

assignment of residents to the aviation training units co-located at Fort Rucker. Here, AM residents provide flight surgeon support that includes aircrew duties, delivery of annual regulatory aeromedical briefs, and Aviation Safety Officer (ASO) duties. The second presentation covers the activities that the residents participate in with the local Army Health Clinic that pertain to provision of aviation troop medicine to the most active aviation units in the Army. The third section will highlight flight surgeon duties that the residents perform to support USASAM including aeromedical coverage of the altitude chamber as well as instructional support for a wealth of aviation medicine courses. Following these presentations, an open panel discussion will be facilitated to elaborate on the presented material while soliciting unique approaches and best-practices from the audience for consideration by GME faculty.

Learning Objective:

1. The audience will familiarize themselves with US Army initiatives to add operationally relevant experiential learning to the US Army residency in Aerospace Medicine curriculum.

[17] ACADEMIC DUE PROCESS IN GRADUATE MEDICAL EDUCATION

Mark Coakwell

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

(Education - Tutorial Proposal)

INTRODUCTION: Failure of residents to meet established standards of knowledge and performance necessitates early and deliberate intervention. **TOPIC:** Intervention may escalate from program level remediation to probation and, ultimately, to termination. Throughout this spectrum, specific protocols and elements of due process must be followed to ensure the best interests and outcomes for both the resident and the program. **APPLICATION:** In this presentation, practical examples for different levels of intervention at various degrees of complexity will be described. Program level intervention steps may include tasks required of the resident, due dates, and information about the steps to be followed if those tasks are not completed on time. The importance of documenting any and all intervention is critical to further steps if and when they are required. Multiple interventions, including academic probation, may be tried before action to terminate residency training becomes necessary. This stepwise approach protects both the resident and the program from post-hoc accusations and it ensures that the process was fair and that due process was followed.

Learning Objective:

1. Participants will gain an understanding of the components of due process that should be followed, and how they should be documented, when addressing concerns associated with a struggling learner in the graduate medical education setting.

[18] PROGRESSIVE DISCIPLINE IN COLLABORATIVE GRADUATE MEDICAL EDUCATION PROGRAMS

Michael Jacobson

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

(Education - Program / Process Review Proposal)

INTRODUCTION: When residents fail to meet established standards of knowledge and performance, progressive discipline is implemented in pursuit of an outcome desirable for both the resident and the training institution. If the training is occurring in an affiliate program, this due process is more complicated and can be hindered or enhanced, depending upon the approach of the respective officials and the agreement that underlies the collaboration. **TOPIC:** Progressive discipline involving a resident in an affiliated Graduate Medical Education (GME) program will not only test the involved resident, but it will challenge leadership of both organizations and require effective communication and cooperation to secure the best interests and outcomes for all concerned. **APPLICATION:** A case will be presented in which a military resident in training at an affiliate GME program underwent progressive discipline for professionalism concerns. While the civilian academic program and institution had primary oversight, military leadership was also engaged and consulted for official guidance to ensure due process. This presentation will describe requirements of the

American College of GME, as well as that of the involved civilian and military institutions. It is hoped that this presentation and discussion will help equip the participant to effectively adjudicate academic due process, should it be faced in the future.

Learning Objectives:

1. Understand essentials to collaborative agreements that can support or adversely affect progressive discipline.
2. Become familiar with ACGME and other organizational requirements for due process.
3. Introduce practical tools and concepts to enable the participant to effectively adjudicate academic due process, should it be faced in the future.

[19] SEXUAL HARASSMENT AS AN ACT OF AGGRESSION : UNDERSTANDING WHAT WORKS AND WHY

Maria-Vittoria Carminati

The Woman's Lawyer, Denver, CO, USA

(Education - Program / Process Review Proposal)

The medical profession, like any other, is plagued by sexual harassment. This is a pervasive, pernicious, and longstanding issue that must be addressed if the profession wants to fully make use of all human resources available to it. Fifty percent of medical school students are women. If the profession drives them away, it is wasting half of its assets. That is unacceptable. Unfortunately, most sexual harassment training fails to properly explain that sexual harassment is an act of aggression. Rather, it is mistakenly depicted as a question of "political correctness," "boys being boys," or singular events. However, sexual harassment is none of those things. Sexual harassment exists on the spectrum of sexual aggression. The only way to tackle it appropriately is to understand it in those terms. Once it is identified and understood as an act of aggression, organizations can work on changing their culture. Sexual harassment will not be addressed on a one-by-one basis. It will be addressed by fundamentally altering the power structures and code of conduct of organizations, top down.

Learning Objectives:

1. The audience will learn about the prevalence of sexual harassment within the medical profession, the forms it takes, and how little is done to address it.
2. The audience will learn that sexual harassment lives on a continuum of sexual aggression and often does escalate to physical assault if left unchecked.
3. The audience will learn how to address sexual harassment as an attempt to take power from the victim rather than an innocent misunderstanding between "well-meaning people."

MONDAY, MAY 6, 2019 WORKSHOPS

Monday, 05/06/2019

8:00 AM

OPENING CEREMONIES & 65TH ANNUAL LOUIS H. BAUER LECTURER

Johann-Dietrich 'Jan' Wörner
"Human Exploration ... and Its Consequences"

Monday, 05/06/2019

10:30 AM

SPECIAL PLENARY SESSION COMMEMORATING THE 50TH ANNIVERSARY OF APOLLO 11 AND THE MOON LANDING

Moderator: Dr. Mike Barratt

Apollo Astronaut: TBD

Apollo Flight Surgeon: Dr. Bill Carpentier

Apollo Flight Director: Gerry Griffin

Apollo Engineering: Milt Heflin (ground test vehicle engineer and test conductor for the development and qualification of water recovery hardware and procedures for the Apollo command module)

There will be a short video highlighting the Apollo 11 mission, followed by a panel discussion with plenty of time for questions from the audience!

Monday, 05/06/2019
Brasilia 1

2:00 PM

[S-07] PANEL: CURRENT RPA TRENDS - ENLISTED AND BEYOND

Chair: Kevin Heacock

PANEL OVERVIEW: This panel presents an educational tutorial regarding the recent policy allowing enlisted Air Force members to train to become remotely piloted aircraft (RPA) pilots. The first presentation provides an overview of the process of selecting enlisted personnel for the highly competitive RPA pilot training program. The second presentation discusses the medical flight screening process used to ensure enlisted RPA pilot applicants are qualified from a psychological perspective to enter the training pipeline. The third presentation discusses the data collected from this psychological testing and looks at the similarities and differences enlisted selectees may have when compared with officer RPA pilots. The fourth presentation discusses the operational issues flight surgeons see in real-world RPA pilots and contemplates how enlisted RPA pilots may function in this environment. The last presentation looks at trends seen at the Aeromedical Consultation Service when evaluating RPA pilots for waivers for mental health diagnoses, providing insight into how enlisted RPA pilots may fare from a psychological perspective.

[20] THE ENLISTED REMOTELY PILOTED AIRCRAFT PILOT PIPELINE

Kevin Heacock

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

(Education - Tutorial Proposal)

INTRODUCTION: Remotely piloted aircraft (RPA) pilots are highly sought after Air Force personnel with extensive training. Good candidates are being encouraged to apply for RPA pilot careers from more and more diverse groups that now include some enlisted personnel. **TOPIC:** In December 2015, the Secretary of the Air Force announced the Air Force would begin training enlisted pilots to operate the unarmed RQ-4 Global Hawk. Eligibility for these positions is limited to the ranks of staff sergeant to senior master sergeant with appropriate retainability not receiving a Critical Skills Retention Bonus. A selection board identifies the next enlisted group to attend RPA Flight Training using a system that mirrors the officer selection process, with the addition of enlisted personnel on the selection board. The Aeromedical Consultation Service conducts the medical flight screening to ensure enlisted RPA pilot applicants are certified physically qualified by Headquarters Air Education and Training Command, Office of the Surgeon General, Physical Standards. These applicants must meet the same criteria all RPA pilots are required to meet. **APPLICATION:** Having an understanding of the process enlisted RPA pilots are required to go through with its similarities to the officer RPA pilot selection process will help flight surgeons manage the care of these highly trained Air Force personnel as well as they do all their patients. **RESOURCES:** <https://www.afpc.af.mil/Retraining/Enlisted-RPA/>

Learning Objectives:

1. The audience will learn about the Air Force's beginning of training enlisted pilots to operate RPAs.
2. The audience will learn about the selection board that identifies the enlisted groups to attend RPA Flight Training.
3. The participant will be able to understand the process enlisted RPA pilots are required to go through for selection to help manage their care.

[21] MEDICAL FLIGHT SCREENING-NEUROPSYCHIATRY PROGRAM

Rebecca Walsh

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

(Education - Tutorial Proposal)

INTRODUCTION: Prior to beginning Undergraduate Pilot Training, every U.S. Air Force (USAF) remotely piloted aircraft (RPA) pilot candidate must complete Medical Flight Screening. In addition to other screenings, this process includes Medical Flight Screening-Neuropsychiatry (MFSN)

baseline testing. The MFSN testing consists of the administration of two cognitive assessments and two personality assessments. The purpose of MFSN is to have an accurate assessment of an RPA pilot candidate's neuropsychological functioning should the pilot need to have a psychological evaluation for waiver consideration in the future. Additionally, the pilot candidate's MFSN data can be used in predictive studies determining what psychological variables contribute to success in completion of RPA training. Typically, RPA pilot candidates consist of USAF members who have earned college degrees whose components consist of active duty, USAF Guard, USAF Reserves, and Reserve Officers' Training Corps duties. In recent times, between 2017 and 2018, a group of 30 enlisted active duty USAF members, without college degrees, were selected to train for RPA pilot slots. The inclusion of this group of enlisted to RPA candidates demonstrates the ongoing evolution of USAF needs, particularly with USAF aviation. An in-depth understanding of the MFSN program is important when examining the expansion of qualified RPA pilot candidates. **TOPIC:** This presentation will focus on the development of the MFSN program, beginning at its inception through current day, and the purpose of the MFSN program. Neuropsychological assessments will be examined and ongoing research studies derived from MFSN data will be discussed. **APPLICATION:** Awareness of the MFSN program is important knowledge for the aeromedical community when determining whether or not "atypical" USAF members are qualified to pursue careers in aviation. Future research studies will also be discussed.

Learning Objectives:

1. To understand the Medical Flight Screening-Neuropsychiatry process.
2. To identify what neuropsychological tests are utilized when screening Enlisted to RPA candidates.

[22] ENLISTED REMOTELY PILOTED AIRCRAFT PILOTS: A NEW HORIZON

Teg McBride

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

(Education - Tutorial Proposal)

INTRODUCTION: The U.S. Air Force (USAF) has initiated a program to select and train enlisted remotely piloted aircraft (RPA) pilots. Prior to a candidate beginning training, an assortment of psychological data is collected. From this wealth of data, similarities and differences between enlisted and traditional officer RPA pilot candidates have been revealed. **TOPIC:** Challenges of RPA personnel have been well documented. One of the most consistent findings is that features of RPA duties, which often include high workloads, shift work, and long hours, can be perceived as strenuous and taxing. Additionally, there continues to be ongoing manning challenges in the face of a pressing need for more RPA pilots. At the end of 2017, the USAF began selecting and training enlisted RPA pilots for the first time. Prior to receiving the go-ahead to begin RPA-specific training, candidates complete Medical Flight Screening, including the administration of several psychological instruments. To date, there have been 30 enlisted RPA pilot candidates evaluated. Information on the cognitive abilities, emotional maturity, conscientiousness, and motivation of these novel enlisted RPA pilot candidates will be elucidated to answer the question, "Are these enlisted personnel ready for the challenges inherent to RPA pilots?" Testing results will also be compared to those of traditional RPA pilot candidates who are, or go on to become, USAF officers. **APPLICATION:** A greater understanding of enlisted RPA pilot candidates affords new insights into future directions of USAF RPA career fields.

Learning Objective:

1. Understand the differences revealed in psychological testing between USAF enlisted and officer RPA pilot candidates.

[23] OPERATIONAL ISSUES FLIGHT SURGEONS SEE IN REAL-WORLD REMOTELY PILOTED AIRCRAFT PILOTS

Chaz Shurlow

USAF School of Aerospace Medicine, Dayton, OH, USA

(Education - Tutorial Proposal)

We will discuss the operational issues flight surgeons see in real-world remotely piloted aircraft (RPA) pilots. The stresses of aerial

flight are distinctively different from those of RPA pilots and require a unique aeromedical mindset. The typical RPA duty day is three 8-h shifts, with the individual crewmember scheduled for a 40-h work week. The day starts with a 1.25-h brief followed by their 8-h shift, then a shift debrief. There are two RPA pilots and two RPA sensor operators who cover their line and are in the seat for a 2- to 4-h time period. They are scheduled for a typical cycle of 4 wk on first shift, 4 wk on second shift, and 4 wk on third shift. This schedule was requested by the unit for family lifestyle. There are also significant challenges in the Air National Guard (ANG) RPA mission, and they are different than the enlisted Global Hawk surveillance platform. The biggest difference between the RQ-4 Global Hawk reconnaissance mission and the RPA MQ-9 mission is the chain of fire responsibilities and stresses of weapon employment. We will discuss the RPA-specific stresses of flight including circadian rhythm disturbance, social media and social interactions / isolation, alcohol use, personality changes, mental health perceptions, and the fact that the ANG is always in mission without dwell time. Additionally, a significant ANG-specific issue deals with the development of a medical issue that results in duties not to include flying and forces the aviator off orders, often causing significant financial difficulties. Finally, we will discuss and solicit prevention ideas and strategies for risk mitigation from the group.

Learning Objectives:

1. The participant will be able to understand the operational issues flight surgeons see in real-world remotely piloted aircraft (RPA) pilots.
2. The participant will be able to understand the stresses of aerial flight are distinctively different from those of RPA pilots and require a unique aeromedical mindset.

[24] TRENDS IN DIAGNOSES, TREATMENT, PSYCHOLOGICAL TESTING, AND OCCUPATIONAL OUTCOMES FOR REMOTELY PILOTED AIRCRAFT PERSONNEL EVALUATED AT THE ACS

Joe Wood, John Heaton

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

(Education - Tutorial Proposal)

INTRODUCTION: Remotely piloted aircraft (RPA) pilots and sensor operators fall under the same enhanced medical standards as manned aircrew. When diagnosed with a mental health condition, RPA personnel must receive treatment and return to baseline psychological functioning prior to consideration of returning them to flying duties. The Aeromedical Consultation Service (ACS) provides comprehensive mental health evaluations utilizing extensive psychological and neurocognitive testing in addition to interviews and collateral information to ensure fliers have received adequate treatment and meet standards to return to their full duties. **TOPIC:** ACS files for the past 48 mo were reviewed. Eight RPA personnel (four pilots and four sensor operators) were evaluated due to their histories of psychiatric conditions. Common diagnoses included anxiety, adjustment, and depressive disorders. Relationship difficulties were often reported. Three of the aviators continued to be treated with antidepressant medication. Only three of the eight aviators received recommendations for a waiver, well below the average waiver rate at the ACS. Intelligence as measured by the Multidimensional Aptitude Battery-II was in the superior range for the group (standard score of 124), consistent with manned aviators. However, measures of psychopathology (Minnesota Multiphasic Personality Inventory-2) and personality (NEO Personality Inventory-3) were atypical, suggesting higher levels of depression and neuroticism than are typically seen. **APPLICATION:** As the RPA career field grows, it will become increasingly important for flight surgeons and mental health professionals to tailor treatment strategies to the unique characteristics of both RPA personnel and the environment in which they work.

Learning Objectives:

1. To learn about typical psychiatric diagnoses in RPA operators.
2. To gain awareness of return to flying recommendations for RPA personnel.

Monday, 05/06/2019

2:00 PM

Brasilia 2

[S-08] PANEL: AIRCREW NECK PAIN PREVENTION AND MANAGEMENT - RECOMMENDATIONS FROM NATO HFM-252

Sponsored by Life Sciences and Biomedical Engineering Branch

Chair: Barry Shender

Co-Chair: Christopher Goff

PANEL OVERVIEW: The prevalence of neck pain in pilots and aircrew of most aircraft types has been a long-standing challenge amongst North Atlantic Treaty Organization (NATO) and other national air forces. The incidents are greatest in high performance jet aircraft and helicopter aircrews. This is often associated with equipment (e.g., head supported devices), non-ergonomic seating, long duration missions, and environmental stresses (e.g., G-loading). Pain can impact performance, reduce situational awareness, affect behavior (i.e., limit aggressive maneuvering), and has led to aircrew grounding. The NATO Human Factors and Medicine (HFM) Aircrew Neck Pain Research Task Group (RTG) 252 had a mandate to contextualize and understand aircrew neck pain, conduct the necessary research to evaluate a variety of mitigating solutions, and generate recommendations for reducing the risk of aircrew neck pain. Thus, the overall objective was to seek and ultimately recommend evidence-based administrative, procedural, ergonomic, engineering, preventative, and treatment solutions to aircrew neck pain. HFM-252 has developed a series of recommendations and guidance arrived at by consensus from the twelve participating nations addressing education, procedures, conditioning, and behavior strategies. The first presentation provides a summary of the evidence-based recommendations. The next four provide specific examples from the Panel members of those recommendations that have already been implemented. From the UK, we describe a comprehensive, multi-faceted aircrew conditioning program (ACP) that has been deployed for fast-jet, rotary wing, and multi-engine aircrew and updated guidelines for head support mass. Next, we present the new RAAF comprehensive mitigation strategy that was developed following a risk assessment and risk control plan leveraging HFM-252 results. This is followed by a summary of the RCAF's strategy that includes concepts for reducing spinal stress from vibration and a program that improves helmet fit. The final presentation summarizes the programs underway in continental Europe; in particular, efforts for tailor-made training programs that have a holistic approach towards spinal health that encompasses both flying and non-flying activities. A final caveat: these recommendations will result in mitigation of the severity and prevalence of neck pain, not eliminate it.

[25] RECOMMENDATIONS FOR MITIGATING AIRCREW NECK PAIN - NATO HFM-252 RESEARCH TASK GROUP REPORT

Barry Shender¹, Philip Farrell², Christopher Goff³, Joel Baudou⁴, Valeria Di Muzio⁵, Nathalie Duvigneaud⁶, Sanna Feberg⁷, Helmut Fleischer⁸, Marina Lopes⁹, Adrian Smith¹⁰, Thomas Wemes¹¹
¹Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; ²Defence Research and Development Canada Toronto Research Centre, Toronto, Canada; ³Dstl Platform Systems Division, Aerospace Systems Group, Fareham, Hampshire, United Kingdom; ⁴Thales AVS, R&D, Merignac, France; ⁵Flight Test Center, Pratica di Mare, Pomezia-RM, Italy; ⁶Center for Physical Medicine & Rehabilitation, Military Hospital Queen Astrid, Brussels, Belgium; ⁷Finnish Defence Force Medical Center, Kouvola, Finland; ⁸Taktisches Luftwaffengeschwader 74, Neuburg/Donau, Germany; ⁹Air Force Aeromedical Center, Lisboa, Portugal; ¹⁰Royal Australian Air Force Aviation Medicine, RAAF Base Edinburgh, Australia; ¹¹Institute of Aviation Medicine Norwegian Armed Forces Medical Services, Oslo, Norway

(Education - Program / Process Review Proposal)

BACKGROUND: The prevalence of neck pain amongst aircrew from NATO nations is a recognized issue. Heavy and unbalanced helmet systems worn in high G and vibrating environments, coupled with tasks and performed in often poor postures and ergonomics of the workspace, contribute to aircrew neck pain. Additional causal factors include mission length, mission type, organizational elements, and human factors such as age, gender, neck strength, and other physical and mental characteristics.

