contribution of having baseline neurocognitive test data when evaluating pilots following TBI.

[221] OPTIMIZING COGNITIVE FUNCTIONING TO RETURN TO DUTY AFTER MILD TRAUMATIC BRAIN INJURY: LESSONS LEARNED FROM MILITARY MEDICINE

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(Education - Tutorial/Review)

BACKGROUND: Many individuals who experienced a mild traumatic brain injury (MTBI) begin rehabilitation with the the goal of returning to their prior level of functioning. In certain professions, such as the military and aviation, before a patient who experienced cognitive changes after a MTBI can safely return to duty, we must ensure they can complete cognitively and psychologically demanding operations necessary for national security and public safety. In these instances, the traditional standard of care may not meet the patients' unique treatment needs. In order to optimize outcomes, treatments are needed that can be applied to the unique operational environments and prioritize functional improvement of the warfighter. Specific to cognition, traditional cognitive rehabilitation (TCR) interventions often rely on methods developed for more severe neurological injury and they use compensatory techniques that have little translation to a demanding and kinetic environment where small mental errors can have catastrophic consequences. **TOPIC:** This presentation will review research on cognitive rehabilitation for warfighters and evaluate comparable effectiveness of TCR to an alternative "top down" treatment approach, Strategic Memory Advanced Reasoning Training (SMART). SMART is an evidence-based training protocol that is more closely aligned with the cognitive domains key to warfighter readiness (mental agility, strategic learning, problem solving, focus, and psychological well-being). **APPLICATION:** Results from clinical trials with civilians and veterans indicate that SMART can positively impact cognitive functioning. Preliminary results from a randomized clinical trial with active duty warfighters revealed SMART to have comparable effectiveness to TCR in improving cognitive impairment and it was completed in less than half of the treatment time. SMART resulted in large improvements in mental processing speed, executive functioning, and memory. Rates of abnormal cognitive performance in the sample of warfighters reduced from 50% to 25% after treatment. These results suggest that SMART, or similar top-down treatment programs, can may be more effective at improving successful return to duty than traditional rehabilitation efforts.

Learning Objectives

1. Detail limitations of current techniques for cognitive rehabilitation of service members who have experienced a mild traumatic brain injury.
2. Identify Strategic Memory Advanced Reasoning Training (SMART) as a potential alternative treatment modality for cognitive rehabilitation in military personnel.
3. Describe preliminary results from a randomized clinical trial showing SMART has relative equivalence in improving cognitive performance and can be completed in fewer treatment hours with more relevance to cognitive demands of the warfighter.

[222] MRI SUSCEPTIBILITY WEIGHTED IMAGING AND THE PREDICTION OF POST TRAUMATIC SEIZURES IN AIRCREW

Peter Letarte
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(Education - Tutorial/Review)

BACKGROUND: Post TBI, the presence of blood on intracranial imaging has long been felt to increase the risk of Post Traumatic Seizures (PTS) to a level unacceptable for continuing many flight duties.

Since many of the seminal papers on the risk of PTS after trauma were published, the resolution of intracranial imaging as improved by orders of magnitude. Much of the hemorrhage visible with modern imaging modalities, such as Susceptibility Weighted MRI or late generation CT, were clearly invisible on the imaging at the time many Post-Traumatic Epilepsy (PTE) papers were written. A Radiology reading of intracranial blood in 2023 likely does not mean the same thing as it did when the seminal papers were written. This observation raises a series of questions that will be explored in this presentation. **OVERVIEW:** The estimated size of hemorrhage in the key PTE literature will be presented. A review of the evolution of the sensitivity of intracranial imaging modalities over the last 50 years will be reviewed. SWI MRI will be used as a use case for this discussion. A comparison of the specifications established by the PTE literature and the capabilities of evolving imaging modalities will be made. A brief discussion of the evolution of thinking on Diffuse Axonal Injury (DAI), a similar clinical area where increasing imaging resolution has changed both our thinking about the pathology and our clinical decision making, will be included. **DISCUSSION:** This presentation will raise a series of questions for further study. Does an imaging reading of intracranial blood mean the same thing in 2023 as it did when the seminal papers were written? Is there a critical volume of intracranial blood, below which the seizure risk decreases? Is the presence of intracranial blood a direct cause of Post Traumatic Seizures or is it also a marker of other mechanisms, such as cortical disruption or axonal injury, that also lead to epilepsy. Can new imaging modalities give us insight into these other mechanisms. Are we removing the flight credentials from the correct patient population after a Traumatic Brain Injury?