OVERVIEW: HFM-252 was formed not only to understand these factors but also to develop proposed solutions that address the causes. Administrative activities, procedural changes, ergonomic-related and engineering solutions, preventative measures, and treatments have been compiled in a final report. **DISCUSSION:** The following are key recommendations to reduce the magnitude and prevalence of aircrew neck pain. (1) The 2018 NATO Aircrew Neck Pain Questionnaire should be used as part of all future surveys to allow comparisons among nations and to facilitate data-sharing. (2) A comprehensive multifaceted aircrew conditioning program that includes enhanced physiotherapy support is recommended to all NATO air forces. Programs should collect data that can be used later to determine effectiveness and cost/benefit of such conditioning programs. (3) Intervention for acute neck problems should occur on the same, or at the latest, the next calendar day. This may require a 24/7 on-call schedule for physiotherapy staff similar to flight surgeons. (4) Aircrew education should focus on a holistic, total lifestyle approach. Relying on musculoskeletal factors related to air operations alone will be insufficient and will not result in lasting benefits and lower injury risk. (5) NATO air forces should devote resources to improve the fit of aircrew helmets and other body-borne equipment through expert personnel, aircrew training, and improved design standards. (6) Procurement offices should consider how the mass properties of each component (helmet, NVGs, microphone, visor, etc.) contribute to future designs of integrated helmet system configurations (day vs. night time, special operations, etc.) to ensure optimal balance and function. (7) The design of aircraft displays, controls, ergonomic handles, and supports should promote biomechanically advantageous postures without compromising capability and workload. (8) Vibration mitigation technologies should be considered for all aircraft seats.

Learning Objective:

1. To obtain information about the consensus recommendations for mitigating neck pain from the NATO HFM-252 Aircrew Neck Pain Research Task Group.

[26] UK IMPLEMENTATION OF RECOMMENDATIONS FROM NATO HFM-252 RESEARCH TASK GROUP REPORT ON AIRCREW NECK PAIN

Ellen Slungaard¹, Sarah Day², Christopher Goff³

¹Royal Air Force Centre of Aviation Medicine, RAF Henlow, Bedfordshire, United Kingdom; ²QinetiQ, Farnborough, Hampshire, United Kingdom; ³Dstl Platform Systems Division, Aerospace Systems Group, Fareham, Hampshire, United Kingdom

(Education - Program / Process Review Proposal)

BACKGROUND: The prevalence of aircrew neck pain amongst NATO nations remains a recognized issue. The NATO HFM-252 Research Task Group (RTG) sought to identify mitigating solutions to reduce aircrew neck pain. **OVERVIEW:** HFM-252 identified key recommendations addressing interventions and mitigations associated with human factors, body-borne equipment, aircrew behaviours, aircraft workspace and organisation to address aircrew neck pain. Some of these recommendations the UK is already implementing. **DISCUSSION:** A comprehensive, multi-faceted aircrew conditioning programme (ACP) has been designed and implemented for use with aircrew from the commencement of flying training through to frontline operational flying in fast-jet, rotary wing and multi-engine aircrew. This programme has undergone content validation and demonstrates a significant reduction in physiological load at a given +Gz in fast jet aircrew. Further work is planned to investigate the efficacy of the ACP on neck pain using a questionnaire which will include the core questions recommended by the RTG. All RAF physiotherapists have undertaken additional training in aviation medicine and deploy in support of all fast-jet squadrons on both operations and exercises in the UK and rest of the world, providing a direct access physiotherapy service.

Advice to UK MOD Procurement has been given on two key helmet projects (fast jet and rotary wing) with respect to the optimisation of mass properties of head supported mass versus the balance of the enhanced capability, as well as advice on how to optimize the use of legacy helmets to minimize neck pain.

Learning Objective:

1. To understand what initiatives the RAF have undertaken to reduce the risk of aircrew neck pain.

[27] MITIGATING THE RISK OF FLYING-RELATED NECK PAIN - THE RAAF EXPERIENCE OF NATO RTG-HFM-252

Adrian Smith¹, Carlos Almenara², James Wallace³

¹Royal Australian Air Force Aviation Medicine, RAAF Base Edinburgh, Australia; ²78WG, RAAF Williamtown, Australia; ³University of Canberra, Canberra, Australia

(Education - Program / Process Review Proposal)

INTRODUCTION: Through its involvement in the Five Eyes (AS, CA, NZ, UK, US) collaborative research agreement [The Technical Cooperation Programme (TTCP)], Australia was invited to participate in NATO RTG-HFM-252 established to evaluate the risk of flying-related neck pain. Through the involvement with NATO RTG-HFM-252, the Royal Australian Air Force (RAAF) has developed and implemented a number of initiatives to mitigate the risk of flying-related neck pain. This presentation provides an overview of the RAAF mitigation strategies, and how these illustrate the recommendations of NATO report. **DISCUSSION:** RAAF have developed a comprehensive mitigation strategy following a risk assessment and risk control plan. This risk-mitigation strategy comprises the following key elements: risk-focused control measures; adoption of the 'elite athlete model' for aircrew; use of training, conditioning, and wellness measures to inform flight scheduling; a targeted conditioning programme based on sports science and management of risk in elite athletes; optimization of mass properties for helmet-mounted equipment through an innovative re-design of a flight helmet; and the use of sports science to assess the risk of neck injury through modelling the acute and cumulative neck forces through encountered in typical flight profiles. **CONCLUSION:** In light of a systematic risk assessment and risk control plan, the RAAF have developed a number of complementary initiatives to mitigate the risk of flying-related neck pain 'so far as is reasonably practicable'. These initiatives illustrate practical application of several of the key recommendations outlined by NATO RTG-HFM-252.

Learning Objective:

1. To understand the comprehensive series of initiatives the RAAF have undertaken to reduce the risk of aircrew neck pain.

[28] ROYAL CANADIAN AIR FORCE IMPLEMENTATION OF RECOMMENDATIONS FOR MITIGATING AIRCREW NECK PAIN FROM THE NATO HFM-252 RESEARCH TASK GROUP REPORT

Erin Smith¹, Heather Wright Beatty², Philip Farrell³

¹Canadian Forces Environmental Medicine Establishment, Toronto, Canada; ²National Research Council Canada, Ottawa, Canada; ³Defence Research and Development Canada Toronto Research Centre, Toronto, Canada

(Education - Program / Process Review Proposal)

BACKGROUND: HFM-252 was formed to better understand factors contributing to aircrew neck pain and to develop and propose solutions which address these causes. Recommendations have been compiled in a final report. Moving forward, it now falls to each nation/organization to implement these recommendations in order to mitigate the prevalence, incidence and operational impact of aircrew neck pain. **OVERVIEW:** The Royal Canadian Air Force (RCAF) is working with stakeholders to adopt a multi-disciplinary and multi-faceted approach in order to implement selected recommendations from the NATO HFM-252. A number of recommendations have already been implemented while others are in progress or have been identified for future work. **DISCUSSION:** The 2018 NATO Aircrew Neck Pain Questionnaire was incorporated into a survey of neck pain in the RCAF Fighter Force in 2016-17; the results are pending and will shape future research and mitigation strategies in this population. Work is underway to introduce a comprehensive exercise program for aircrew in the RCAF. As part of this initiative, the self-directed portion of the UK Aircrew

Conditioning Program will be implemented across the RCAF in 2019. Multiple stakeholders are engaged in updating existing aircrew training to include neck pain education early, as well as at recurrent intervals throughout their careers. Occupation-specific education is also being incorporated, such as task sharing between aircrew and improved postures during specific tasks. In order to teach improved fit of aircrew helmets and other body-borne equipment, experienced Aircraft Life Support Equipment (ALSE) technicians from the Canadian Forces Environmental Medicine Establishment (CFEME) conducted a 'road show' across the RCAF in 2017. Similar annual training will continue while the updated helmet fit procedure is incorporated into the training curriculum for all ALSE technicians. Finally, the National Research Council (NRC) conducted several studies evaluating vibration mitigation seat cushions in RCAF rotary wing aircraft. A passive vibration absorbing seat cushion was designed and integrated into the new CH-146 Griffon armored pilot seats. As each of these interventions are implemented, baseline and longitudinal data will be collected to assess effectiveness in reducing the operational impact on neck pain in aircrew. As such, there remains opportunity for international collaboration with other organizations conducting similar work.

Learning Objective:

1. To understand the multi-faceted approach, including equipment and training, the RCAF have undertaken to reduce the risk of aircrew neck pain.

[29] IMPLEMENTATION OF NATO HFM-252 RTG RECOMMENDATIONS FOR MITIGATING AIRCREW NECK PAIN IN PARTICIPATING NATIONS

Nathalie Duvigneaud¹, Helmut Fleischer², Di Muzio Valeria³, Sanna Feberg Medical Center⁴, Marina Lopes⁵, Roope Sovellius⁶, Marieke van den Oord⁷, John Crowley⁸, Mark Davies⁹, William Dodson¹⁰, Bethany Shivers⁸

¹Center for Physical Medicine & Rehabilitation, Military Hospital Queen Astrid, Brussels, Belgium; ²Taktisches Luftwaffengeschwader 74, Neuburg/Donau, Germany; ³Aero Space Medicine Department Pratica di Mare, POMEZIA- RM, Italy; ⁴Finland Defence Force, Kouvola, Finland; ⁵Air Force Aeromedical Center, Lisboa, Portugal; ⁶Finnish Defence Force, Pirkkala, Finland; ⁷Center for Man in Aviation, Soesterberg, Netherlands; ⁸U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; ⁹Gentex Corporation, Ottawa, Canada; ¹⁰USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review Proposal)

BACKGROUND: Neck pain due to heavy and unbalanced helmet systems, high-G-loading, vibration and often poor ergonomics of the workspace is an increasing problem for aircrew. NATO HFM-252 RTG was set up to look at the issue from as many sides as possible and to come up with solutions to mitigate neck pain. This common goal led to quite different emphases in the various participating nations, since in many areas the literature is not yet sufficient to be able to offer evidence-based solutions. **OVERVIEW:** The purpose of this presentation is to illustrate the different approaches by the participating nations based on the recommendations of NATO HFM-252 RTG. Although there is a great deal of consensus about the basic necessities, such as aircrew education, a tailor-made training program, the quick access to a physiotherapy treatment, the helmet design and fitting, cockpit ergonomics and vibration mitigation technologies the respective focus in the individual nations leads to considerable differences that need to be discussed. **DISCUSSION:** Almost all nations have recognized the problem of neck pain in aircrew and are making considerable efforts, financially and operationally, to make improvements to their aircrew. Nevertheless, it must be clear that all these ideas will lead only to a mitigation, but in no way to a solution of the problem. It must now be a primary objective to closely scrutinize these efforts through well-planned and conducted studies in order to consolidate the various programs through a database in order to arrive at evidence-based solutions.

Learning Objective:

1. To obtain information about the ways in which the nations participating in the NATO HFM-252 Aircrew Neck Pain Research Task Group have applied the lessons learned from each other to implement programs to reduce aircrew neck pain incidence and severity.

Monday, 05/06/2019

2:00 PM

Brasilia 3

[S-09] SLIDE: SAFETY IN CIVIL AVIATION

Chair: Eduard Ricaurte

Co-Chair: Christopher Nagle

2:00 PM

[30] TRUTH IN REPORTING 2009-2014

Charles DeJohn, Richard Greenhaw, Russell Lewis
FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA

(Original Research)

INTRODUCTION: There is a growing trend in the use of drugs which could increase the likelihood of an aircraft accident. Evidence exists that pilots do not report all their medications to the Federal Aviation Administration (FAA). The purpose of this study was to compare medications discovered by post-accident toxicology testing to those reported to the FAA to determine the veracity of reported medications. **METHODS:** Medications reported on applications for medical certificates were compared to those discovered during post-accident toxicology testing. Logistic regressions were performed using Age, Gender, Type of Flight Operation, Medical Class Issued, and whether a Special Issuance (SI) medical certificate was issued as independent covariates. Truthful in Reporting a medication was the outcome variable. **RESULTS:** Age and a SI medical certificate were good predictors of the likelihood of truthfully reporting medications. For each year of age the probability of a case being truthfully reported increased by 5 percent, while a pilot with a SI was 3.12 times more likely to be truthful than a pilot without a SI. When reported medications were limited to cardiovascular drugs, Age was the only good predictor of truthful reporting, and for every additional year of age the probability of a case being truthfully reported increased by 3 percent. **CONCLUSIONS:** This study showed that the probability of a pilot truthfully reporting medication use increases with Age and a SI medical certificate. When reported medications were limited to cardiovascular drugs, Age was the only good predictor of truthful reporting.

Learning Objectives:

1. The audience will learn if pilots truthfully report their medications to the Federal Aviation Administration on their medical certificate applications.
2. The audience will learn the two factors that significantly affect whether pilots truthfully report their medications to the Federal Aviation Administration on their medical certificate applications.
3. The audience will learn the impact of pilot age on truthful reporting of medications to the Federal Aviation Administration on their medical certificate applications.

2:15 PM

[31] SURVIVING A NON-SURVIVABLE ACCIDENT: LAMIA FLIGHT 2933

Julian Echeverri¹, Diego M Garcia², Anthony Brickhouse²
¹Colombian Civil Aviation Authority, Bogota, Colombia; ²Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Program / Process Review Proposal)

BACKGROUND: An Avro 146-RJ85, performing a charter flight LAMIA LMI2933 for the Brazilian Chapecoense football team, was destroyed after impacting a wooded hillside south of Rionegro/Medellin Airport, Colombia. The official accident investigation board included over 20 experts from 5 states; the board determined fuel exhaustion as the cause of the crash. Out of 77 occupants only six survived the accident: One cabin crew member and four passengers suffered serious injuries and one passenger sustained minor injuries. A crashworthiness and survivability analysis were performed to assess the conditions that allowed these occupants to survive the occurrence. **OVERVIEW:** Accident investigators use CREEP methodology (Container, Restraint, Environment, Energy absorption and Post-crash factors) to assess the different factors that influence survivability in a crash. Actual flight data, crash scene analysis, medical and forensic information and personal interviews from

this accident were gathered to determine acceleration loads magnitude and duration, aircraft structural collapse and energy absorption. Also injury causation, search, rescue and healthcare services for the aircraft occupants. All five CREEP factors are depicted and weighted for each one of the six survivors in order to evaluate what specific conditions contributed to their survivability. **DISCUSSION:** Occupant survival analysis derived from aviation accidents are crucial for crashworthiness design, but also for education, research, and safety enhancement of current aerospace systems. A comprehensive survival analysis, especially when occurrence circumstances diminish the odds of survival for occupants like in this case, can contribute to the enhancement of aircraft design and restraint systems, the improvement emergency services, the advance of accident investigation techniques, and in general an augmented awareness and understanding of safety promotion and accident/injury prevention for the general public, operators and regulators.

Learning Objectives:

1. Review crashworthiness and survivability assessment for major aviation accidents.
2. Study CREEP factors for investigating crash survivability.
3. Analyze how accident dynamics, aircraft design, injury prevention countermeasures, and post-crash elements interact and affect occupants in an aviation safety occurrence.

2:30 PM

[32] HAZARD IDENTIFICATION: VOLUNTARY SAFETY REPORTS OF POTENTIAL CONTAMINATED BLEED AIR EVENTS

Mary O'Connor¹, Alan Stolzer²

¹CDC/NIOSH and Embry-Riddle Aeronautical University, Anchorage, AK, USA; ²Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Original Research)

INTRODUCTION: Safety Management Systems (SMS) are a formal, top-down organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls, and are required for U.S. air carriers operating under 14 CFR part 121. An SMS includes safety policies, formal methods of identifying hazards, and controlling, and continually assessing risk and safety performance. The potential for risk from exposure to contaminated bleed air from an aircraft's engines is increased as aircraft crews and passengers spend time in aircraft. Exposure to harmful chemical substances that may be present in contaminated air can have acute and chronic health effects. Currently, no standardized training is required for U.S. aircraft crew on recognition, procedures, or reporting of potential contaminated bleed air events, and no standardized reporting system exists to report or track these events. **METHODS:** Reports from the Aviation Safety Reporting System received during 2016-2017 were analyzed for exposure to potentially contaminated air. Reported hazards, safety issues, and outcomes from these voluntarily submitted reports were identified and characterized.

RESULTS: Three hundred and forty one events categorized as smoke/fire/fumes/odor were reviewed. Over one third of the events (119, 35%) were associated with potentially contaminated bleed air, and were filed by pilots, flight attendants, a maintenance technician, and a passenger. One third (40, 34%) of these events were reported by at least two crew members, and 35% of the events resulted in general injury or incapacitation of at least one crew member or passenger. Symptoms reported most frequently included headaches, nausea, and dizziness. The smell of dirty socks, which is associated with jet oil fumes, was present in more than 20% (28, 24%) of the events reported. **DISCUSSION:** The reports contained varying degrees of detail of the event, symptoms, and health outcomes. These findings suggest inclusion of potentially contaminated bleed air as an identified hazard in appropriate components of air carriers' SMS, establishment of a database and reporting system, and further research to identify symptoms and health effects of exposure to potentially contaminated bleed air.

Learning Objectives:

1. The audience will learn about the role and importance of hazard identification and risk assessment in safety management systems.
2. The audience will be able to identify frequently reported characteristics and symptoms of exposure to potentially contaminated bleed air.

2:45 PM

[33] OCCUPANT INJURY SEVERITY IN GENERAL AVIATION ACCIDENTS INVOLVING EXCESS AIRSPEED

Douglas Boyd

Houston, TX, USA

(Original Research)

INTRODUCTION: General aviation accounts for 94% of civil aviation fatalities. Of all flight phases, accidents during landings are the most frequent. Of these, poor speed management during landing has ramifications for injury severity since (i) impact forces increase as a square of forward velocity (ii) an aerodynamic stall, associated with inadequate landing speed, imparts high vertical G forces. Herein, the proportion of landing accidents involving deficient airspeed control and occupant injury severity was determined. **METHODS:** General aviation landing accidents (1997-2016) were identified from the NTSB database. Criteria for a high-air-speed (high-energy) accident were: airplane porpoising or multiple bounces or floating. An inadequate airspeed (low-energy)-related mishap was one citing this term or in which an aerodynamic stall occurred. Statistical analyses used Poisson distribution and Chi-Square tests. **RESULTS:** Relative to the earliest period (1997-2001), the landing accident rate was undiminished ($p > 0.05$) for later years (2007-2016). Of 235 accidents, 38% involved high-energy whereas 4% were inadequate airspeed-related. For the former, 17% resulted in occupants with fatal-serious injuries, two-fold higher ($P = 0.026$) than for mishaps absent for evidence of mis-speed. **CONCLUSION:** For landing accidents involving airspeed mismanagement, those related to excessive energy predominate and result in more severe injuries. Two mitigating strategies are advanced (i) installation of inflatable restraints for reducing injury severity (ii) a discussion of landing airspeed adjustment for aircraft weight during pilot training/recurrency.

Learning Objective:

1. The audience will learn about occupant injury severity in general aviation accidents in which landing airspeed was mismanaged.