Learning Objectives

1. The learner will understand that current brain Imaging is able to show us hemorrhages that are much smaller than anything visible when the key papers on post traumatic hemorrhage and epilepsy were written.
2. The learner will understand that the clinical impact of very small bleeds on epileptogenicity and fitness for flight is unknown.

[223] THE ROLE OF EEG AND IMAGING IN ASSESSING THE DEVELOPMENT OF TBI SEIZURES

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(Education - Tutorial/Review)

INTRODUCTION: Traumatic Brain injury is an increasingly common and vexing problem for both pilots and aerospace medicine practitioners. Evaluating fitness for flight from a neurological perspective from TBI continues to be a significant issue with inconsistent application of testing and evidence to individual pilot cases. One of the most crucial concerns is the risk of post traumatic brain injury seizures and epilepsy. Predicting post TBI seizures is often based on EEG and imaging results. This presentation will outline current best evidence for predicting the risk of post traumatic brain injury seizures based on clinical history, imaging and EEG. Specific details to be covered include, type of MRI, type and length of EEG and whether a population of aviators can be identified that are at least risk for seizure development.

Learning Objectives

1. The audience will learn about the roll of EEG in evaluating an aviator with TBI for aeromedical certification.
2. The audience will learn about various MRI findings and post-traumatic epilepsy risk.

[224] TWO CONTROVERSIAL AEROMEDICAL DISPOSITIONS FOLLOWING HEAD INJURY

Aven Ford
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(Education - Tutorial/Review)

INTRODUCTION: Traumatic brain injury (TBI) is graded as mild, moderate, or severe, based on clinical and imaging characteristics. The severity grades are helpful in predicting clinical outcomes and seizure risks after injury; however, due to changes in imaging modalities and diagnostic tools the classification systems have changed throughout the years, making it difficult to apply older studies on current cases. In this panel presentation two cases that defy easy classification and easy risk assessment. **TOPIC:** The waiting period prior to waiver consideration in pilots that have made a complete clinical recovery is often driven by high-risk imaging findings that are associated with high rates of seizure in the first 2-5 years following injury. The first case to be presented is a cargo pilot who fell while riding a rented electric scooter (unhelmeted). His initial loss of consciousness lasted less than 10 minutes and would be clinically classified as mild. However, his initial head CT had concerning features. When seen by neurology 3 weeks later, he had no complaints and a completely normal neurologic exam. MRI of his brain showed no evidence of previously noted blood products and was read as normal. This case had clinically mild features, CT features concerning for a severe injury, and essentially a normal MRI brain. Where should this pilot be classified and how long should he wait for a waiver? The second case is an RPA (drone) pilot with a head injury secondary to a motor vehicle rollover. His injury was clinically mild, as he had only brief loss of consciousness (LOC) lasting a few seconds and no post-traumatic amnesia (PTA) or other alteration of consciousness (AOC). However, his CT scan performed at the ER showed a depressed left parietal skull fracture. What is the proper observation period for this pilot? **APPLICATION:** This presentation will discuss the appropriate approach to an aviator with complicated traumatic brain injury, focusing on the clinical and imaging classification and the rationale behind waiting periods.

Learning Objectives

1. Discuss the approach to the aviator with various types of head injury.
2. Discuss the appropriate classification of aeromedical-head injury and use that information to guide observation periods prior to waiver recommendation.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon C3

[S-43]: SLIDES: HYPOXIA POTPOURRI

Chair: Benise Lester
Co-Chair: Rowena Christensen

[225] COGNITIVE AND PHYSIOLOGIC RESPONSES TO NORMOBARIC HYPOXIA VERSUS HYPOBARIC HYPOXIA

Bianca Cerqueira[1], Bria Morse[1], Zachary Kerns[1], Holly Chapapas[1], Pete Ramos[1], Kelly McKay[1], Jeremy Beer[1], Andrew Mojica[1], Megan Gallo[2], Paul Sherman[3]
[1]KBR, San Antonio, TX, United States; [2]U.S. Air Force Research Lab, Dayton, OH, United States; [3]USAFSAM, San Antonio, TX, United States

(Original Research)