3:00 PM

[34] MOLECULAR PATHOLOGY IN THE DIAGNOSIS OF HEART DISEASE AS THE CAUSE OF AIRCRAFT ACCIDENTS

Michael Schwerer¹, Stina Hansen², Oliver Peschel², Matthias Graw²

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

²Institute of Legal Medicine, Ludwig-Maximilians-University, Munich, Germany

(Original Research)

INTRODUCTION: A significant subset of pilot license holders suffer from longstanding heart disease. Regular and comprehensive aeromedical examination as well as compliance in therapy allows the maintenance of the medical certificate in many of those pilots. However, in the aftermath of an aircraft accident the results of the underlying aeromedical assessment will be questioned. Hence, the best possible standards in forensic pathology must be compiled to ensure reliable evaluation of the case. **METHODS:** A literature review was performed to identify recently developed techniques for detecting a pre-existing heart disease and acute heart failure. In addition, heart tissue sections and blood samples, obtained from 300 forensic autopsies, were employed for the evaluation of these procedures in accident investigation. The results of these novel DNA and RNA based methods were compared to the findings obtained during standard histology examinations. **RESULTS:** Differences in the activity of the HIF-1 (hypoxia-inducible factor 1) gene were demonstrated between fatalities following *longstanding or repeated* cardiac ischemia and sudden death cases without previous heart problems. In histology, a good correlation could be obtained between conventional markers, including CD56, and the molecular findings. The presence of markers for *acute* ischemia, including a broad panel of microRNAs, in the heart itself and in the bloodstream also differed between cases of sudden cardiac death and death resulting from an extra-cardiac mechanism, which may have led to an acute stagnation of circulation. However, an artificial distribution of molecular markers for cardiac disease into the bloodstream was observed in cases with extended agony or mechanical

resuscitation. In those cases, a false positivity for markers of acute ischemia in histology, including the immunohistochemical assessment of fibronectin, was also possible. **DISCUSSION:** The DNA based assessment of the transcription of genes induced by hypoxic episodes, as well as the RNA based investigation of post-translational gene regulation in acute heart failure extends the possibilities of forensic pathology, which studies aircraft mishaps. Successful molecular examination can also involve blood samples. A valid assessment is thereby no longer limited to heart tissue histology.

Learning Objectives:

1. Knowing about the problem of pre-existing heart disease in a significant subset of pilot license holders.
2. Knowing about the fact, that aircraft accident investigation necessarily includes a judgement about pre-existing diseases as a possible cause of an accident.
3. Getting to know recently developed methods in forensic pathology and how these techniques improve the possibilities in aircraft accident investigation to assess pre-existing heart disease.

3:15 PM

[35] COMPARISON OF TOXICOLOGY FINDINGS BETWEEN AUTOPSY REPORTS AND THE CIVIL AEROSPACE MEDICAL INSTITUTE, 2012-2016

John Soper, Kacey Cliburn, Christy Hileman, Kristi Craft, Philip Kemp

FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA

(Original Research)

INTRODUCTION: The Civil Aerospace Medical Institute's (CAMI) Forensic Toxicology Research Laboratory provides forensic toxicology services for the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). The Autopsy Program Team obtains autopsy reports for fatal aviation accidents. These autopsy reports may include toxicology reports from external laboratories. A comparison of these results has not been previously performed, and it is important to determine if there any significant discrepancies between them. Our hypothesis is that there are none. We have examined a five-year period to see if this thesis is correct. **METHODS:** Information from these cases is stored in a database called ToxFlo. ToxFlo was queried for the period from 2012-2016. During this time, CAMI received autopsy reports for 1,415 fatalities and specimens from 1,338 victims. In 756 of these cases external laboratories performed toxicology. Of the cases that had both CAMI and external toxicology results, 227 cases were positive for one or more drugs. The data was investigated under protocol 18011, providing exempt review, as approved on 5/30/18. **RESULTS:** The aim of this study was to compare the results of toxicology performed by an external laboratory with the toxicology results from CAMI. Overall, CAMI reported more positive results than the external laboratories in five categories of drugs (Impairing/Controlled, Routine over-the-counter (OTC), Cardio Active-Related, Rx Impairing, and Other Drugs). CAMI reported 1,051 positive results from the analysis of 166 different drugs, while external laboratories reported 327 positive results from 82 different drugs. CAMI reported positive results for every drug found by the external laboratories, while reporting results for an additional 84 drugs. The Impairing/Controlled Group had the most number of positives for both CAMI and the external laboratories. The relative number of positives for CAMI, relative to external laboratories, was highest for the Cardio Active-Related Group. Diphenhydramine (Benadryl, Sominex) was the most commonly detected drug by both CAMI and the external laboratories. Ethanol was found positive in 22 cases by CAMI and the external laboratories. **DISCUSSION:** This presentation will describe the findings of this study and provide possible explanations for the observed differences in toxicology results found between CAMI and the external laboratories.

Learning Objective:

1. The audience will learn about the most prevalent drugs detected in autopsies conducted by both CAMI laboratories, and external laboratories. In addition, the audience will learn about any possible differences in drugs detected by the two groups of laboratories.

Monday, 05/06/2019

Brasilia 4

2:00 PM

[S-10] SLIDE: AVIATION VISION

Chair: Harriet Lester

Co-Chair: Sarper Karakucuk

2:00 PM

[36] NEURO-OPTOMETRY HISTORY, DESCRIPTION AND CURRENT APPLICATIONS

Deborah Zelinsky¹, DeAnn Fitzgerald²

¹Mind-Eye Connection, Northbrook, IL, USA; ²OD & Associates, Grand Rapids, IA, USA

(Education - Program / Process Review Proposal)

Neuro Optometric concepts were discovered in the 1920s but the International Organization of Neuro-Optometric Rehabilitation Association [NORA] was not founded until 1989. During those 60 years, Dr. Skeffington revamped Optometric testing. He discovered eye aiming and eye focusing are different from each other but they always work together. So testing them individually is not representative of how a person functions. The peripheral eyesight is crucial to neurologic function yet it's not tested during regular eye exams nor is the eye-ear connection. During development, an outpouching of brain tissue becomes the retina. It acts as a two-way interface between external eyesight and internal comfort. Light rays enter each eye and activate some of the 126 million light sensing cells. Once signals leave the retina for further brain processing, they are routed through various brain structures. Some of the signals stimulate the brainstem, and others the limbic system. Those internal systems react more quickly than the slower eyesight signals. The eyesight signals are split into Peripheral awareness and Central attention. Traditional Optometry measures eyesight and eye health. Neuro Optometry measures signals that affect the brain stem, posture centers, and the limbic system pathways. Overall, Neuro-Optometrists have the capability to selectively stimulate biochemical and neurological activity in the entire body. Each of these systems have some connections to the eye muscles, eyesight, and the corneal Integrity tear layer. When patients have post-traumatic stress disorder or concussions, their systems are compromised and they no longer can function in a noisy or brightly-lit environment. Taking medications can calm their nervous system but it does not remove this stimulating environment. Specialized eyeglasses are able to mute the environment. Optometrists who focus on Central eyesight are not able to help PTSD or TBI patients with their symptoms. By combining various types of lenses to correct Central but also affect Peripheral vision in a person who has sustained a TBI or has PTSD, symptoms can be lessened. When the symptoms are lessened and the body is more comfortable, the peripheral eyesight expands, the person becomes less anxious and depressed, and their brain can regenerate.

Learning Objectives:

1. To introduce the new sub-specialty of Neuro-Optometry to the field of Aerospace Medicine which includes Optometry as a division within the specialty of Aerospace Medicine.
2. To propose a new and clinically successful treatment for Total Brain Injury but also a possible new and exciting therapy for many other Neurologic and Psychiatric disorders including PTSD.

2:15 PM

[37] AVIATION EXPERIENCE AND THE ROLE OF STEREOPSIS IN ALTITUDE ESTIMATION

Brittney Hartle¹, Aishwarya Sudhama¹, Lesley Deas¹, Robert Allison¹, Elizabeth Irving², Mackenzie Glaholt³, Laurie Wilcox¹

¹York University, Toronto, Ontario, Canada; ²University of Waterloo, Waterloo, Ontario, Canada; ³Defence Research and Development Canada, Toronto, Ontario, Canada

(Original Research)

INTRODUCTION: The relevance of stereopsis as a medical selection variable for aircrew is a longstanding question in aviation medicine. In a prior study we observed superior altitude estimation when

subjects viewed simulated terrain images in stereoscopic 3D compared to monocular viewing, thus supporting the relevance of stereopsis to aviation (Deas et al., AsMA 2016). However, the prior study used undergraduates as a subject population, and professional aircrew undergo rigorous selection and training that might be expected to enhance their use of specific depth cues during altitude estimation. In the present study we investigated this possibility by comparing the performance of military aircrew and undergraduates as they estimated altitude in a simulation under binocular and monocular viewing conditions. **METHODS:** Thirty-one trained military rotary-wing aircrew and thirty undergraduate observers participated in the experiment. Stimuli consisted of high-resolution images depicting a virtual helicopter skid above a ground plane with one of four different high-resolution terrain textures. The scenes were rendered stereoscopically and the apparent altitude of the skid varied from zero to five feet. Observers were asked to judge the relative distance between the skid and the ground plane under binocular (wearing stereo glasses) and monocular (wearing an eye patch) viewing conditions. **RESULTS:** The aircrew were found to be more accurate than the undergraduates in the monocular viewing condition, though for both groups monocular altitude estimates were less accurate than binocular estimates. During binocular viewing, both groups tended to make accurate altitude estimates and there was no evidence that the aircrew were superior to undergraduates when binocular cues were available. **DISCUSSION:** The finding of superior performance for aircrew compared to undergraduates during monocular viewing is consistent with the hypothesis that selection and experience can enhance the use of monocular depth cues. However, the aircrew performed similarly to undergraduates during binocular viewing and both groups were shown to benefit from binocular viewing compared to monocular viewing, suggesting that stereopsis contributes in the same manner to rotary-wing altitude estimation regardless of aviation experience. Future work might seek to extend these findings to more natural viewing conditions and link individual differences in stereopsis to altitude estimation performance.

Learning Objective:

1. Learn about the relevance of stereopsis to altitude estimation for rotary wing aircrew.

2:30 PM

[38] VISUAL FIELDS AND BINOCULAR SUMMATION IN AVIATION
Harriet Lester¹, Kevin Gildea², Benisse Lester³

¹Federal Aviation Administration, Jamaica, NY, USA; ²Federal Aviation Administration, Oklahoma City, OK, USA; ³N/A, Washington, DC, USA

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: Cases of airmen with visual field defects will be presented and we will explore the prediction of binocular visual performance from monocular visual fields using theoretical methodology. **BACKGROUND:** Experienced aviators who develop visual field defects may no longer meet medical certification standards. Visual fields are commonly assessed with monocular clinical tests, which were developed for diagnostic rather than functional purposes. Binocular visual performance may in some ways exceed monocular visual performance, including acuity, contrast sensitivity, and brightness perception. Binocular sensitivity may exceed monocular sensitivity by 40%. Visual system pathology can reduce sensitivity to varying degrees and in widely differing locations for each eye. Prediction of binocular performance in the presence of reduced monocular visual fields is important and not fully understood. There are few means to directly test binocular visual fields and inherent limitations and problems with these methods. Several models have been used to try to predict binocular performance from monocular visual field measurements with varying degrees of accuracy depending on the severity and location of the scotomas and the characteristics of the visual stimuli. **CASE PRESENTATION:** Case presentation will include airmen with visual field loss in both eyes assessed with monocular testing, including anterior and posterior visual system pathology. Theoretical predictive methodology and also attempts to directly assess binocular visual field will be discussed in the context of these cases. **DISCUSSION:** There are limited tools available to assess visual field. And aviation visual perception is not fully understood. When an experienced aviator develops visual field defects, it is very challenging to attempt to assess remaining function. We

will discuss monocular and binocular visual field testing as well as binocular summation theory and its application to the aviation environment.

Learning Objective:

1. The participant will better understand some limits of visual field testing and the premise of binocular summation.

2:45 PM

[39] THE EFFECT OF PERIPHERAL LASER FLASHES ON DIVIDED ATTENTION TASK PERFORMANCE

Leon McLin¹, Ellen Szubsiki², Julie Lovell¹, Paul Garcia³, John Rickman³, Peter Smith³

¹711th Human Performance Wing, San Antonio, TX, USA; ²Clemson University, Clemson, SC, USA; ³Engility, San Antonio, TX, USA

(Original Research)

INTRODUCTION: There is a serious problem with people maliciously and illegally using handheld lasers to target aircraft, 6,753 reported to FAA in 2017. This study was undertaken to quantitatively assess the distraction effects of off-axis laser flashes. **METHODS:** The experiment used a divided attention task. Subjects were briefly presented with either a mountain or desert scene and tasked to remember a central target and the sector location of a peripheral target. Presentation times were decreased if both choices were correct, and increased if incorrect. The dependent variable was the threshold display duration to identify both targets correctly. The first session was practice for the subject to become proficient on the task. On two additional sessions, subjects were randomly exposed to laser flashes that illuminated the eye and moved between four locations along the perimeter of the screen. A 2 (Background Scene) x 2 (Avg. Screen Luminance) x 2 (Laser Presence) repeated measures ANOVA was completed. Voluntary informed consent was obtained from each subject. Twelve volunteer subjects participated, mean age 35.1 years, SD 12.6. **RESULTS:** Even relatively low powered laser pointers degraded performance. Threshold presentation times were 1.76 s, SE 0.12, when laser flashes were present compared to 1.44 s, SE 0.10, when laser flashes were not present, $F(1,11)=166.28$, partial $h^2=0.94$, $P<0.001$. With a desert background, the presentation time was 1.76 s, SE 0.13, with laser flashes compared to 1.26 s, SE 0.14 without. For the mountain scene, the presentation time was 1.77, SE 0.10, s with the laser compared to 1.62 s, without, SE 0.08, $F(1,11)=70.89$, partial $h^2=0.87$, $P<0.001$. With an average background of 10 $\text{cd}\cdot\text{m}^{-2}$ the presentation time was 1.90 s, SE 0.12, with the laser flashes present and 1.42 s, SE 0.11, without. With an average background of 60 $\text{cd}\cdot\text{m}^{-2}$ the presentation time was 1.62 s, SE 0.12, with the laser flashes present and 1.47 s, SE 0.10, without, $F(1,11)=22.56$, partial $h^2=0.67$, $P=0.001$. **DISCUSSION:** This experiment demonstrated that laser flashes cause disruption of performance mediated by visual attention mechanisms and higher-level cognitive processes. Laser distraction could affect the safe completion of aircrew missions. A quantitative measure of the effect of laser distraction on visual processing could help to assess the hazardous effect of laser distraction and could aid in setting requirements for laser eye protection.

Learning Objectives:

1. To gain an awareness of the problem of laser strikes on aircraft.
2. To understand factors that influence the distraction and attention effect of peripheral laser flashes.

3:00 PM

[40] THE Z-BELL™ TEST MEASURES NON-IMAGE-FORMING RETINAL PROCESSING AND THROUGH CLOSED EYELIDS: PRELIMINARY RESULTS FROM A MONTHS-LONG LARGER STUDY

Clark Elliott

DePaul University, Chicago, IL, USA

(Original Research)

INTRODUCTION: Neurodevelopmental optometric rehabilitation and cognitive restructuring have shown remarkable successes in treating difficult head-injury cases. One therapeutic device used is the Z-bell™ test, which measures the link between the non-image-forming retinal pathways and our hearing. Although in clinical use for more than two decades Z-bell™ has allowed for some skepticism because it measures retinal processing through CLOSED EYELIDS. Preliminary data

from a months-long double-blind study at DePaul University is presented. **METHOD:** With EYES CLOSED throughout subjects try to locate a pitched bell in space by pointing to it. Retinal input treatments such as prescription lenses, occlusions and colored layers are used to alter the non-image-formal retinal processing, resulting in improvements in the subject's ability to find the bell. Room 1: An O.D. prescribes Rx glasses: SET-A to improve non-image-forming retinal processing and SET-B to hinder it. Room 2: SET-A glasses are altered randomly with externally identical SET-B and SET-C (neutral, control) glasses. 96 trials run with differently pitched bells, and two light conditions. Extremely rigorous controls used throughout to isolate any leaking of knowledge of which glasses were SET-A. Later X,Y, and Z dimensions were superimposed as grids over three video streams, and independent coders assessed distance from the bell when subjects reached to touch it. Note that we believe that because these were generally healthy brains, 96 recorded trials for each subject allowed for adaptation, limiting the results. **PRELIMINARY RESULTS:** Using Y and Z distances (preliminary analysis N=14) we found a statistically significant difference when comparing the distances in the neutral-accurate condition, $t_{(27)}=2.12$, $p < .05$, $d = .404$ (small to medium effect). The combined average distance for the neutral Rx was 5.06 (sd = 2.33) units (units were 1/2 inch), while the average distance for the accurate Rx was significantly less at 4.42 units, sd = 2.31) indicating that the accurate glasses improved participants abilities to locate the bell in space. The differences between the accurate and impaired narrowly failed significance, $t_{(27)}=2.12$, $p = .073$; the combined average distance for the impaired prescription was 5.06 (sd = 2.72). (Full study N = 41.)

Learning Objective:

- Attendees will understand how the Z-bell™ test works, how it is used as a diagnostic tool for treating brain trauma cases, and how we measured its effectiveness in a formal experimental setting.

Monday, 05/06/2019
Brasilia 5

2:00 PM

[S-11] PANEL: THE AGING PILOT AND THE AGING TRAVELLER

Sponsored by Air Transport Medicine Committee

Chair: Jim Chung

Co-Chair: Simon May

PANEL OVERVIEW: As most countries are experiencing a demographic shift towards a more aging population. This panel will examine the unique needs and challenges encountered by commercial aviation with both an aging workforce, in particular pilots as well as the increasing challenges and medical implications from an aging passenger demographic. The first presenter will discuss the changing age standards and medical requirements for commercial pilots highlighting various civil aviation authorities across the globe. The second presentation will then discuss her study on the aging pilot and physiological changes as well as cognitive changes in aging. The third presentation will be from the Life Research Institute at the University of Ottawa and their work and research in the field of aging and transportation. The fourth presentation will review statistics of types of medical events by systems on travelers over age 65 and how they differ from medical events from those under 65 and how to optimize travel for older travelers.

[41] HOW OLD IS TOO OLD? A REVIEW OF COMMERCIAL PILOT UPPER AGE LIMITS

D. Helen Hoar

Bristol Aviation Medicals, Bristol, United Kingdom

(Education - Program / Process Review Proposal)

BACKGROUND: Mandatory upper age limits for commercial pilots have been in existence since the early 1920's, a mere two decades after the first powered flight. Since then, age limits have been subject to various reviews and revisions over the years. As life expectancy

increases, there have and will inevitably be further challenges to the upper age limits. **OVERVIEW:** Back in the pioneering days of aviation, when the average flying time of an Air Mail Service pilot before death was estimated to be only 900 hours, little consideration was given for an upper age limit for pilots. Following post-war expansion of the aviation industry and recognizing the need for international co-operation to improve safety, the International Commission for Air Navigation (ICAN) was established in the early 1920s to set standards for licensing, medical certification and engineering. Under ICAN regulations, commercial pilots were not permitted to fly beyond the age of 45 years. This limit remained for over two decades until ICAO was established following the Chicago Convention in 1944. Whilst many of the principles of ICAN were transposed across, no upper age limit was written into ICAO's Standards or Recommended Practices at this time. Further change was seen in 1959 with the introduction of the "Age 60 rule" by the FAA, whereby pilots involved in commercial air transport were no longer permitted to work after their 60th birthday. ICAO followed suit some four years later, with a Recommendation for a maximum age of 60 for pilots in command (PIC). This subsequently became an ICAO Standard for pilots in command in 1978, whilst remaining a Recommendation for co-pilots. In 2006, the ICAO age limit was revised upwards to the current limit of 65 years in multi-crew operations, provided that the other pilot is under 60 and that pilots over 60 undergo six monthly medical examinations. This change was applicable to multi-crew operations only and an ICAO age limit of 60 years for single pilot operations remains. **DISCUSSION:** This presentation will review the changes to upper age limits in commercial pilots over time and compare differences to the ICAO age limits filed and currently implemented by various countries. Mandatory age limits have been subject to a number of reviews and challenges; arguments both for and against age limits, such as changes in life expectancy, medical incapacitation, operational proficiency, age discrimination legislation and pilot shortages will also be discussed.