The goal of this study was to compare effects of normobaric hypoxia versus hypobaric hypoxia on physiology and cognitive performance in a limited subject group (n=7). Cognitive performance was evaluated before, during, and after exposure using the SYNWIN multi-task synthetic workstation. SYNWIN assesses short term memory, arithmetic calculations, visual and auditory vigilance, and the executive timesharing required to perform the tasks simultaneously and has been used successfully to assess cognitive performance in hypobaric hypoxia conditions. The study included two "flights" per subject – hypobaric hypoxia (altitude chamber at 25,000 ft with no supplemental oxygen) and normobaric hypoxia (sitting in the altitude chamber breathing from the reduced oxygen breathing device set to hypoxia equivalent of 25,000 ft). Physiologic metrics included heart rate, SpO_2, and respiration metrics including rate and depth of breathing, minute ventilation, and the composition

of respiration gases, transcranial Doppler cerebral blood flow within the middle cerebral arteries, serum cytokine analysis, and blood miRNA sequencing. Epochs for analysis included 1) Ground Level, 2) Pre-Breathe, 3) 25k feet altitude or "ROBD 25k" including ascent time, and 4) Recovery. We found a significant effect of epoch on SYNWIN composite score with overall performance lower in the hypobaric condition. Within the physiology/oximetry metrics, we found significant effect of epoch on heart rate and heart rate spiked more in the hypobaric condition compared to normobaric condition. SpO_2 measures mirrored heart rate, with SpO_2 dipping more in hypobaric conditions. Blood analysis found that hypobaric hypoxia increased serum levels of Chemokine ligand 13, also known as B lymphocyte chemoattractant (BLC (CXCL13)) and Chitinase-3-like protein 1 (YKL-40 (CHI3L1)) compared to normobaric hypoxia. The effectiveness of aircrew training depends on the explicit assumption that inducing altitude-equivalent hypoxia effects via ROBD, physiologically and cognitively, is directly equivalent to hypobaric exposure as experienced in the cockpit. Our results suggest that in a limited dataset, cognitive and physiologic responses to normobaric hypoxia differ from those resulting from hypobaric hypoxia. This data can be used to inform decisions on aircrew training protocols and to determine the effectiveness of Altitude Physiology curricula primarily employing ROBD hypoxia exposures as opposed to hypobaric hypoxia.

Learning Objectives

1. The audience will learn that heart rate increases more during hypobaric exposure compared to normobaric hypoxia.
2. The audience will learn that oxygen saturation decreases more during hypobaric exposure compared to normobaric hypoxia.
3. The audience will learn that cognitive performance is affected more during hypobaric hypoxia compared to normobaric hypoxia.

[226] HYPOXIA TOLERANCE PREDICTORS

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Israeli Air Force, Ramat Gan, Israel

(Original Research)

INTRODUCTION: Hypoxia may be induced by either cabin pressure failure or oxygen system malfunction during flight. Personal tolerance will determine performance level under hypoxic conditions. Tolerance for hypoxia can be tested during altitude chamber training sessions, designed to expose aircrew to hypoxic conditions in a controlled setting. The aim of this study was to examine the influence of different parameters on hypoxia tolerance. **METHODS:** During altitude chamber training sessions participants reached simulated altitude of 25,000 feet (7,620 meters) and were exposed to oxygen partial pressure of 59.2mmHg. At this altitude they took off their oxygen masks in order to recognize their personal symptoms of hypoxia. Hemoglobin saturation level was measured at 10 second intervals until oxygen mask was returned. **RESULTS:** We retrospectively analyzed the records of 167 trainees. Mean age was 24.5±4.9, and 22 were women (13.2%). Lower hypoxia tolerance was significantly and independently correlated in men with hemoglobin level below 13.9gr/dL ($p=0.01$), nonsmoking ($p=0.01$), and BMI below 20.6kg/m^2 ($p=0.03$). Age, gender, and physical activity were not found to be correlated with hypoxia tolerance. **DISCUSSION:** Aircrew with hemoglobin level under 13.9 gr/Dl should perform ROBD training instead of altitude chamber training for exposure to hypoxic conditions in order to improve the safety of the trainee. Aircrew with BMI under 20.6 kg/m^2 should be aware of their lower resistance to hypoxic conditions, and therefore for their higher risk during pressurization or oxygen system failure.

Learning Objectives

1. Hemoglobin level, smoking and BMI may predict tolerance to hypoxia.
2. High risk trainees and mitigating measures should be implied during altitude chamber training.

[227] MEASURING ARTERIAL OXYGEN SATURATION USING WEARABLE DEVICES UNDER CONDITIONS RELEVANT TO THE FLIGHT ENVIRONMENT: A PRELIMINARY STUDY

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King's College London, London, United Kingdom

(Original Research)

INTRODUCTION: Pilots are increasingly flying with wearable monitoring devices ('wearables') that can provide arterial oxygen saturation (SpO_2) measurements. It is therefore important to establish whether these wearables determine SpO_2 reliably under conditions associated with the flight environment such as environmental hypoxia and concurrent body motion. The aim of this study was to conduct an initial evaluation of wearables under these conditions and generate preliminary results to provide a basis for further definitive studies. The hypothesis was that the performance of wearables in measuring SpO_2 would be the same as that of a standard pulse oximeter. **METHODS:** Ten healthy participants (six men and four women) were studied breathing air and breathing 11.8% oxygen in a normobaric chamber (≈ 15,000 ft equivalent altitude). SpO_2 was measured using two consumer-grade wearable devices (Apple Watch Series 6 and Garmin Fēnix 6 watch) and two wearables designed for clinical use (Cosinuss° Two in-ear sensor and Oxitone 1000M wrist-worn pulse oximeter). Data was collected while stationary at rest, during very slight body motion, and during moderate body motion, and was compared with simultaneous measurements from a standard pulse oximeter. Standardized body motion was induced by cycling on an ergometer at very low intensity (30W) and moderate intensity (150W) respectively. **RESULTS:** 'Missed readings', defined as failure to record an SpO_2 value within one minute, occurred commonly with all four wearable devices. Even in the presence of only very slight body motion, most wearables missed most readings (percentage of missed readings ranging from 12-82%). The percentage of missed readings increased with increasing body motion, ranging up to 20% at rest, 82% during very slight body motion, and 95% during moderate body motion. When values were successfully obtained, the wearables tended to under-report (one device) or over-report (three devices) SpO_2, and this was generally exacerbated under hypoxic conditions. **DISCUSSION:** The four wearable devices studied did not perform to the same standard as a traditional pulse oximeter. This could have important implications in safety-critical operations and, until further data are forthcoming, these preliminary results indicate a need for caution regarding the use of wearables for in-flight SpO_2 monitoring.

Learning Objectives

1. The audience will learn about recently-developed wearable monitoring devices that can be used to measure arterial oxygen saturation.
2. The audience will learn about the possible limitations of using wearables for arterial oxygen saturation monitoring during flight operations.

[228] RISK OF DECOMPRESSION SICKNESS IN JUMPMASTERS DURING HIGH-ALTITUDE MISSIONS

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(Original Research)

INTRODUCTION: Military parachute operations, with drop of troops or equipment, are often performed at very high altitude, and without pressurization of the parachuter/cargo compartment. Present Swedish Airforce regulations permit exposure of the jumpmasters/loadmasters (JM) to altitudes up to 11000 masl (36000 ft), and the JMs are regularly exposed to 29500 ft for 60 min. Anecdotal information suggests that the JMs may experience decompression sickness (DCS) during such

high-altitude exposures. The aims of this study were to investigate (*i*) the risk of DCS during a simulated JM mission at high altitude and to (*ii*) compare two strategies of pre-oxygenation, conducted either at sea level before take-off or during ascent to mission altitude. **METHODS:** Ten JM were examined in a hypobaric chamber on two separate occasions, both during which they were breathing 100% oxygen during 60 min at 28000 ft, after 45 min of pre-oxygenation. In condition N, the pre-oxygenation was performed at sea-level, whereas in condition (H), pre-oxygenation was performed at 8200 ft. The degree of decompression strain was determined from ultrasound-derived assessment of the presence of venous gas emboli (VGE), using a 6-graded scale (0-5). **RESULTS:** During the exposure to 28000 ft, 2 JMs experienced DCS in condition H and none in condition N. The prevalence of VGE was higher in the H than the N condition, both at rest, median range (3.3 (0-4) vs 0 (0-4); $p<0.04$) and after weighted squats (3.7 (0-4) vs 0 (0-4); $p<0.01$). **CONCLUSIONS:** A preoxygenation/altitude procedure commonly used by Swedish military jumpmasters, with a 1-hr exposure to 28000 ft after pre-oxygenation for 45 min at 82000 ft is associated with high risk of DCS. It appears that the risk can be reduced if the pre-oxygenation is conducted at sea level. Presumably, the increased decompression strain after preoxygenation at altitude, reflects a stabilization of micronuclei by Boyle expansion.

Learning Objectives

1. The participant will be able to understand the risk of decompression sickness at high altitude missions even within regulated exposures.
2. The participant will be able to understand the increased risk of Decompression Sickness when preoxygenating in lower ambient pressure compared to sea level.