Learning Objectives:

- The participant will learn about the origin and evolution of upper age limits for commercial pilots.
- The participant will learn about the justifications for and against the existing upper age limits for pilots.

[42] THE AGING PASSENGER

Paulo Alves¹, Neil Nerwich²

¹MedAire Inc., Phoenix, AZ, USA; ²International SPS, London, United Kingdom

(Original Research)

INTRODUCTION: In-flight medical events (IFME) are a direct function of the number of passengers travelling, their pre-existing medical conditions and risk factors. The prevalence of certain serious medical conditions increases with age. It is therefore expected that serious IFMEs should be relatively more frequent with advancing age groups of the travelling public. **METHODS:** MedAire's case database was reviewed for IFMEs and passenger fitness to fly assessments in the period of January to September 2018. Passenger age and gender were captured along with flight operational details for every case. Cases were medically categorized according to the clinical presentation. Airlines were categorized as mainline, low-cost, leisure and regional according to their business model. Passengers were divided in two age groups, above (A) or below (B) the age of 60. **RESULTS:** 31,054 cases were available for analysis. IFMEs affecting Group A passengers diverted in 3.05% of the times versus 1.41% for Group B (OR = 2.21, 1.85 < OR < 2.64, P < 0.0001). Group A passengers have proportionally more neurological, respiratory and cardiovascular cases, regardless of flight duration. Group A presented with more stroke cases. Leisure and regional airlines had significantly more Group A cases. **CONCLUSION:** IFMEs incidence mirrors the figures of the general population. Airlines carrying a greater percentage of passengers in the age groups above 60 years may be exposed to a higher number of diversions due to the associated more severe nature of the medical presentations affecting that these age groups.

Learning Objective:

- Understand epidemiological aspects around in-flight medical events affecting elderly passengers.

[43] PILOT FACTORS AND SIMULATED FLIGHT PERFORMANCE

Rani Tolton

*Transport Canada, Vancouver, British Columbia, Canada**(Original Research)*

INTRODUCTION: Requirements for greater cognitive skills have increased with expanding complexity of aircraft and the flying environment. The relationship of age, cognition, and experience was investigated to simulated flight performance in general aviation pilots. **METHODS:** Fifty-four pilots, aged 21 to 79 years, flew a Cessna 172 simulator in low and high workload conditions. Flight performance was determined by altitude, heading, and speed deviations on the downwind portion of the "perfect" circuit. Cog-Screen AE, a computerized cognitive battery, was used to measure pilot working memory, processing speed, and visual tracking. **RESULTS:** In the low workload condition, older pilots did not perform as well as the younger pilots, $r = -0.406$, $p = 0.002$. In the high workload condition, there was a trend for older pilots not to perform as well as younger pilots but this was not significant $r = -0.253$, $p = 0.065$. In the low workload condition model, significant contributions by working memory, visual tracking, and expertise determined flight performance, $F = (8,45) = 6.457$, $R^2 = 0.496$, $p < 0.001$. In the high workload, experience was the only significant contributor with working memory and processing speed adding variance to the model, $F = (9,44) = 2.627$, $R^2 = 0.350$, $p = 0.016$. Logistic Regression Probability Value (LRPV), a value obtained from the CogScreen-AE and often used to determine flight performance, correlated significantly in the high difficulty condition only but was not predictive of significant variance in the final linear regression model. Secondary analysis showed expertise had an enhancing effect in moderating between working memory and flight performance. **CONCLUSION:** Working memory, processing speed, tracking abilities as well as expertise and age are some of the factors influencing general aviation flight performance in varied conditions. LRPV which is used as an indicator for flight performance was not a predictive factor for general aviation pilots.

Learning Objectives:

1. The participant will be able to name the three contributors in flight performance in the low workload condition.
2. The participant will be able to explain the performance of younger and older pilots in different workload situations.
3. The participant will be able to explain which pilot factor was significant in the high workload situation.

[44] DEMENTIA-FRIENDLY AIR TRAVELLinda Garcia¹, Shelley Vaillancourt², Sheila Bauer³, Maurice Taylor¹, Natasha Poushinsky⁴, Jim Chung⁵

¹University of Ottawa, Ottawa, Ontario, Canada; ²Alzheimer Society of Cornwall and District, Cornwall, Canada; ³The Dementia Society, Ottawa, Ontario, Canada; ⁴Champlain Dementia Network, Ottawa, Ontario, Canada; ⁵Air Canada, Toronto, Ontario, Canada

(Education - Program / Process Review Proposal)

The number of persons aged 60+ on our planet is expected to more than double by 2050. In high income countries, the fastest growing sector of the population is 85+ and Alzheimer Disease International reports that the number of people with dementia will double every 20 years, reaching 131.5 million people by 2050. As societies, including the business sector, adapt to become more age-friendly, the desire for older adults to maintain activities such as travel will continue to increase. People living with dementia or companions traveling with older adults with dementia will, just through sheer numbers, put a strain on the air travel industry, leaving airports, border security and cabin crews scrambling to make these experiences as pleasant and safe as possible for all involved. Working with a group of experts on dementia and academics in the field of adult learning, we have consulted existing practices for training cabin crew and looked at the existing literature. We will present recommendations based on this preliminary work that foster better inclusion and dementia-friendly skies. Focus will be brought on what can be done at the time of ticket purchase, prior to embarking on the plane as well as cabin training for in-flight events. Working with an expert on adult learning, the team will propose avenues for change of practice as well as for further research. Sensing the impact of dementia-specific

symptoms, there is a worldwide trend, and the numbers would argue – need, for dementia-friendly communities. We will adapt some of these principles to the air travel industry.

Learning Objectives:

1. Attendees will learn about the unique challenges associated with travelers with dementia and their companions.
2. Attendees will learn about how environmental factors can exacerbate the dementia symptoms.
3. Attendees will learn about the worldwide dementia - friendly initiative.

[45] THE AGING PILOT - A UK MILITARY PERSPECTIVEIan Mollan¹, Andrew Timperley², Edward Nicol¹

¹RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom; ²RAF Medical Services, RAF High Wycombe, United Kingdom

(Education - Program / Process Review Proposal)

BACKGROUND: The medical effects of increasing age are relevant in the regulation of military aviation. The loss of trained aircrew because of advancing age causes deficits in experience and manning. Upper age limits for aircrew are an active area of concern for the UK military. **OVERVIEW:** Age-based policies in the absence of scientific evidence contravenes the requirements of Equality legislation. Therefore, the military Regulator needs an objective assessment in order to maintain military aviation safety. **DISCUSSION:** Reproduction of civilian rules into military policy is not suitable because the aviation risks are different. Military aircrew can be subject to other stressors including acceleration forces, thermal stress and those of the deployed operational environment. The effect of increasing age on risks to flight safety may have its' preponderance on the cardiovascular system, however other systems are affected. The RAF currently allows aircrew over the age of 60 to fly single-seat, subject to 2-yearly exercise ECG (enhanced cardiac screening; flying beyond the age of 65 is disallowed on the grounds that the baseline cardiovascular risk is at 1% per annum. However, cardiac perfusion scanning and CT angiography could help with further risk-stratification by the identification of those without coronary artery disease. The test's prognostic value goes beyond clinical risk scoring and can provide a cardiac event free warranty period. Consideration also needs to be given to the other medical systems and identification of the relevant issues. The ergonomics of some military platforms, mission duration, requirements for protective and/or imaging equipment and the exposure to acceleration forces are important stressors with the medical effects of advancing age on the musculoskeletal system (osteoarthritis, osteopenia and sarcopenia). Motion can be objectively determined, but at what stage should this be tested? Cognition declines with advancing age; this normal process is relevant in aviation as memory, processing speed and reasoning gradually decline with age. However, testing for cognitive impairment is problematic in the early identification of problems. The medical understanding of a Commanders' tolerance of 1st, 2nd, and 3rd party risks are vital in order to set a appropriate medical standard.

Learning Objective:

1. Understand the medical factors which have an influence on aviation safety certification with increasing age.

Monday, 05/06/2019**2:00 PM****Brasilia 7**

[5-12] PANEL: BEHAVIORAL HEALTH AND PERFORMANCE OPERATIONS AND RESEARCH IN HUMAN SPACEFLIGHT

*Sponsored by Space Medicine Association***Chair: Stephen VanderArk****Co-Chair: Gary Beven**

PANEL OVERVIEW: There are two distinct functions of the Behavioral Health and Performance (BHP) specialists at NASA Johnson Space Center, with a shared goal of optimal performance during all phases of an astronaut's career. The BHP Operations team is active in

areas such as selection, training, routine behavioral healthcare services, and spaceflight preparation/monitoring for NASA astronauts. The BHP Laboratory is engaged in research in space and analog platforms to address the risks and other challenges associated with future deep space missions. Their research focuses on topics that align with the NASA Human Research Program's Human Factors Behavioral Performance Element goals. This panel will provide details of recent work by BHP Operations and the BHP Laboratory at NASA-JSC and will demonstrate their shared goals of achieving optimal performance for astronauts. In late 2018, NASA implemented a longitudinal behavioral health surveillance plan for former astronauts, an element of behavioral health and wellness that has never before occurred in the human space program. This plan will provide insight into the behavioral health and wellness of former astronauts after they have departed the active Astronaut Corps. This presentation will provide a summary of NASA's long-term longitudinal behavioral health surveillance efforts that will span from the end of an astronaut's active spaceflight career until end of life. Juxtaposed with the focus of this new surveillance plan, the next presentation will focus on the BHP team's activities during the initial entry into the astronaut career as Astronaut Candidates (ASCANs). This presentation will describe the process and lessons learned from embedding an operational psychologist in ASCAN expeditionary skills training, which was done for the first time with the ASCANs selected in 2017. The third presentation will focus on BHP's cognitive assessment practices with ISS crewmembers, describing what the findings indicate after 20 years of successful ISS missions. The final two presentations will focus on NASA's use of spaceflight analogs to inform its future behavioral healthcare work during long-duration spaceflight missions. One presentation will focus on initial study results of BHP standard measures collected in various analogues; and one presentation will focus on a broader view of each analog's fidelity and resulting generalizability of results to spaceflight as well as some important ethical considerations.

[46] LONG TERM BEHAVIORAL HEALTH SURVEILLANCE OF FORMER ASTRONAUTS AT THE NASA JOHNSON SPACE CENTER

Gary Beven¹, Al Holland¹, Jim Picano², Steve Vander Ark²

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

(Education - Program / Process Review Proposal)

INTRODUCTION: NASA has not previously performed longitudinal assessment and surveillance of astronauts' behavioral health after they departed the active Astronaut Corps. This presentation will provide a summary of the behavioral health implementation plan for long-term longitudinal surveillance of former NASA astronauts at the Johnson Space Center. **TOPIC:** The Behavioral Health and Performance Operations Group (BHP) at the NASA Johnson Space Center is comprised of aerospace psychiatrists, operational psychologists and behavioral health specialists that provide comprehensive behavioral health and performance services to astronauts throughout the breadth of their active astronaut career. Components of BHP operations include astronaut candidate selection, training, mission preparation, and annual, elective, preflight, inflight, and postflight behavioral health assessments. Historically, BHP has ended its service provision once an active astronaut leaves flight status to become a management astronaut or departs the space agency. Therefore, a significant knowledge gap has formed over the past 60 years of NASA's existence, as until now there has been no dedicated behavioral health assessment of former astronauts allowing for an analysis of potential behavioral health occupational risks, the initial signs of which may occur later in life. **APPLICATION:** Initiation of the Johnson Space Center's behavioral health plan for long-term longitudinal surveillance began in late 2018. This comprised the development of a concept of operations and implementation plan including hiring of an experienced clinical psychologist to implement the behavioral health evaluation elements of this plan, and the design of a comprehensive psychological assessment that provides clear understanding of the former astronaut's psychological health and wellness. Components of this evaluation include diagnostic interview, neurocognitive assessment, and psychological screening measures. Longitudinal surveillance for conditions that include depression, anxiety, dementia, traumatic stress disorders, substance use, and any other behavioral health condition of significance will occur—the ultimate goal being the understanding of how a career as an astronaut, and spaceflight in particular, affects behavioral health and wellness until the end of life.

Learning Objective:

1. Understand NASA's need for, and implementation of, longitudinal surveillance with regard to the behavioral health of astronauts following their active duty spaceflight careers.

[47] LESSONS LEARNED FROM EMBEDDED OPERATIONAL PSYCHOLOGY IN ASTRONAUT CANDIDATE TRAINING

Rachel Passmore

University of Texas Medical Branch/KBRWyle, NASA Johnson Space Center, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: Spaceflight poses varied and unique risks to team and individual functioning that can degrade performance and compromise mission success. Furthermore, these threats may increase in severity for longer duration exploration missions farther from Earth and especially as NASA transitions to smaller operational platforms. This presentation will describe the process and lessons learned from embedding an operational psychologist in Astronaut Candidate expeditionary skills training. **TOPIC:** Reduction of risks to team functioning and individual performance during spaceflight missions requires uniquely tailored assessment, training, and feedback provided to astronauts in various stages during their training. Astronaut Candidate (ASCAN) training is the required comprehensive two-year period of instruction before candidates promote to the rank of Astronaut. ASCAN training encompasses multiple team evolutions where ASCANs learn expeditionary skills necessary to be effective on long-duration spaceflight missions. Operational psychology training for ASCANs involved providing individual developmental feedback on assessment data, delivering didactic training on behavioral performance risk areas and for the first time providing real-time individual/team feedback during expeditionary skills trips. Lessons learned from embedding an operational psychologist include the importance of establishing relationships with ASCANs, setting clear expectations of roles, developing well-formulated individual performance goals and providing timely feedback. Ethical considerations are also addressed. **APPLICATION:** Our process and the impact from it may be helpful to aeromedical professionals that work with small, high performing teams. Our specific findings regarding embedded operational psychology are of significance to professionals who desire to maximize individual and team performance in mission critical situations and in isolated and confined environments.

Learning Objective:

1. The audience will learn about maximizing individual and team performance in mission critical situations and in isolated and confined environments.

[48] RECOMMENDATIONS FOR UPGRADING COGNITIVE ASSESSMENT CAPABILITIES ONBOARD THE INTERNATIONAL SPACE STATION

James Picano, Kimberly Seaton

University of Texas Medical Branch/KBRWyle, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: Spaceflight poses varied and unique risks to the brain and cognitive functioning including radiation exposure, sleep disturbance, fatigue, fluid shifts (increased intracranial pressure), toxin exposure, elevated carbon dioxide, and traumatic brain injury, among others. These potential threats to cognitive functioning are capable of degrading performance and compromising mission success. Risks to brain health and performance posed by spaceflight missions require sensitive tools to assess cognitive functioning of astronauts in flight. For the last several years, we have engaged in a systematic process to assess our current capabilities and incorporate new advances into our approach. This presentation describes the outcome of this process and our recommendations for transitioning new cognitive assessment tools to operational use. **TOPIC:** The Spaceflight Cognitive Assessment Tool for Windows (WinSCAT) is the automated cognitive assessment tool currently deployed onboard the International Space Station (ISS). WinSCAT provides astronauts and flight surgeons with objective data to monitor neurocognitive functioning. WinSCAT assesses five discrete cognitive domains, is sensitive to changes in cognitive functioning and takes less than 15 minutes to complete. However, our current cognitive

assessment tool and testing procedures may not be optimally sensitive to subtle fluctuations in cognitive functions that might be important to mission success caused by sleep loss, fatigue, or other environmental factors. Consequently, we previously recommended 1) adding a vigilance test to the current cognitive assessment protocol to measure more efficiently subtle cognitive fluctuation, and 2) evaluating the need for more frequent but briefer testing sessions. In light of these recommendations, we now discuss our specific choice of vigilance test, and empirically evaluate the temporal stability of WinSCAT and the need for multiple baseline and proficiency testing in an effort to optimize crew time for cognitive testing. **APPLICATION:** Our specific findings are of significance to professionals who must assess readiness to perform in mission critical situations in environments involving threats to cognition and performance. Our process and the results that flowed from it may also be helpful to aeromedical professionals charged with transitioning research findings and tools to operational use.

Learning Objective:

1. The audience will learn about our recommendations for changes to the current cognitive assessment tool and protocol onboard the International Space Station.

[49] OVERVIEW OF NASA BEHAVIORAL HEALTH & PERFORMANCE STANDARD MEASURES IN ISOLATED, CONFINED, AND EXTREME ENVIRONMENTS

Pete Roma¹, Jason Schneiderman², Lauren Blackwell Landon²
¹KBRwyle/NASA Johnson Space Center, Houston, TX, USA;
²BHP Lab, KBRwyle/NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: Future deep space exploration missions will present challenges to crew behavioral health and performance greater than those currently faced by astronauts working and living in Low Earth Orbit on the International Space Station (ISS), including unprecedented duration and distance, isolation, and confinement under increasingly autonomous operations. Over the years, studies in spaceflight and space analog environments such as remote Antarctic stations have provided valuable insight on the behavioral health and performance risks facing individuals and teams in extended isolation and confinement. However, a limitation of this research and applications to future exploration missions is a lack of standardized measures to enable insights, comparisons, and countermeasure development relative to behavioral health and performance across laboratory, field, operational, and spaceflight settings. **METHODS:** The inaugural generation of the NASA Behavioral Health & Performance Standard Measures suite (BHP-SM) includes the Cognition neurocognitive test battery, the Robotics Onboard Trainer (ROBoT) operational performance task, actigraphy, physical proximity sensors, cardiovascular monitors, and subjective self-reports of mood, depression, and various team and social processes and performance outcomes. We implemented BHP-SM protocols in NASA's Human Exploration Research Analog (HERA) at Johnson Space Center (completed four 45-day missions, n=16; eight more missions planned) and the SIRIUS/NEK analog facility in Russia (completed one 19-day mission, n=6; a four-month mission is in progress, and an eight-month mission is planned). **RESULTS:** Operational feasibility was high in HERA and NEK. Operational acceptability and protocol compliance were higher in HERA than NEK, especially for wearables. Preliminary analyses of HERA sleep/wake patterns and cognitive performance suggest considerable interindividual differences in responses to partial chronic sleep restriction, countermeasure use, and behavioral health and performance effects. **DISCUSSION:** The NASA BHP Standard Measures suite and components thereof may be used to inform and monitor behavioral health, individual and team performance, and social processes in research and operations across laboratory, spaceflight, defense, aviation, maritime, energy, business, and other high-performance team and 24/7 operational environments.

Learning Objective:

1. The audience will learn about NASA's efforts to quantify multiple individual and team behavioral health and performance risks in isolated, confined, and extreme environments.

[50] SPACEFLIGHT ANALOGS: FOSTERING FIDELITY, GENERALIZABILITY, AND ETHICAL BEHAVIORAL SCIENCE RESEARCH

Thomas Williams, Alexandra Whitmire
 NASA Johnson Space Center, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: Spaceflight analogs are invaluable to evaluate human adaptation to several spaceflight risks, such as isolation and confinement, environmental controls, and physiological changes. These analog settings provide opportunities to evaluate task performance and to assess the efficacy, effectiveness, and acceptability of technology and countermeasures to mitigate the effects of spaceflight hazards. This presentation will describe the importance of maintaining fidelity in analogs in order to maintain scientific rigor that serves a primary purpose of analogs: generalizability of the analog research findings to the spaceflight environment. **TOPIC:** Spaceflight analogs are tailorable to provide meaningful and relevant experimental conditions for high quality research. They allow NASA the opportunity for applied science in controlled-settings to design, develop and validate tools, technology, and countermeasures that mitigate risks in both human and mission operation systems. Results inform and enable the modification or development of standards and guidelines related to human health and performance. An important characteristic of analogs relates to identifying the "best fit" for both the type of science and the research participants in order to ensure limited research funds are used effectively. Several important variables have been identified that directly impact the analog fidelity. These include the environmental characteristics (e.g., type of habitat; psychosocial characteristics (e.g., types of stressors; spaceflight scenario fidelity (e.g., authentic mission scenarios). Fidelity of analog settings in spaceflight research also relates to the ethical requirement for beneficence; ensuring the sacrifice of the research participant is considered against the benefit and generalizability of the knowledge gained. Scientific rigor and a commitment to realism in analogs helps promote good science and the benefits that accrue from that science. **APPLICATION:** Assessments of human performance in aerospace medicine and for spaceflight operations in analogs requires attention and scientific rigor to ensure fidelity. Only then can we have confidence in the protocols used within the analogs to reduce the uncertainty surrounding human health and performance risks, validate the technologies and human-systems interactions within the spacecraft and have confidence in the updates to our standards focused on operationally-relevant crew health and performance.

Learning Objective:

1. The participant will comprehend the importance of maintaining high fidelity in spaceflight analogs and how that fidelity helps ensure scientific rigor and ethical human research.

Monday, 05/06/2019

2:00 PM

Miranda 5/7

[S-13] PANEL: PERCEPTUAL MODELING TO EXPLAIN AND REDUCE SPATIAL DISORIENTATION MISHAPS

Chair: Angus Rupert

Co-Chair: Chris Brill

PANEL OVERVIEW: This panel presents modifications to current perceptual models of spatial orientation that improve the capability of predicting pilot perception and provides solutions to prevent spatial disorientation mishaps. These traditional models are based on acceleration information processed by the vestibular system. The first presentation utilizes animations of two recent helicopter mishaps to demonstrate the capability of modeling to explain mishap causation and also where the current models fail to predict orientation accurately. The second presentation provides recent perceptual in-flight data that permits expansion of the model to explain mishaps involving hover and hover transition to flight. The third presentation provides a revised model incorporating data from the hover transition experiments described in the second presentation. The fourth presentation provides an alternate

model to incorporate the experimental data from additional sensory channels that will provide continuous orientation information. Continuous orientation information provides the capability of maintaining orientation under conditions of pilot distraction during degraded visual environments. The final presentation provides an historical overview of perceptual modeling with several examples and sets the stage for open discussion how the recent changes lead to practical materiel solutions to solve spatial disorientation in the aerospace environment.

[51] SPATIAL ORIENTATION MODELING – TEST AND VALIDATION THROUGH AVIATION MISHAP ANALYSIS

Chris Brill¹, Angus Rupert², Torin Clark³, Bruce Mortimer⁴

¹Air Force Research Laboratory, Wright-Patterson AFB, OH, USA;

²U.S. Army Aerospace Medical Research Laboratory, Ft. Rucker, AL, USA;

³University of Colorado - Boulder, Boulder, CO, USA;

⁴Engineering Acoustics, Inc., Casselberry, FL, USA

(Original Research)

INTRODUCTION: This presentation kicks-off a panel on spatial orientation modeling by presenting overviews of two Class A rotorcraft mishaps involving spatial disorientation and the extent to which they are explainable by an existing model. Both mishaps involved Army UH-60M Blackhawk helicopters flying over-water night missions in degraded visual environments (DVE). One mishap occurred off the coast of Navarre, FL, during slow translational movement (drift) while hovering and transitioning to hover. The second mishap happened off the coast of Oahu, HI. An instructor pilot was abruptly handed the controls and pitched the aircraft into the sea. Flight recorder data suggest instruments were fully functional, and both aircraft were equipped with autohover systems. **METHOD:** Flight data from both mishaps were processed through an existing model of spatial orientation. The model dynamically and continuously computes resultant gravity vectors in 3-dimensional space as a function of acceleration. **RESULTS:** The model effectively accounted for loss of control due to erroneous pilot inputs for the Oahu mishap, but it failed to account for the Navarre mishap. For the Oahu mishap, the model suggests the pilot experienced a gravity vector inversion, causing the pilot to add power and feel like he was climbing when the aircraft was, in fact, nosing into the sea. The gravity vector hypothesis is highly consistent with the pilot's control inputs. In contrast, the model could not account for the Navarre mishap, whose major contributors included slow undetected aftward drift and yaw rotation in a DVE. **DISCUSSION:** Our results demonstrate how real-world data from aviation mishaps can be used for model test and validation. In this case, the model failed to effectively explain loss of spatial orientation due to subthreshold translational movement during hover and hover transition in DVE. As such, we propose the model requires expansion to account for these and additional factors, including perceptual data for hover-drift sensitivity. To that end, the next panelist will present perceptual threshold data, including perceptual thresholds for translational movements during hover and hover transition.

Learning Objective:

1. The audience will learn about limitations in current mishap modeling techniques and efforts to expand the model.

[52] EXPANSION OF MISHAP PERCEPTION MODEL ENVELOPE TO INCLUDE HELICOPTER HOVER AND HOVER TRANSITION

Angus Rupert¹, Chris Brill², Torin Clark³, Brad McGrath⁴, Bruce Mortimer⁵

¹U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL, USA; ²Air Force Research Laboratory, Dayton, OH, USA; ³University of Colorado at Boulder, Boulder, CO, USA; ⁴University of Canberra, Canberra, Australia; ⁵Engineering Acoustics Inc, Casselberry, FL, USA

(Original Research)

INTRODUCTION: Flight performance data obtained from flight data recorders have been used to predict pilot perception in mishaps attributed to spatial disorientation. Although these models perform well for fixed wing platforms moving at high speeds, they do not predict accurately for helicopter mishaps associated with hover transition, due in part to a lack of data for translation perceptual thresholds in the high vibration and noise environments associated with helicopters. The

current experiment provides the threshold perception data extending the model to include helicopter mishaps involving hover and hover transition. **METHODS:** Twelve H-60 helicopter instructor pilots (age 32 to 51, average 37.2 yrs.) volunteered to be blindfolded subjects in the passenger compartment of an H-60 helicopter. Subjects were exposed to varying acceleration conditions to determine thresholds of both linear and angular perception while experiencing the typical noise and vibration present in an Army Blackhawk helicopter. A Systron Donner (SDN500) precision accelerometer was used to record linear and angular accelerations. The pilots provided indication of angular and/or linear position and motion with hand gestures recorded by infrared sensors. In addition, verbal and video recordings were obtained for each acceleration event. **RESULTS:** Accelerometer data from the SDN500 revealed that a "simple" translation maneuver involved significant angular acceleration (e.g., roll acceleration to establish a lateral drift). All pilots could readily detect the roll, pitch, and/or yaw acceleration associated with any translation that was detectable. Translation perceptions were typically always more than 3 times those experienced under ideal lab conditions, although there were wide variations between subjects and decreased sensory capabilities in the older subjects. **DISCUSSION:** With the incorporation of accurate threshold information into the model, it is now possible to more accurately predict pilot perception during helicopter operations involving hover and hover transition. A video animation of a recent mishap will be shown to demonstrate the enhanced capability of the extended model as well as providing technological directions to maintain situation awareness even under subthreshold acceleration and motion conditions. With further refinements, the model will be capable of more accurate real-time prediction of mishap events leading to opportunities of mishap prevention.

Learning Objective:

1. The participant will understand the change in perception of motion associated with noise and vibration of the platform.

[53] DEVELOPMENT AND VALIDATION OF MULTISENSORY INTEGRATION IN A SPATIAL ORIENTATION PERCEPTION MODEL

Torin Clark

University of Colorado-Boulder, Boulder, CO, USA

(Original Research)

INTRODUCTION: Mathematical models for human spatial orientation perception have been proposed and validated in a wide range of scenarios, at Earth gravity (i.e., 9.81 m/s²). However, pilots of high performance aircraft regularly experience altered gravity environments. For example, a tight coordinate turn or when "pulling Gs" yields a hyper-gravity environment. Dynamic models of spatial orientation fail to predict tilt perception in hyper-gravity. While alterations in perception are presumed to be due to the increased stimulation to the otolith organs, little is known of how other sensory cues (e.g., semicircular canal, visual, or somatosensory) impact these perceptions. **METHODS:** In our first experiment, eight subjects were exposed to a hyper-gravity environment on a long-radius centrifuge (1.5 and 2 Gs, along with 1 G as a control). In the dark, subjects were passively roll tilted to various angles (10, 20, 40 degrees) at various frequencies (0.0625, 0.125, 0.25 Hz) and reported their perception of self-tilt by aligning a bar with their perceived horizontal. In our second experiment, with ongoing data collection, we are testing pitch tilt and combined pitch and roll tilts. This will allow us to explore the influence of somatosensory vs. otolith cues (which have the utricular plane pitched up ~30 degrees). Further, we will test conditions in which reliable, out-the-window visual cues are provided. **RESULTS:** As hypothesized, we found overestimation of roll tilt, with more overestimation for larger angles and higher G-levels (~35% of the actual tilt angle per G level, P<0.001). Interestingly, the amount of overestimation decreased for higher frequency (faster) tilts (P=0.006), suggesting the integration of semicircular canal cues. By adding differential weighting of otolith stimulation in the utricular plane, the model was able to predict the static and dynamic overestimation of roll tilt observed in hyper-gravity. Our current experiments will assess the model's validity in different tilt axes, with visual cues, and quantify the contribution of somatosensory cues. **DISCUSSION:** Advancing the spatial orientation model to reliably predicting human perception in hyper-gravity is critical for scenarios involving high performance aircraft. In particular, integration of

multisensory cues, particularly in altered gravity environment regularly experienced by pilots, is an essential added capability for our mathematical model of spatial orientation.

Learning Objectives:

1. The audience will learn about the state-of-the-art in mathematical models for human spatial orientation perception.
2. The participate with understand the contributions of multisensory integration to human orientation perception.

[54] DEVELOPING A SPATIAL ORIENTATION MODEL WITH COUNTERMEASURES FOR DISORIENTATION

Bruce Mortimer¹, Jon French², Jon Tapson¹, Greg Mort¹, Gary Zets¹, Angus Rupert³, Bradden McGrath²

¹Engineering Acoustics, Inc., Casselberry, FL, USA; ²Embry-Riddle Aeronautical University, Daytona Beach, FL, USA; ³U.S. Army Aeromedical Research Laboratory, Ft Rucker, AL, USA

(Original Research)

INTRODUCTION: Spatial orientation (SO) awareness and associated Spatial Disorientation (SD) is a complex and multi-faceted problem that is often implicated in military and civilian aviation mishaps. This presentation describes the development of an Advanced Spatial Orientation (ASO) model that can provide orientation information to pilots. Tactile cueing can potentially provide continuous orientation information and maintain SO under conditions of pilot distraction during degraded visual environments.

METHODS: We tested the model by measuring the perceived orientation of a small group of ten experienced (certified flight instructors- CFIs) participants during a series of flight maneuvers under various sensory conditions. The flight maneuvers were selected to induce well known perceptual illusions including; sub-threshold illusions (roll/pitch), washout illusions (sustained roll/pitch), false movement illusion (immediately after the washout illusion; on a straight and level flight) and airspeed / pitch illusions. The sensory cue conditions were controlled under: no visual references, flight instruments visuals, continuous tactile cues, and visual & tactile cues. The participants provided an indication of their perceived orientation by orientating their hand (recorded by infrared camera sensors) during each component maneuver. **RESULTS:** The ASO model has been refined and validated using data from flight maneuvers and also applied to the mishaps described in the preceding panel papers. The ASO model was extended to include tactile cueing symbology that is representative of veridical aircraft orientation. Most flight orientations can be accurately represented using a torso worn tactile array and seat containing tactile actuators. **DISCUSSION:** Continuous, accurate aircraft orientation information can be provided using the ASO with a tactile array and participants can maintain situation (orientation) awareness even under illusory conditions. Further testing is needed to confirm the limits under which situation awareness is maintained, for example, when the participants are under high-workload and they are the active pilot during maneuvers.

Learning Objective:

1. The participant will learn about the ASO (perceived orientation) model and how additional sensory channels can provide continuous orientation information. Participants will learn about the flight test experiments that were used for validating the model and using tactile array cueing as a countermeasure for SD.

[55] HISTORY OF MODELING OF HUMAN ORIENTATION PERCEPTION IN AIRCRAFT MISHAP INVESTIGATION

Braden McGrath¹, Chris Brill², Angus Rupert³

¹University of Canberra, Canberra, Australia; ²Air Force Research Laboratory, Dayton, OH, USA; ³U.S. Army Aeromedical Research Laboratory, Ft Rucker, AL, USA

(Original Research)

To maintain spatial orientation in a dynamic environment, humans must centrally integrate sensory information and then select an appropriate pattern of muscular response. In the normal earth-bound terrestrial environment, information is provided by three relatively independent and redundant sensory-motor systems: Visual, Vestibular, and Proprioceptor systems. In aerospace flight all of these systems function, however, both the vestibular and proprioceptor systems can only detect the resultant gravito-inertial force which the

CNS, based on all previous experience, incorrectly interprets as the direction of the gravity vector. In addition, the aviation environment generates angular motion outside normal terrestrial frequencies resulting in inaccurate information from the vestibular angular rate sensors. Modeling of the spatial orientation system and predicting six degree-of-freedom spatial orientation perception represent a classic bioengineering problem. The primary model is the "observer theory model" introduced by Larry Young at MIT in 1970. These models are based on the hypothesis that the CNS includes internal models of sensory dynamics, body dynamics and physical relationships and only differ in their mathematical implementation. These models were developed to explain how the CNS integrates sensory information from disparate sensory modalities to estimate body motion and spatial orientation. Three types of internal models have emerged for human spatial orientation perception and include: Optimal estimator approach; Constant gain estimator; and Sensory weighting. The observer theory models have been shown to successfully model many aspects of human spatial orientation perception and represents the majority of work used in tools developed to investigate mishaps that involve Spatial Disorientation. However, to varying degrees, existing models are not designed with overall pilot performance in the dynamic aviation environment, including night flying, hovering, and G loading. Issues such as distraction, psychological factors, excessive G and other inputs need to be included for a comprehensive output relevant to performance parameters such as mission effectiveness in addition to mishap investigation. The intent here is to review the timeline of modeling pilot orientation, and to suggest what additions or changes might be made to existing models and to indicate what direction future modeling efforts might take to best achieve future objectives.

Learning Objective:

1. The participant will be able the understand the historical development of aviation perceptual models.

Monday, 05/06/2019

4:00 PM

Brasilia 1

[S-14] PANEL: ADVANCES IN AEROSPACE MEDICINE IN IBEROAMERICA

Sponsored by Iberoamerican Association of Aerospace Medicine (IAAM)

Chair: Angela Gomez

Co-Chair: Francisco Rios-Tejada

PANEL OVERVIEW: In 2019, the panel sponsored by the Iberoamerican Association of Aerospace Medicine (IAAM) celebrates its 22nd year of sharing scientific advances in Iberoamerica. Conducted in the Spanish language, it will be chaired by the IAAM members, Dr. Lina Sanchez, of Colombia, and co-chaired by Dr. Francisco Rios-Tejada, of Spain, the panel will commence with a description of a human factors study conducted by Dr. Diego Garcia, of Colombia. Next, Dr. Beatriz Puentes, of Spain, will talk about the new CIMA (Centro de Instrucción de Medicina Aeroespacial - Aerospace Medicine Instruction Center): The Human Performance Challenge. Dr. Jean Carlos Duenes, of Venezuela, will then discuss a research about the presence of rhythm disorders in class I airlines pilots and Class II cabin crews. The panel will continue with a presentation by Dr. Hugo Fajardo, of Colombia, with a clinical case about a possible whiplash syndrome in aviation. Dr. Nancy Labastida, of Mexico, will complement the session by discussing review of emergency medical attention for application in long duration space missions. As always, the panel offers an opportunity to learn from our colleagues and encourages an internationally united environment towards enhancing world aviation safety.

[56] HFACS INTER-RATER VARIABILITY AMONG COLOMBIAN CODERS

Diego Garcia¹, Johana Giraldo², Albert Boquet¹

¹Embry-Riddle Aeronautical University, Daytona Beach, FL, USA;

²Colombian Civil Aviation Authority, Bogota, Colombia

(Original Research)

INTRODUCTION: HFACS is a renowned used tool for assessing human performance in aviation accident investigations and in other safety-critical industries. Due to its popularity, HFACS has been liberally translated and modified across both civilian and military Colombian aviation entities, allowing some HFACS elements to be lost in translation or distorted in their original meaning. This study aims to determine the HFACS reliability among Colombian raters. **METHODS:** Using an online survey sent to 24 coders, coders analyzed and classified 8 contributory factors from an accident report using the HFACS version they used more frequently. Demographic data was also collected (type of organization; years of experience using HFACS; and HFACS training, version, language, and whether they used nanocodes). Coders' responses were compared against a gold standard established by HFACS experts. Individual Cohen's kappa was calculated and a Kruskal-Wallis test between groups analysis using SPSS was performed to study reliability among the different demographic groups. **RESULTS:** 17 coders (70.8%) answered the survey. Of these responders, 58.8% were civilian and 41.2% military, the majority (58.8%) had < 5 years of experience using HFACS. Only 17.6% of the coders had formal HFACS training. A total of 35.5% used liberally adapted HFACS versions, 17.6% used the version from the developers, and 64.7% used HFACS versions translated into Spanish. Agreement with the gold standard was higher for coders with 6-10 years of experience (Md= 15.13) than those with less than three years (Md= 3.70) and 3-5 years of experience (Md= 8.00), $\chi^2= 12.33$, $P= 0.006$. Coders with formal HFACS training (Md= 15.5) had higher scores than coders with other training (Md= 9.75) and without training (Md=4.75), $\chi^2= 9.47$, $P= 0.009$. Original HFACS version coders (Md= 15.50) scored better than those using the U.S. Department of Transportation's version (Md= 12.88), U.S. Department of Defense's version (Md= 7.25), and liberally adapted versions (Md= 4.33), $\chi^2= 13.04$, $P= 0.005$. Finally, coders using HFACS in English (Md= 14.00) ranked better than coders using HFACS translated into Spanish (Md= 6.27), $\chi^2= 9.17$, $P= 0.002$. **DISCUSSION:** HFACS reliability has been proven in several studies, but elements such as language, experience, framework adaptations, and analyst training had not been previously taken into account. This study shows that these factors may have a detrimental effect on HFACS reliability. **Learning Objective:**

1. Discuss differential factors, variability and reliability among Colombian HFACS raters.

[57] THE NEW CIMA: THE HUMAN PERFORMANCE CHALLENGE!

Beatriz Puente

*CIMA, Spanish Air Force, Madrid, Spain**(Education - Program / Process Review Proposal)*

BACKGROUND: The Spanish Air Force Aviation Medicine Institute has expanded its capabilities to enhance aircrew performance, especially improving Aeromedical Training with new technologies and new fields of training. **OVERVIEW:** CIMA stands for "Centro de Instrucción de Medicina Aeroespacial," being "Aviation Medicine Institute" in Spanish. It was born back in 1940, belonging to a very young AF. Some years later, CIMA became part of the Spanish Ministry of Defense, as a "Central Service," but recently the Institute returned to the AF moving to a new location in Torrejón AFB. From the very beginning, CIMA has had many responsibilities, including selection of aircrew for all Spanish Armed Forces, investigation, and aeromedical training. Furthermore, CIMA is an European Aviation Safety Agency (EASA) approved Aeromedical Center (CMA). The Spanish AF has made a big effort to modernize the Institute. This effort has been especially remarkable in relation with aeromedical training and human performance. Thereby, the Aeromedical Training Unit has grown exponentially: The Altitude Laboratory counts with two Chambers and a Normobaric Hypoxia facility, as well as another new Normobaric Hypoxia facility that allows to maintain oxygen saturation constant. The Disorientation Laboratory has two simulators (basic and advanced). Regarding Night Vision training, the Unit counts with a spatial disorientation (SD) simulator, night vision goggle (NVG)-compatible, linked with the Night Laboratory. The Night Laboratory uses two different Terrain Model Boards, and an ultimate virtual trainer. CIMA also has new training facilities for Underwater Escape Training and for Emergency Evacuation from commercial planes. There is also a new Climatic Chamber and a brand new Ergonomics Laboratory. The latter includes new technologies for biomechanical analysis as well as cardiopulmonary

exercise testing with gases consumption analysis (both fixed and portable). **DISCUSSION:** Enhancing and increasing aircrew performance is absolutely necessary, in all kind of scenarios, not only in flight but also in demanding situations such as night, degraded visual environments, extreme temperatures, etc. That is the aim of the growth of the Aeromedical Training Unit, to improve flight safety through training and knowledge, supporting all Services, as well as International and civilian aircrew.