[229] CHALLENGES IN THE DIFFERENTIATION OF ATAXIA AND CONFUSION IN A PATIENT AT HIGH ALTITUDE

Ari Epstein[1], Karen Ong[2], Sawan Dalal[3], Michael Gallagher[4]
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(Education - Case Study)

INTRODUCTION: This case report describes a high-altitude hiker who develops nausea, ataxia, and acute confusion at a remote point without immediate EMS access. A decision was made to instead complete the ascent to access EMS care at the summit and then initiate a faster, safer descent. **BACKGROUND:** Increasing interest in extreme sports has prompted more high-altitude and remote travel, often without sufficient acclimatization or recognition of the risks of altitude-associated illnesses (e.g. Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HAPE), and High Altitude Cerebral Edema (HACE)). Diagnosis and management of these conditions is challenging, particularly in austere environments or for those who have not encountered them. **CASE PRESENTATION:** A 25-35-year-old individual presented with bitemporal mild/moderate headache following gradual ascent to 11,000′. Despite oral NSAIDs, the headache worsened to severe intensity with associated nausea, ataxia, and acute confusion by 13,000′. The patient had consumed 5L of water without electrolytes and minimal solid food over 5 hours. Symptoms did not resolve despite electrolyte and glucose consumption following illness onset. Given medical care availability and road access at the summit, the hiking party continued its ascent to >14,000′ and notified EMS. Upon EMS arrival, the patient was confused, ataxic, had cool edematous extremities, and exhibited hypoxia that resolved with oxygen via nasal cannula. Ataxia resolved after descending 3000′, but nausea and headache persisted despite anti-nausea medications. After completing the descent and presenting to the Emergency Department (7000′ total descent to 6000′ above sea level), symptoms of ataxia, confusion, and hypoxia resolved completely. Electrolytes were found to be within normal limits, and non-contrast head CT showed no evidence of increased intracranial pressure or cerebral edema. Given concern for HACE, the patient was discharged with oral Dexamethasone and Acetazolamide and advised to temporarily avoid exposure to increased altitudes. **DISCUSSION:** Hyponatremia, hypoglycemia, and HACE may have overlapping symptoms, but all cases of altered mental status at altitude must be assumed to be HACE and treated with immediate descent if able. We discuss risk factors, decision-making in austere environments, and management including medications, complications, temporary altitude restrictions, and risk management for future high-altitude travel.

Learning Objectives

1. The audience will learn about the clinical diagnosis of and management for common high altitude illnesses, including Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HAPE), and High Altitude Cerebral Edema (HACE).
2. The audience will be able to understand the decision-making processes for evacuation in austere environments without EMS access for rapid descent.
3. The audience will learn about travel planning processes to mitigate medical risk before, during, and after high altitude exposures, especially for participants with elevated risk factors to develop high altitude illnesses and their complications.

[230] NORMOBARIC HYPOXIA SYMPTOM RECOGNITION IN THREE RECURRENT TRAINING SESSIONS

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(Original Research)

INTRODUCTION: In-flight physiological episodes compromise flight safety. Hypoxia training is mandatory for military pilots worldwide. Our previous study shows that only 64% of pilots recognize hypoxia faster in their 2nd normobaric hypoxia (NH) training compared to the first NH training. Our aim of the present study was to evaluate if the 3rd NH training session would enhance hypoxia recognition. **METHODS:** This study was conducted under normobaric conditions in a tactical F/A-18C Hornet simulator in three training sessions. The pilots performed visual identification missions and breathed 21% oxygen in nitrogen. Blinded to the pilot, the breathing gas was changed to a hypoxic mixture containing either 8%, 7% or 6% oxygen in nitrogen. Data were collected from 102 pilots from the Finnish Air Force (101 males and 1 female). The peripheral capillary oxygen saturation and the time taken to notice hypoxia symptoms were measured as the primary outcome parameters. The study was approved by the Committee on Research Ethics of the University of Eastern Finland, Joensuu, Finland (no. 24/2018). The study had the institutional approval of the Defense Command Finland. **RESULTS:** Hypoxia symptoms were recognized in the 1st training session with 8% O_2 in 101 s, with 7% O_2 in 91 s and with 6% O_2 in 78 s. In the 2nd training significantly faster, in 88 s, 80 s, and 72 s, and in the 3rd training in 80 s, 70 s, and 66 s, respectively. However, 24% of the pilots recognized hypoxia symptoms slower during the 3rd session compared to the 1st session. There was a large between-individuals variation in hypoxia symptoms recognition. **DISCUSSION:** Hypoxia symptom recognition time was improved the further the training went. The 3rd training further enlarged the group that improved their recognition time. More emphasis should be put on the group of slow hypoxia symptom recognizers and offer more individualized hypoxia training for this group on an annual basis.

Learning Objectives

1. The audience will understand the benefits of repeating normobaric hypoxia training.
2. The audience will understand that hypoxia training does not benefit all equally good and individual training should be held to gain more knowledge for all pilots.