Learning Objective:

1. Learn the new capabilities of an Aeromedical Center regarding Aeromedical Training.

[58] PRESENCE OF RHYTHM DISORDERS DURING THE TAKE-OFF, CRUISE, AND LANDING PHASES IN CLASS I AIRLINES PILOTS AND CLASS III CABIN CREWS

Jean Duenes

*Venezuelan Civil Aviation Institute, Bogota, Colombia**(Original Research)*

INTRODUCTION: For a long time the Human being has been exposed to flight conditions where cardiovascular risk factors can be accentuated during flight, though there is little information about studies on possible disorders that may arise. **OBJECTIVE:** To determine electrocardiographic changes in class I commercial pilots and flight attendants through Holter studies during the flight phases takeoff, cruise, approach, and landing **METHOD:** A prospective, study was performed on 80 Venezuelans of which 55 were class I male commercial pilots of various Venezuelan airlines and 35 were class III female cabin crew. All participants were asymptomatic from a cardiovascular perspective. **RESULTS:** The sample participants had a mean age of 40.2 years, Medical Profiles were done obtained thirty minutes before the flight, including vital signs. Electrocardiographic recordings were obtained thirty minutes before the flight, including vital signs. Electrocardiographic recordings were obtained via a Holter monitor, Pre-flight conditions included sinus rhythm in 87.5%, sinus bradycardia in 5%, sinus tachycardia in 1.25%, ventricular extrasystoles in 2.5%, and supraventricular extrasystoles in 3.75%. During the takeoff phase, present were sinus tachycardia in 90%, supraventricular extrasystoles in 5%, atrial fibrillation in 3.75%, and ventricular bigeminy in 1.25%. During the Cruise Phase, present were sinus rhythm in 94.545% of the pilots sinus tachycardia in 5.4545%, in the women (cabin crew) present were sinus tachycardia 24% A total of 76% showed electrocardiographic changes. Sinus rhythm in the total population were 95%, and sinus tachycardia 5%. During the Landing phase, present were sinus tachycardia in 67.5%, ventricular extrasystoles in 11.25 %, supraventricular extrasystoles in 17.5%, and atrial tachycardia in 3.75%. **DISCUSSION:** There were more electrocardiographic changes during the takeoff and landing phases that during the flight itself or pre-flight activities. **CONCLUSIONS:** During the takeoff and landing phases is when the greatest presences of electrocardiographic changes were found, possibly due to stress.

Learning Objectives:

1. Describe the different heart rhythm disorders found in pilots and cabin crews.
2. Identify what is the most frequent rhythm disorder during flight in pilots and flight attendant.
3. Evaluate the arrhythmogenic density of this population.

[59] CLINICAL CASE: IS THERE A WHIPLASH SYNDROME IN AVIATION?

Hugo Fajardo

*National University of Colombia, Bogota, Colombia**(Education - Case Study: Clinical / Human Performance)*

INTRODUCTION: This case was presented voluntarily for study and analysis as to the probable relationship of the condition presented with turbulence experienced during a local flight. **BACKGROUND:** As part of this case report, a literature review was conducted regarding the whiplash syndrome experienced in automotive vehicles. Then, a case was found describing vertebral artery dissection during turbulence. **CASE PRESENTATION:** A 28-year-old woman on a local air trip suddenly exposed to turbulence, jerking, abrupt descent and lateral movements, minutes later reported a strong tension in her neck and right arm. The next day, symptoms persisted and increased in intensity interfering with daily activities. A month half later, she was diagnosed with cervicgia. Treatment included the

dexamethasone, nimesulide, and physical therapy. One week later she went to the clinic for emergencies due to persistent pain. A computerized axial tomography of the neck found central protrusions of the C3-C4, C4-C5, C5-C6, which indentate and rectify the thecal sac, apparently connecting the spinal cord. The degree of cervical lordosis appeared abnormal. In view of this finding, magnetic resonance imaging (MRI) was performed. Results found a prominent right subarctic protrusion located at C6-C7 level, which contacted the right half of the spinal cord without altering its signal intensity, and small central disc protrusions at C4-C5 and C5-C6 that did not compress spinal cord. The patient was discharged with medication, physiotherapy sessions and outpatient orthopedic management clinic for more than a year, without significant improvement of her pain which radiated to the right upper limb. In the physical examination, vertebral spasms had always been documented, but no neurological deficit. One year later, MRI results reported incipient spondylosis changes and apparent degenerative disc disease in the lower cervical segment. Also found were herniation of the intervertebral discs at levels C4-C5 C5-C6 that slightly indentated the dural sac, and C6-C7 broad-base hernia at the right subarticular location. Results from electromyography and nerve conduction velocity were compatible with neuropathy due to entrapment of the median nerve at the level of the moderate right carpal tunnel. The patient reported that pain and mobility had improved with the therapy, but neither of these symptoms had not resolved. **DISCUSSION:** there are no aviation studies on whiplash and its relation to a flight.

Learning Objective:

1. The participant will know about whiplash syndrome.

[60] REVIEW OF EMERGENCY MEDICAL ATTENTION FOR APPLICATION IN LONG DURATION SPACE MISSIONS

Nancy Labastida

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(Original Research)

INTRODUCTION: This study involved the reported medical incidents in space missions that involved traumatic injuries. There are three injuries that cause a traumatic death: hemopneumothorax, hemorrhagic hypovolemic shock, and cranioencephalic trauma. Faced with a traumatic injury due to physiological changes in microgravity, fluid redistribution and diuresis are generated and need to be considered to provide adequate prevention and treatment. **OBJECTIVE:** Analyze the kinematics of trauma, weight in space, mass retention, and the significant acceleration forces that can be generated from objects that are important to the evaluation of traumatic injuries. Also examined were how to be prepared with protective equipment to limit the damage before the trauma, strategies during the emergency, and the medical attention for the traumatic injuries to crew members that may be experienced during long-term space missions. **METHODS:** A review of the literature was conducted by searching for articles related to trauma, aerospace medicine, and aerospace physiology. Mechanisms of damage to trauma injuries, including changes in autoregulatory systems such as those that result in 10% to 23% reduction in blood volume as in Class I hemorrhage, dramatically increasing as the lesion progresses and the autonomic nervous system is restored with a greater sensitivity of the beta receptors to vasoconstriction, thereby altering the coagulation and healing of the lesions. **RESULTS:** The use of helmets and space suits could reduce the likelihood and severity of serious thoracoabdominal injuries. The priority is to maintain adequate ventilation and fluid administration based on the experience of parabolic flight. The volume by infusions of constant and titrated fluids should be easily administered in weightlessness through degassed solutions administered with constant pressure. Improvement strategies for communication systems will be the key to the team's immediate response to the emergency. **DISCUSSION:** Considering the long duration of space flights, there are not always doctors on board. The principal problem in telemedicine is the limitation of the speed of light and delay in conversations with the remote medical team. The future long-term flights crews require for their planning a critical emergency specialist trained surgically with innate abilities to solve problems and improvise with limited resources in microgravity environments

Learning Objective:

1. Emergencies in space missions have been based on experience or on data, there are no guidelines like in an emergencies room, the purpose of this work is to present the revision of the literature of pathophysiology of traumatic injuries and their diagnosis and therapeutic options to long duration space missions.

[61] CONSUMPTION OF NON-ALCOHOLIC BEVERAGES IN RELATION TO DENTAL EROSION

Leon Dychter

Dental College of Rosarito, Tijuana, Mexico

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION AND BACKGROUND: Dental erosion is defined as the loss of tissues that are part of the tooth (enamel, dentin, and cement) caused by a chemical demineralization process without the intervention of organic agents. **BACKGROUND:** This type of dental erosion consists of a chemical phenomenon of wear, which is irreversible. This phenomenon or pathology is prevalent in industrialized countries, in which certain modern eating habits are prevalent, specifically from non-alcoholic beverages. **CASE PRESENTATION AND DISCUSSION:** This presentation will attempt to demonstrate the effects of non-alcoholic beverages, such as gaseous, energy, bottled juices, and sugary/non-sugary on the dental tissues, mainly through the destruction of the dental enamel.

Learning Objective:

1. To present data on dental erosion through the consumption of non-alcoholic beverages.

Monday, 05/06/2019

4:00 PM

Brasilia 2

[S-15] SLIDE: HYPOXIA AND BREATHING

Chair: Thomas Smith

Co-Chair: Amanda Lippert

4:00 PM

[62] IMPACT OF THE SUPER HORNET FLIGHT ENVIRONMENT ON RESPIRATORY FUNCTION

Adrian Smith

RAAF Institute of Aviation Medicine, Adelaide, Australia

(Original Research)

INTRODUCTION: RAAF Super Hornet (SH) aircrew have reported a number of hypoxia-like physiological episodes in a pattern similar to that reported by other operators of this platform. The PEs have occurred in the absence of obvious deficiency of the breathing air system. A review of SH aircrew revealed reports of respiratory insufficiency during flight, persisting for up to 48 hours after landing. The SH has a breathing system that delivers >90% oxygen from an OBOGS via a non-dilution regulator; by contrast, the RAAF 'Classic Hornet' (CH) delivers oxygen from LOX via a dilution-demand regulator. Given that SH but not CH aircrew are exposed to conditions known to produce atelectasis, this study was conducted to explore if respiratory changes consistent with atelectasis occurred in this population. **METHODS:** A study comprising four matched sorties in the SH and CH was undertaken; all sorties included both the front- and back-seat aircrew; aircrew wore their mask and breathed from the aircraft breathing system from engine start until engine shut-down. The sorties were matched for duration (1.1 h), maximum sustained +Gz (+5Gz), and maximum peak +Gz (+7.5Gz); the participants were matched for age, height, mass, and baseline vital capacity. Participants had vital capacity and oximetry recorded at seven intervals: baseline in flying suit, wearing ALSE, strapped into the seat before flight and again within 10 minutes of landing; after egressing the cockpit; after removing their flying equipment; and after the Aircrew Controlled Breathing Cycle. **RESULTS:** Aircrew in both SH and CH displayed a 12% reduction in vital capacity when strapped into the ejection seat; however, the SH but not CH cohort experienced a further 15% reduction in vital capacity (t-test P<0.001) immediately after flight. This was associated with a 3-point reduction in oximetry (t-test P<0.001), and symptoms of respiratory insufficiency (Chi-square P<0.001). Vital capacity did not reach baseline levels until the ACBC was performed 40 minutes after landing. **DISCUSSION.** The reduction in vital capacity seen in SH but not CH aircrew is consistent with atelectasis arising from the differences in the supplied breathing oxygen. The correlation with mild hypoxemia and symptoms of respiratory insufficiency shows that this is physiologically significant. The development of atelectasis may explain hypoxia-like symptoms reported by SH aircrew.

Learning Objectives:

1. The audience will be reminded of the conditions responsible for the development of atelectasis in fast-jet aircrew.
2. The audience will be reminded that atelectasis can have aeromedically significant consequences.
3. The audience will be reminded that there are plausible physiological explanations for 'unexplained PEs'.

4:15 PM

[63] HYPOXIA RECOGNITION AND RECOVERY TRAINING IN ROYAL AUSTRALIAN AIR FORCE F/A-18F AND EA-18G AIRCREW

Gregory Hampson

RAAF Institute of Aviation Medicine, Brisbane, Australia

(Education - Program / Process Review Proposal)

BACKGROUND: Standard hypoxia awareness training did not optimally prepare aircrew for the range of physiological episodes (PEs) experienced in modern high-performance aircraft, this affected aircrew confidence and ability to manage in flight PEs. In the context of no change to aircraft systems 82 WG looked to enhance aircrew training to mitigate the flight safety risk posed by PEs. **OVERVIEW:** 82 WG and the RAAF Institute of Aviation Medicine (IAM) sought to provide high fidelity PE related hypoxia recognition and recovery training (HRRT). In combination with a commercial hypoxic training system supplier HRRT commenced in 2012 in F/A-18F low cost trainers, evolving to the full tactical simulator in 2016. This presentation will outline the features/benefits of the current HRRT system including: conduct in the full tactical flight simulator, ALSE use, variable levels of hypoxia used to induce effects (similar to reported PE symptoms), recovery with aircraft systems and checklists, aircrew flying instructor and senior aviation medical officer instruction. **DISCUSSION:** HRRT facilitates recognition of degraded performance while operating in the aircraft environment using systems and performing the role that high performance aircrew do routinely. It reinforces consideration of symptoms and positive communication between the crew so both are optimally involved in recognition and recovery, consistent with CRM principles. HRRT rehearses optimal recovery techniques including, emergency oxygen, control of the rate and depth of breathing, time for recovery, and reduction of chest restriction. Flying the aircraft during PE recognition and recovery allows for demonstration of airmanship considerations, including simulation of exhaustion of emergency oxygen supply and execution checklist actions to safely recover the aircraft. The presentation will review HRRT flow and 2018 data. 82WG aircrew consider with current available systems that HRRT provides optimal PE recognition and recovery training. 82WG AVR documentation identifies HRRT as a major risk mitigation factor. HRRT is mandatory annual training requirement for all 82WG aircrew; and is expected to be expanded to PC-21 and F-35 platforms in due course.

Learning Objectives:

1. Understand limitations of standard hypoxia awareness training in preparing aircrew to manage the range of physiological episodes experienced in high performance aircraft.
2. Understand the benefits of Hypoxia Recognition and Recovery Training using the full tactical flight simulator.

4:30 PM

[64] REPEATED NORMOBARIC HYPOXIA TRAINING IN TACTICAL F/A-18C HORNET SIMULATOR

Tuomo Leino¹, Antti Leinonen², Hannu Kokki³

¹Air Force Command Finland, Tikkakoski, Finland; ²University of Eastern Finland, School of Medicine, Kuopio, Finland; ³Kuopio University Hospital, Department of Anesthesiology, Kuopio, Finland

(Original Research)

INTRODUCTION: Incidence of hypoxia-like-symptoms is increasing in military aviation. These cases can be related to onboard oxygen generating system (OBOGS) malfunction, loss of cabin pressure, air contamination and hyperventilation or combination of these factors. Normobaric hypoxia training in tactical Hornet simulator has been mandatory at every 3 years in Finland since 2008. Training may help

aviators to recognize their individual hypoxia symptoms earlier and refresh hypoxia emergency procedures in a realistic cockpit environment.

METHODS: The study was conducted in 118 fighter pilots from Finnish Air Force. All the subjects performed normobaric hypoxia training in a tactical F/A-18 Hornet simulator (WTSAT) twice in 3-year intervals. Pilots wear full flight suit with JHMCS helmet and mask. Five different gas mixtures were used: 100% O₂, 21% O₂, 8% O₂, 7% O₂, and 6% O₂ in nitrogen in three different set-ups. Forehead peripheral oxygen saturation (SpO₂) and ECG was continuously monitored. Pilots performed simulated visual identification sortie in international airspace at high altitude until they recognized hypoxia symptoms. After that they aborted flight set-up and performed hypoxia emergency procedures (EPs) with 100% oxygen and did return to base (RTB) at low altitude in instrument weather conditions (IMC). **RESULTS:** During the first hypoxia training, pilots recognized hypoxia symptoms with 8% oxygen in a mean of 103 seconds at SpO₂ of 78%, with 7% oxygen in 99 seconds at SpO₂ of 74% and with 6% oxygen in 81 seconds at SpO₂ of 73%. Three years later, in the second hypoxia training the same pilots recognized hypoxia in a significantly shorter time, mean difference 13 - 23 seconds faster compared to the first training, P<0.05. Individual hypoxia symptoms differ between the two hypoxia trainings. **DISCUSSION:** Repeated hypoxia training in 3 years intervals gives fighter pilots a possibility to refresh recognition of hypoxia symptoms and emergency procedures in tactical fighter simulator. Repeated hypoxia training shortens hypoxia recognition time and hypoxia severity. Difference in individual hypoxia symptoms experienced between training sessions can be due to difference in ventilation rate and hypocapnea.

Learning Objective:

1. Understand role of normobaric hypoxia training in tactical fighter simulator.

4:45 PM

[65] A COMPARISON OF HYPOXIA TRAINING AT 7000m AND 7500m

Xiaopeng Liu, Dongqing Wen, Lei Tu, Jingbing Wu, Zhao Gu, Guiyou Wang, Lihao Xue, Weiru Shi, Lihua Yu, Yan Zhang
Institute Of Aviation Medicine Of China, Beijing, China

(Original Research)

INTRODUCTION: Pilots may suffer acute hypoxia due to high-altitude aviation activity. All military aircrew must undergo hypoxia awareness training by exposing themselves to hypobaric hypoxia in altitude chamber, which is refreshed every 3 years in China. The risk of developing decompression sickness (DCS) is the main concern with this training. Alternatively, a safer hypoxia training protocol has been developed involving low altitude. The purpose of this study is to compare the physiological responses, psychomotor performances and hypoxia symptoms of hypoxia awareness training between 7000 m and 7500 m exposure. **METHODS:** 78 male pilots aged 23-35 (26.8±2.6) underwent hypoxia awareness training by breathing air in the altitude chamber. 33 were exposed to 7000 m and 45 were exposed to 7500 m. Heart rate, arterial oxygen saturation and breathing rhythm were continuously monitored. The duration of hypoxia was also recorded. Psychomotor performance was assessed using the computational task throughout the periods of hypoxia. In addition, participants were requested to complete questionnaire related to hypoxic symptoms after hypoxia exposure. **RESULTS:** The duration of hypoxia was above 160s and 57.6% was no less than 360s in 7000m group, while it was above 100s and 4.4% was no less than 360s in 7500m group. There were no significant differences in pilot's heart rate or breathing rhythm between two exposures. The SpO₂ response at 7500m was slightly severer than at 7000m. There were no significant differences in calculation error rate between the two types of hypoxia exposure. The three most frequently reported symptoms are dizziness, inattention and dullness, which are same in both types of hypoxia. **DISCUSSION:** Pilots were at critical stage when exposed above 7000m. Critical supersaturation ratio (R) decreased from 2.0 to 1.86 when altitude descend from 7500m to 7000m, which could obviously lower the possibility of DCS. There were concordant symptoms, psychomotor performance and very similar physiological responses between 7000m and 7500m hypoxia training. Our results indicate that 7000 m hypoxia awareness training might be an alternative of 7500m hypoxia training with lower DCS risk and longer time.

Learning Objectives:

1. Hypoxia symptoms and the effect of hypoxia on performance were similar in 7000m and 7500m hypoxia training protocol.
2. Hypoxia tolerance time was significantly longer in 7000m hypoxia training protocol than 7500m hypoxia protocol.

5:00 PM**[66] PHYSIOLOGICAL AND BEHAVIORAL FACTORS THAT AFFECT HYPOXIA TOLERANCE**

Barak Gordon, Asaf Glass, Uri Eliyahu, Idan Nakdimon,

Anna Levkovsky, Shani Sarfati

*Aero-Medical Center, Israeli Air Force and the Medical Corps, Israeli Defense Forces, Tel Hashomer, Israel**(Original Research)*

INTRODUCTION: Tolerance to hypoxia is known to vary among different individuals, yet which factors affect this tolerance is unclear. The goal of this study is to evaluate the effects of several factors on hypoxia tolerance. **METHODS:** The study included Israeli Air Force air crew randomly selected from routine scheduled hypoxia trainings. The participants were exposed to hypoxic conditions (25,000ft) and were monitored using finger pulse-oximeter. Hypoxia tolerance was defined using three criteria: (1) the area under the saturation curve (AUC) measured 60, 100 and 120 seconds from the beginning of the hypoxic drill; (2) the breaking point between two consecutive saturation values with the largest gap measured; (3) saturation level measured 60, 100 and 120 seconds from the beginning of the drill. Age, gender, smoking status, physical activity, body mass index (BMI), hemoglobin concentration and spirometry values were the factors examined. Statistical analyses included parametric and non-parametric tests. **RESULTS:** There were 161 aircrew members who participated in this study, ages 18-47 (Mean 24.48, SD ± 5.5), 144 were males and 17 females. BMI was found to be a significant factor for hypoxia tolerance (Saturation 60 seconds: effect coefficient = -0.56, P=0.01; AUC 100 seconds: effect coefficient = -3.58, P=0.001 and other criteria) as was hemoglobin concentration (Saturation 100 seconds: effect coefficient = 1.24, P=0.004; AUC 120 seconds: effect coefficient = 9.26, P=0.007 and other criteria). Age was found to be significant factor as well (positive effect for AUC 100 and 120 seconds and saturation 100 and 120 seconds criteria) as was smoking but for fewer criteria (negative effect for AUC 100 seconds and saturation 60 seconds). **DISCUSSION:** During hypoxic state, a higher BMI and active smoking showed a negative correlation while blood hemoglobin levels and age showed a positive correlation to hypoxia tolerance. These findings support the current approach on pilot's flight qualification which is hemoglobin level dependent. These results also underline the importance of smoking cessation and prevention, and promotion of lower BMI among aviators. Further research may include other factors that might affect the hypoxia tolerance.

Learning Objectives:

1. The audience will learn about physiological factors affecting hypoxia tolerance.
2. The audience will learn about behavioral factors affecting hypoxia tolerance.
3. The audience will learn about novel definitions of hypoxia tolerance.

Monday, 05/06/2019**4:00 PM****Brasilia 3****[S-16] SLIDE: FATIGUE MONITORING****Chair: Thomas Nesthus****Co-Chair: John Allen****4:00 PM****[67] HUMAN PERFORMANCE (FATIGUE) EFFECTS ON NORMAL FLIGHT OPERATIONS ASSESSED BY FLIGHT DATA MONITORING (FDM)**Trond-Eirik Strand¹, Ross Philips², Stein Arne Lien³, Stian Antonsen⁴, Tor Erik Evjemo⁴¹Civil Aviation Authority Norway, Oslo, Norway; ²Institute of Transport Economics, Oslo, Norway; ³Accident Investigation Board Norway, Lillestrøm, Norway; ⁴SINTEF, Trondheim, Norway*(Original Research)*

INTRODUCTION: This is preliminary results from the HumP-FDM project where Flight Data Monitoring (FDM) is used to assess the effects of fatigue on normal flight operations. **METHODS:** All, 103,247 flights with 737 during year 2017 in a modern airline company in Norway were selected. Predicted fatigue (alertness score / KSS) was estimated for all pilots at all flights (top of descent) applying the BAM algorithm by Jeppesen to their rosters. Simple explorative statistics were used for a selection of 72 predefined key performance values. **RESULTS:** In 8412 flights the worst recording by the pilots at flight deck corresponded to KSS score 6 or more (sleepy pilot). Correspondingly, for about 17,149 flights the most fatigued flight deck officer had a score of 4 or less (alert pilot). Comparison of these two groups by visualization on overlay histograms identified the following: Sleepy pilots more often had critical low speed 20 ft to and at touchdown, landed slightly harder (more acceleration at touch down), had higher speed when flaps extended, were using slower taxi speed, had auto pilot engaged closer to take off and landing and possible had higher fuel consumption compared to the alert pilots. The two groups of pilots is not directly comparable where pilots estimated to be sleepy underwent operations with more flight legs, longer flight duration and they had more night duty. **DISCUSSION:** The results are raw and not adjusted for any factors that could explain some of the differences and the groups are not equal so interpretation of results must be careful. However, the results are consistent with a priori hypothesis and so promising that they are worth presenting to encourage more research and collaborative partners for the follow-up project. If results are confirmed it is of great value for operators, pilots and regulators who all could benefit from the knowledge and this could teach us more about the potential in FDM towards human performance.

Learning Objectives:

1. The audience will explore the potential effects of fatigue in daily flight operations.
2. The potential in FDM data to investigate human performance will be covered.

4:15 PM**[68] ASSESSING LEVELS OF WORKLOAD, FATIGUE AND RECOVERY IN ROYAL NORWEGIAN AIR FORCE SEARCH AND RESCUE OPERATIONS (RNOAF SAR)**

Jannicke Sandvik, Anders Meland, Anthony Sverre Wagstaff

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INTRODUCTION: RNoAF SAR has 15 min. response time 24/7/365, in addition to training and other work. Fatigue has been cited as a possible contributing factor in a few incidents that have occurred in the last few years. There is currently relatively little relevant published research on fatigue in regards to SAR operations. To ensure future safe operations and to contribute to closing this knowledge gap, the aim of the current study was to examine levels of workload, fatigue and recovery in the RNoAF SAR. **METHODS:** The study was approved by the Norwegian Centre for Research Data and the Norwegian Armed Forces approval committee of research on military personnel. Subjects included all helicopter and maintenance crew, predominantly male, from all five bases of the RNoAF SAR (N= approx. 250). A combination of an online questionnaire, daily logs, and a psychomotor vigilance test (PVT), was used to collect data on the current levels of workload and fatigue, and the underlying mechanisms. The questionnaire included measures related to recovery, such as mindfulness, mental resilience and motivation; and factors related to workload/fatigue, such as burnout, turnover intention, stress and depression. The daily log was tailored to fit the operational setting and included measures of sleep and activity and the corresponding workload and fatigue levels. PVT was performed at the start and end of every shift. In addition, a randomly selected helicopter crewmember completed a PVT after every flight, and maintenance crew on call after call-outs. A series of descriptive analysis and correlations were performed. **RESULTS:** Results show clear differences between different crew categories on number of hours worked, workload and fatigue levels. There were also differences between the bases and to what degree these variables correlate with

underlying factors of fatigue and recovery. **DISCUSSION:** These results will help better our understanding of the flight safety risk involved in SAR operations, although there are limitations due to differential levels of participation and possible selection bias. The results will be the basis for the development of new work-rest guidelines and fatigue risk management strategies, including measures focused on supporting recovery, for RNoAF SAR operations.

Learning Objectives:

1. The audience will learn about fatigue, workload and recovery levels of NRoAF SAR crew.
2. The audience will learn about the methods used to assess fatigue, workload and recovery Levels of RNoAF SAR crew.

4:30 PM

[69] AN OBJECTIVE TOOL FOR ASSESSING FATIGUE: OCULOMETRIC PARAMETERS

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(Original Research)

INTRODUCTION: The full impact of fatigue due to sleep loss is often underappreciated, but many of its deleterious effects have long been known to cause significant decrements in cognitive functioning which includes slow thinking process, increased attention lapses, memory impairment, decreased vigilance and reduced capacity for sustained attention leading to significant reduction in performance of the aircrew thus elevated risk of accidents. This study is intended to analyze if oculometric parameters like pupillary diameter and blink rate can be used as an objective tool to assess fatigue due to sleep deprivation over a duration of 26 hours of continuous wakefulness. **METHODS:** A total of 20 individuals have participated in the study. The participants were administered subjective questionnaires GSQS (baseline), SSS, CFQ and psychomotor performance by PVT monitor, oculometric parameters by mobile eye tracker were recorded at baseline i.e., 0800-1000 h. The participants were allowed to carry out their normal day to day activities till the second reading at 1700-1900 h (Session I). After second reading the participants stayed in the sleep lab at Department of Human Engineering, Institute of Aerospace Medicine, Indian Air Force with subsequent recordings at Session II (0000-0200 h), Session III (0300-0500 h) and Session IV (0800-1000 h). **RESULTS:** The participants in the study had good amount of sleep both quantitatively and qualitatively as shown by the GSQS score, score-0 (19 participants) and score-1 (01 participant) at baseline. The subjective scores measured by SSS & CFQ have shown that the level of sleepiness has increased from baseline to session IV. The psychomotor vigilance performance showed significant increase in mean and median reaction time from 245±4.58(ms) in baseline to 360.1±12.03(ms) and 229.6±3.97(ms) in baseline to 296.9±2.0(ms) in session IV respectively. The pupillary diameter has increased significantly from 112.9±19.04 (eye tracker units) in baseline to 350.8±30.7 in Session IV. The blink rate has raised from 10.75±1.51 in baseline to 23.3±2.53 in session IV. **DISCUSSION:** The pupil diameter and blink rate have increased as the time of wakefulness increased from baseline to session IV i.e., 26 hours of continuous wakefulness. This study has shown the efficacy of Pupillary diameter and Blink rate as an objective tool in assessing the fatigue of aircrew due to sleep deprivation and its operational use thereby enhancing aerospace safety.

Learning Objectives:

1. The participants/audience will be able to understand the role of oculometric parameters like pupillary diameter and blink rate in assessing fatigue due to sleep deprivation.
2. The participants/audience will be able to understand the procedure of recording oculometric parameters along with Do's and Dont's while recording to increase the efficacy of oculometric parameters in assessing fatigue.
3. The participants/audience will be able to understand and compare the oculometric parameters with other objective and subjective tests and thus the efficacy of oculometric parameters like pupillary diameter and blink rate in assessing fatigue.

4:45 PM

[70] QUANTIFYING AIRCREW FATIGUE USING PASSIVE PHYSIOLOGICAL MONITORING

Brian Bradke

Norwich University, Northfield, VT, USA

(Original Research)

INTRODUCTION: Human error is a broad term which encompasses many facets of mishap causes. Recognized as an operational risk factor, fatigue has long been associated with poor decision making and increased accident rates. With sustained airborne operations at their highest levels and an ongoing shortage of qualified, experienced aircrew, the operational demands facing pilots is higher than ever before. These factors have created a "perfect storm" scenario which has led to escalating mishap rates across all of America's air forces. Current practices for mitigating risk due to human factors is subjective at best, asking pilots to assess their mental and physical wellbeing. To date, no objective metric for quantifying physiological stress has been successfully implemented. **METHODS:** Twenty United State Air Force T-6 pilots were outfitted with a passive biomonitoring system on a non-interference basis. Over 100 sorties worth of data were collected from fifteen minutes before takeoff through five minutes after landing. Heart rate, SpO₂, acceleration (Gz), temperature, and cabin pressure were recorded at 1Hz and then analyzed post flight. Custom analysis software combined these variables into a Relative Performance Index (RPI) for pre, post, and in-flight regimes for each subject. **RESULTS:** In-flight analysis of performance showed a significant increase in physiological stress as determined by RPI as compared to pre-flight (P=0.001). Similarly, subjects exhibited a relative decrease in stress levels post-flight (P=0.005). When subjects flew twice in one day, their RPI decreased in the second sortie as compared to the first sortie (P=0.03). These results suggest that RPI may be a valid indicator of fatigue levels both in-flight and intra-flight. **DISCUSSION:** Human factors have long been recognized as the leading cause of aviation mishaps. For the last decade, operational risk management tools have sought to account for these factors by asking pilots to assess their readiness to fly before each mission. As the USAF attempts to maximize training effectiveness and human performance while mitigating risk, an objective tool to quantify physiological levels of fatigue is becoming an urgent need. A relative performance index as developed and presented herein could ultimately improve training effectiveness while accurately quantifying risk due to cognitive and physical fatigue.

Learning Objectives:

1. The audience will learn about current practices for human performance risk mitigation and their limitations.
2. The audience will learn about new technology which can quantify and predict physiological risk factors.
3. The audience will learn about how physiological monitoring could be used to debrief sortie effectiveness and reconstruct mishaps.

5:00 PM

[71] SLEEPINESS AND SLEEP QUALITY PREDICT AVIATOR PERFORMANCE WHEN TESTED OUTSIDE OF CIRCADIAN NORM

Kathryn Feltman, Jared Basso, Amanda Kelley, Ian Curry

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

(Original Research)

INTRODUCTION: The impact of individual differences in performance has gained attention in recent years. In attempts to identify the underlying causes of variability in cognition, individual differences have been studied. While previous researchers have identified the role of the following as influencing aviator performance: individual differences related to personality (Rose et al., 2014), cognitive abilities (Carretta et al., 2014), and multitasking abilities (Barron & Rose, 2017), the impact of differences related to circadian rhythms has not been extensively studied. The main objective of the study was to evaluate sleep-related factors to determine if they significantly influence performance during early morning flights. **METHODS:** There were 32 rated Army aviators (29 males) who participated in the study ($M_{age} = 31.31$). They completed two flights

in a Black Hawk simulator at 0400 hrs. Workload was manipulated in each flight. Participants completed the surveys to assess chronotype, daytime sleepiness and sleep quality. Performance metrics included rate of turn, trim adjustments, altitude, and airspeed. **RESULTS:** Multiple hierarchical regressions were conducted to evaluate whether the predictor variables (chronotype, daytime sleepiness, and sleep quality) accounted for variance in the performance metrics. Reported here are the results of turn maneuvers. Final models for turn rate during the right turn were predicted ($F = 2.30, p = 0.05$). The final model accounted for 23% of variability, the addition of *daytime sleepiness scores* into the model accounting for 14% of variation. The final model for rate of turn during the left turn was significant, $F(6, 45) = 2.80, p = 0.02$. *Sleep quality* significantly contributed to the model, adding 16% to variability explained, and the final model explained 27% of the variability. **DISCUSSION:** Poorer sleep quality predicted a slower turn rate during the *right turn*, *chronotype* became a significant predictor when *sleep quality* was added. Rates of turn during the *left turn* were predicted by both *daytime sleepiness* and *sleep quality*; higher levels of *daytime sleepiness* and worse *sleep quality* each predicted a slower turn rate. These sleep factors may have had an influence on attention which affected the regulation of motor control. Further probing of these factors influencing attention by examining individual-based variables may provide a more operationally relevant perspective of factors affecting operator performance.

Learning Objective:

1. The audience will learn the importance of considering individual differences when interpreting performance metrics.

5:15 PM**[72] DIFFERENTIAL EFFECTS OF MODAFINIL ON PERFORMANCE OF FATIGUE-SUSCEPTIBLE AND FATIGUE-RESISTANT INDIVIDUALS**

J. Lynn Caldwell¹, Christina L. Kunkle², Nicole L. Beasley³, Chelsea B. Levin²

¹Naval Medical Research Unit Dayton, Wright-Patterson Air Force Base, OH, USA; ²Henry M Jackson Foundation for the Advancement of Military Medicine, Wright-Patterson Air Force Base, OH, USA; ³University of Dayton, Dayton, OH, USA

(Original Research)

INTRODUCTION: The effects of total sleep deprivation are clear and pronounced, affecting attention, judgment, response speed, accuracy, and task-shifting ability. Traditionally, study results are based on average responses which do not take into account individualized reactions to reduced sleep. However, studies show that some individuals experience a marked decrement in performance while deprived of sleep, while others tend to be more resilient to the impact of sleep loss. Perhaps pharmacological alertness-management therapies should take these individual differences into account, individualizing medications based on fatigue vulnerability. The current study investigated whether modafinil would improve the performance of fatigue-susceptible individuals more than those who are fatigue resistant. **METHODS:** In a double-blind, repeated measures study, participants were tested over 2 separate periods of 35 hours of continuous wakefulness. All received 200 mg of modafinil at midnight during one period of wakefulness and placebo during the other. The psychomotor vigilance task (PVT) was administered every hour from 0800 to 1700. Based on PVT lapses that occurred under the placebo condition, subjects were first grouped according to fatigue vulnerability. Next, the performance of the two groups under modafinil and placebo was compared. **RESULTS:** Data from 19 participants were included in the analysis, 9 in the fatigue-resistant group and 10 in the fatigue-vulnerable group. Difference scores between the placebo and modafinil performance were calculated for number of PVT lapses. Mixed model ANOVA using fatigue resistance as the grouping variable and session as the repeated-measures variable showed a significant interaction between group and session ($F(29,493)=1.62, P=0.023$), and main effects for both group ($F(1,19)=10.90, P=0.004$) and session ($F(29,493)=8.059, P<0.001$). Independent *t*-tests between groups at each session indicated that, as expected, the vulnerable group benefited more from modafinil than the resistant group, particularly in the early morning hours. **DISCUSSION:** Identification of fatigue vulnerable individuals will allow tailored

implementation of fatigue countermeasures, providing aids such as modafinil primarily to those who need it most while avoiding unnecessary dosing of those who do not. By tailoring pharmaceutical countermeasures to specific individuals, overall mission effectiveness and safety could increase without over-reliance on medication.

Learning Objective:

1. Understand individual responses to sleep loss and how modafinil affects individuals differently.

Monday, 05/06/2019**4:00 PM****Brasilia 4****[S-17] SLIDE: THE 'EYES' HAVE IT****Chair: Dan Buckland****Co-Chair: Shehzad Botliwala****4:00 PM****[73] CLASSIFICATION OF DISTORTION PRODUCT OTOACOUSTIC EMISSION PHASE MAPS**

Keith Covington¹, Allison Anderson¹, Jay Buckley², Abigail Fellows², Catherine Rieke²

¹University of Colorado Boulder, Boulder, CO, USA; ²The Geisel School of Medicine at Dartmouth, Lebanon, NH, USA

(Original Research)

INTRODUCTION: Many astronauts return to Earth with the spaceflight associated neuro-ocular syndrome (SANS). Because intracranial pressure (ICP) is an important factor in understanding this syndrome, there's a need for practical, non-invasive ways to measure intracranial pressure in space. This research investigates the feasibility of distortion product otoacoustic emission (DPOAE) phase mapping as a proxy measure of intracranial pressure. **METHODS:** To create a phase map, the phase difference between the DPOAE and the primary tones (f_1, f_2) was calculated at multiple f_2 frequencies and f_2/f_1 ratios and plotted as a 2D image. Data were collected in two experiments: a repeatability study where maps were collected in the same group of subjects repeatedly over time, and a posture study where subjects were supine and prone both with and without the application of lower body negative and positive pressure (LBNP/PP) in order to induce bodily fluid shifts. Binary classification algorithms were developed using support vector machines (SVM) to classify experimental test subjects' phase results by experimental condition. SVM binary classification models were trained from the two populations of subjects using bootstrapping. Models were trained to classify phase results in the supine LBPP, prone LBPP, and prone atmospheric pressure conditions as the "Elevated ICP" condition and the Seated postural condition as the "Non-Elevated ICP" condition. The models were then tested on a reserved population of maps (not seen before by the model). **RESULTS:** The final model achieved a correct rate of 83.5%, with 76.0% sensitivity and 85.8% specificity. These results indicate DPOAE phase maps change with posture, and subjects can be classified by qualitative ICP status. Notably, in this approach where the phase map is classified using SVM, a subject specific baseline is not required to classify subjects, thus eliminating one of the primary limitations of DPOAE methodologies. **DISCUSSION:** Subject-independent features exist in the DPOAE phase maps that may indicate body fluid shifts. This classification method may provide a useful screening tool for determining whether increases in ICP have occurred.

Learning Objective:

1. [The audience will learn about...] DPOAE phase mapping techniques and the analysis performed using SVM classification.

4:15 PM**[74] A VISUAL PERFORMANCE SURVEY OF PRESBYOPIC ARMY AVIATORS**

Morris Lattimore, Gina Jurek, Raquel Goosey, James Truong
U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: The ability to see effectively at all distances is important in aviation, due to alternating attention between instrumentation

and the outside environment. Intermediate and near distances become blurry with age. Beginning as early as in the twenties, presbyopia increases its demand annually, with most requiring reading assistance by their forties. This process occurs in everyone, even those with a history of refractive surgical correction. This condition is commonly treated with reading glasses of varied design. The survey sought to determine job-associated costs of advancing presbyopia. The underlying hypothesis concerned sources of job dissatisfaction. We sought to capture in the survey the effects of a continually increasing visual workload demand. **METHODS:** This interview-based survey's goal was to determine the practical utility of current aviator spectacle correction methods. All volunteer subjects were provided an informed consent process, which assured anonymity. The protocol was approved by MRM's Institutional Review Board (IRB). One aspect of the study was to determine the degree of correction variability subjects had obtained. The wearing of corrective spectacles, with ear protection, requiring helmet display unit (HDU) alignment, is very uncomfortable and potentially hazardous to duty performance. **RESULTS:** The results of the interview survey were varied: 1) 30% of our subjects expressed difficulties donning and aligning the now-standardized HGU-56P flight helmet; 2) 25% expressed problems focusing from far to near (noting a near blur, or often near diplopia); 3) the 37 subjects possessed 7 different types of spectacle correction, along with 2 contact lens types, and 2 refractive surgery procedures. 4) 25% had varied degrees of difficulty in achieving spectacle alignment under the HGU-56P flight helmet. **DISCUSSION:** Standard spectacles were unsatisfactory for many. Literature reports have related spectacle modification efforts by presbyopic aviators creating more functional configurations. These modifications are unsafe because they tend to leave sharp edges, and are unstable. Difficulty in achieving spectacle alignment under the HGU-56P flight helmet was a complaint that was thought to have been fixed, now requiring more attention. The application of these surveys will also serve as authoritative sources for the identification of current vision issues beyond spectacle design, such as transitional blur and vergence control.

Learning Objective:

1. HGU-56P helmet wear has been demonstrated to interfere with proper multifocal spectacle under-helmet alignment. Visual performance while piloting a rotary-wing aircraft with a mis-positioned helmet is difficult to begin with; then wearing misaligned progressive-add spectacles paired with a mis-positioned helmet can become outright dangerous.

4:30 PM

[75] UNILATERAL OPEN ANGLE GLAUCOMA IN AN AIRLINE PILOT AND THE APPROACH TO MEDICAL RECERTIFICATION

Azeem Ali

Qatar Airways Clinic, Doha, Qatar

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a commercial pilot that experienced reduced peripheral vision in the right eye due to glaucoma, the aeromedical implications and challenges with recertification. **BACKGROUND:** Glaucoma is the leading cause of global irreversible blindness in the 40-80 age group with a prevalence of 3.54%. Pilots risk being denied medical certification because high intraocular pressure (IOP) can damage the optic nerve causing suboptimal vision. It occurs more frequently in individuals > 40 years, family history, certain ethnicity groups, high IOP and in far or near-sighted. The aeromedical concern with glaucoma is the visual field restriction limiting cockpit awareness of internal and external visual cues. Other potential incapacitating symptoms include severe ocular pain, nausea, blurred vision, transitory loss of accommodation and side-effects from medication. **CASE PRESENTATION:** The subject pilot is a 61-year-old male, South Asian ethnicity and is an experienced B777 Captain with 22,000 flying hours. He had a gradual onset of right sided headaches with tunnel vision for 1 month and an increase IOP in the right eye which led to a diagnosis of primary open-angle glaucoma. A failed therapeutic laser peripheral iridotomy led to an Ahmed valve implantation and 7 months after surgery he had a nasal defect in the right Esterman visual field. Post-op, the best corrected visual acuity was OD 6/12, OS 6/5, OU 6/4 with good near vision

standards (aided) and bilateral IOP were normal. A medical flight test (MFT) was done under normal and emergency flight conditions; with photopic, mesopic and scotopic lighting. The MFT software was modified to test the pilot's external visual cues with wing-tip and engine awareness compared to another pilot's unaided vision. Based on his binocular vision, ophthalmologist report and a satisfactory MFT, he was declared fit for a class 1 medical by the civil aviation authority with an operational multi-crew limitation (OML) and annual ophthalmology evaluation. **DISCUSSION:** This case highlights the challenges that pilots with glaucoma and suboptimal vision face when getting re-certified. The modified MFT was reassuring for the safety critical role in the cockpit and demonstrated that his eyes adapted well > 6 months post-op with good depth cues. Considering the prevalence of glaucoma in the global population and the aeromedical implications, perhaps pilots that are high-risk can undergo detailed screening.

Learning Objectives:

1. The audience will learn about the aeromedical implications for an airline pilot with sub-optimal vision secondary to glaucoma.
2. Participants will be able to understand the rationale in developing an action plan for evaluating a pilot with glaucoma and know when it is appropriate to return them to flight duties.

4:45 PM

[76] WILSON DISEASE IN A MILITARY HELICOPTER PILOT: A CASE REPORT

Yael Frenkel-Nir, Tom Kotler, Barak Gordon

Aero-Medical Center, Israeli Air Force and the Medical Corps, Israeli Defense Forces, Tel Hashomer, Israel

(Education - Case Study: Clinical / Human Performance)

INTRODUCTION: This case report describes a military helicopter pilot who was diagnosed with Wilson's Disease (WD) and the treatment he received in order to return to flight duties. **BACKGROUND:** Wilson's disease is an autosomal recessive disorder in which copper accumulates in the body, mostly in the liver and the brain. This consequently leads to liver disease and neuropsychiatric symptoms, such as parkinsonism, seizures, migraines and cognitive impairment. Psychiatric symptoms may include depression, anxiety and psychosis. The liver disease may manifest as tiredness, increased bleeding tendency or hepatic encephalopathy, up until acute liver failure. **CASE PRESENTATION:** The subject pilot is a 27-year-old helicopter pilot, whose sister was diagnosed with Wilson's disease. After her diagnosis he was sent to complete test results of liver functions, ceruloplasmin levels, urine copper levels, abdominal sonography, genetic tests and eventually liver biopsy, who lead to the diagnosis of WD. Ophthalmological examination revealed no Kaiser-Fleischer rings and brain MRI was normal. Liver function tests were normal. CogScreen was administered as per Air force policy and was found normal. Trientine, a copper chelating agent, was administered, to help the excretion of copper. **DISCUSSION:** As described, WD, if left untreated, can influence heavily on the pilot's functioning and endanger the pilot, the helicopter and the mission, especially in military operations. In order to control the disease, a regular treatment is needed. Trientine's side effects may include muscle spasms, iron deficiency, dystonia, myasthenia gravis, neurological deterioration, gastritis, joint pain and rash. The neurological side effects, although rare, usually appear within the first month of treatment, during which the pilot was grounded. No side effects were experienced. A waiver was granted to return to flight with a frequent follow-up regimen, including a yearly neurologist examination – to exclude any neurologic manifestations of WD or side effects. This is the first case of Wilson's disease in the Israeli Airforce. Due to the absence of clinical symptoms and the lack of side effects of the treatment, a waiver was granted to fly under strict follow-up routine.

Learning Objectives:

1. The audience will learn about the impact of Wilson's disease on fitness for flight.
2. The audience will learn about the medical aviation considerations on a waiver granted for a pilot with Wilson's disease.

5:00 PM

[77] DESIGN AND DEVELOPMENT OF A COMPUTERIZED TEST FOR THE TRAINING OF DICHOPTIC VIEWING IN AH-64E PILOTSChao-Chien Cheng^{1,2}, Chi-Lien Lee¹, Pi-Chun Huang^{2,3}, Hsin Chu⁴, Chung-Yu Lai¹, Min-Yu Tu^{1,5}

¹Aviation Physiology Research Laboratory, Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan; ²International Doctoral Program in Principles and Implications of Mind Sciences, National Cheng Kung University, Kaohsiung City, Taiwan; ³Department of Psychology, National Cheng Kung University, Tainan City, Taiwan; ⁴Civil Aviation Medical Center, Civil Aeronautics Administration, Taipei City, Taiwan; ⁵Department of Biomedical Engineering, Hungkuang University, Kaohsiung City, Taiwan

(Original Research)

INTRODUCTION: The unique helmet display unit of Apache helicopter requires pilots to view composite information with right eye and cabin instrumentation with left eye. This raised several issues in pilot selection and training, including dichoptic viewing and switching, binocular rivalry and ocular dominance. We tried to develop a computerized education and training program to reduce the possible drawbacks.

METHODS: 103 observers (58 pilots, 31 student pilots, and 14 staffs) participated in our study. The hardware was designed to mimic the dichoptic viewing configuration of Apache helicopter pilots. Visual stimuli were presented 20 cm in front of the right eye via micro projector and presented on a computer screen 100 cm in front of the left eye. We used the motion coherence task and manipulated the alteration rate between two eyes. The participants needed to tell the motion direction presenting in front of target eye and were challenged with switching between two eyes. All participants need to finish four sets of tests with increasing difficulty level. The study protocol was approved by the Institutional Review Board of Kaohsiung Armed Forces General Hospital.

RESULTS: Results indicated that correct response rate of each eye significantly increased with increasing difficulty level. The performance improvement was universal, did not differ whether the participants had the flight experience or not. **DISCUSSION:** The preliminary result suggests that our test had positive effect for the training of dichoptic viewing. We concluded that this dichoptic motion coherence task is beneficial for Apache pilot dichoptic viewing training and could be included in the training program. Dichoptic visual tasks under different lighting, noise, task conditions could be also investigated in the future.

Learning Objective:

1. The participants will be able to know the design and development of a computerized test for the training of dichoptic viewing in AH-64E pilots.

5:15 PM

[78] LONG TERM OUTCOMES OF PHOTOREFRACTIVE KERATECTOMY IN YOUNG ASIAN AVIATORS WITH LOW-MODERATE MYOPIA: A 10-YEAR FOLLOW-UP

Isaac Chay, Max Wong, Feng Wei Soh

Republic of Singapore Air Force, Singapore, Singapore

Endorsed by: Associate Fellows Group

(Original Research)

INTRODUCTION: Singapore has a high prevalence of myopia in its population, limiting the pool of suitable servicemen for military vocations within the Air Force requiring high visual performance. The Republic of Singapore Air Force (RSAF) consequently introduced photorefractive keratectomy (PRK) to expand its aircrew recruitment pool at the end of 2005. While previous studies have established good safety and efficacy profiles in PRK, there is a paucity of research evaluating its long-term safety and efficacy. Our study aims to evaluate the 5 and 10-year visual outcomes of PRK performed on young Asian aviators with low-moderate myopia and to study the evolution of postoperative refraction and uncorrected visual acuity. **METHODS:** This is a retrospective consecutive cohort study of 154 RSAF servicemen who underwent PRK from Dec 2005 to Dec 2013. Anonymized records and ophthalmic investigation results were analyzed to evaluate the

post-operative uncorrected distance visual acuity (UDVA) and refraction during a 10-year follow-up. **RESULTS:** The median patient age at the time of the operation was 21 years (range, 18 – 28 years) and the mean preoperative spherical equivalent refraction was -3.39 ± 1.19 D. At the 12-month follow-up, 98.5% of eyes had an uncorrected distance visual acuity (UDVA) of 20/20 (0.00 LogMAR) and 100.0% of eyes had an SER of within ± 0.50 D of intended correction. At the 5-year follow-up, UDVA was 20/20 or better in 97.0% of 232 eyes; of the 7 eyes which did not achieve UDVA of 20/20, mean UDVA was 0.25 LogMAR with mean SER of -0.50 D. At the 10-year follow-up, UDVA was 20/20 or better in 96.6% of 58 eyes; 2 eyes regressed to a UDVA of 0.18 LogMAR with mean SER of -0.70 D. **DISCUSSION:** PRK was the only approved corneal refractive surgery in the RSAF prior to the introduction of laser-assisted in-situ keratomileusis in 2014. It remains the most commonly performed corneal refractive surgery in the RSAF to date. The results of this study suggest that PRK performed within the context of a stringent and structured corneal refractive surgery program on young Asian eyes with low-moderate myopia is efficacious and safe with minimal regression of UDVA and SER at 5 and 10 years post-surgery. The long-term visual outcomes of PRK is critical in the military aviation context with its high visual demands and as most patients who undergo corneal refractive surgery do so at a relatively young age.

Learning Objectives:

1. Appreciate the long-term visual outcomes of photorefractive keratectomy performed on young Asian aviators with low-moderate myopia within the context of a stringent and structured corneal refractive surgery program.
2. The Republic of Singapore Air Force Corneal Refractive Surgery program – eligibility criteria for enrolment, safety and efficacy of the corneal refractive surgery performed.

Monday, 05/06/2019

4:00 PM

Brasilia 5

[S-18] PANEL: FAA FEDERAL AIR SURGEON'S ONCOLOGY SUMMIT: INTEGRATING AEROMEDICAL CERTIFICATION AND THE LEADING EDGE OF ONCOLOGY RESEARCH AND PRACTICE

Endorsed by: American Society of Aerospace Medicine Specialists

Chair: Michael Berry

PANEL OVERVIEW: The Aerospace Medicine Specialists of the FAA recognized a growing disparity between the aeromedical risk evaluation of pilots with cancer, and the improved medical treatment advances in oncology today. In September 2018, the FAA held an 'Oncology Summit' to review current oncology basic science, practice and treatments. Focusing on "Finding a path to Yes," experts in Aerospace Medicine, and leading national oncology specialists jointly addressed the nexus of aeromedical risk assessment, oncology clinical advances and FAA aviation safety regulations. The Summit resulted in: re-baselining FAA aerospace medicine procedures and protocols for evaluating pilots with cancer; integrating more clinically current information on active treatment and precautions when considering returning a pilot with cancer to the cockpit; and a model for adapting rapidly changing clinical practice to aeromedical risk assessment and decision-making to other medical specialty areas. The purpose of this Part 1 Panel is to share the lessons learned from this Summit. The presentations will address the problems faced by the FAA and the conceptual basis for the Oncology Summit, followed by a discussion of the FAA's current approach to evidence-based risk assessment (EBRA) and innovation adoption.

[79] APPLICATION OF EVIDENCE-BASED RISK ASSESSMENT (EBRA) IN AIRMEN WITH ONCOLOGIC CONDITIONS, GETTING TO 'YES'

Judith Kerber Frazier

FAA, Washington, DC, USA

(Education - Program / Process Review Proposal)

INTRODUCTION: This presentation will review how the FAA is implementing evidence-based risk assessment (EBRA) methodology to incorporate generally accepted clinical standards, guidelines and current outcome data to certification decisions on airmen with oncologic conditions. **TOPIC:** Advances in oncology include complete clinical remission of cancers previously considered untreatable or uniformly fatal, stable partial remissions, cancer as a chronic indolent disease, and maintenance chemotherapy to prevent recurrence. Improved therapies and clinical outcomes now allow patients to live years with an active lifestyle despite extant cancer or ongoing treatment, often with “no evident disease” (NED) long before being considered a clinical cure. The FAA is systematically applying EBRA methodology to protocols regarding hazards from oncologic conditions. The criterion for certification is acceptable mitigation of the overall risks for sudden or subtle incapacitation. Factors considered include NED or stable non-progression, therapy with low risk for aeromedically significant side effects, an effective surveillance plan, and favorable long-term prognosis. **APPLICATION:** Previous FAA policy dictated that certain types of cancers were disqualifying, while for others special issuance could be considered if specified requirements were met. These requirements included documentation of remission (or a “clinical cure”) and completion of all treatment (surgery, chemotherapy, and/or radiation therapy). Frequently, airmen had to be off all treatment for a minimum specified time period, which could be a year or more. Airmen could also potentially qualify for an unrestricted medical certificate if the cancer diagnosis was considered “remote” (5 or more years ago) and not metastatic. If the airman was diagnosed within the previous five years, many solid tumors would qualify for the CACI (Conditions AMEs Can Issue) program. Those who were outside CACI policy-based criteria could be evaluated for a special issuance. Overall, the evaluation process lacked consistency across the spectrum of oncologic diagnoses, treatments and outcomes, and lacked flexibility for a nuanced approach to new advances. Pursuant to the FAS Oncology Summit, the FAA has revisited several cancers by applying EBRA methodology, resulting in revision of FAA protocols for certification decision-making in cancer. Examples will be reviewed.

Learning Objectives:

1. The audience will understand the shortcomings of policy-based decision making when applied to current state-of-the-art oncologic practice.
2. The audience will learn about how the FAA is implementing EBRA for oncologic risk stratification.
3. The audience will learn how the FAA is applying the EBRA methodology to consider airmen with oncologic malignancies who are currently undergoing chronic active treatment, maintenance therapy, or treatment to prevent recurrence.

[80] CHRONIC LYMPHOCYTIC LEUKEMIA: UPDATES AND ADVANCES IN 2019Caitlin Costello*University of California, San Diego, La Jolla, CA, USA**(Education - Tutorial Proposal)*

INTRODUCTION: The understanding of the pathogenesis of chronic lymphocytic leukemia in the past two decades has led to the development of new prognostic tools and dramatically changed the therapeutic landscape. **TOPIC:** Chronic lymphocytic leukemia has been one of the most dynamic fields of clinical research for the past two decades. The disease is characterized by clonal proliferation and accumulation of mature B-cells within the blood, bone marrow, lymph nodes, and spleen, and may be due to the gain or loss of chromosomal material, leading to leukemic transformation. Comprehensive genomic analyses have allowed for a better understanding of prognostic information but also have presented targets for therapeutic intervention. Traditional Rai and Binet staging systems are now complemented by genetic and biologic factors to create risk categories and a prognostic index known as the CLL-International Prognostic Index. This remains the best validated tool in predicting time to first therapy among previously untreated patients. For many patients with chronic lymphocytic leukemia, treatment with chemotherapy and anti-CD20 monoclonal antibodies remains the standard of care. The introduction of highly effective oral targeted therapies and next generation anti-CD20

monoclonal antibodies have led to improved outcomes, even among patients with high-risk features such as del17p13 or TP53 mutation and unmutated immunoglobulin heavy chain (IGHV) genes. **APPLICATION:** This tutorial will summarize the current approach to risk stratification and management of patients with chronic lymphocytic leukemia, and provide aerospace medicine practitioners with a current evidence-based clinical background for making informed aeromedical dispositions of airmen with this disease.

Learning Objectives:

1. The audience will learn about key advances in basic science in the chronic lymphocytic leukemia.
2. The audience will learn about key advances in clinical practice.
3. The audience will learn about significant issues/concerns of the condition, treatment or surveillance monitoring as they relate to the risks for sudden incapacitation or subtle incapacitation/impairment.

[81] AN INTRODUCTION TO CANCER-RELATED COGNITIVE IMPAIRMENTSTodd Horowitz*National Cancer Institute, Rockville, MD, USA**(Education - Tutorial Proposal)*

INTRODUCTION: Cancer survivors often report difficulties with cognitive function, termed “cancer-related cognitive impairments” (CRCI). This presentation will cover what is known about the nature and prevalence, and duration of CRCI, in addition to known risk factors and intervention strategies. **TOPIC:** Between 17% and 75% of cancer survivors who have undergone chemotherapy experience CRCI. Colloquially, CRCI is often referred to as “chemofog”, or “chemobrain”. However, current research indicates that the causes of CRCI are multifactorial, including not just chemotherapy but other cancer treatments, the stress of being a “cancer patient”, and potentially the disease itself. CRCI is observed not just during and immediately after chemotherapy, but months and even years after treatment. Deficits have been reported across several cognitive domains, notably attention, executive function, and memory, but also including language, visuospatial ability, and motor ability. CRCI is associated with changes to both structural and functional brain measurements. Risk factors include older age, lack of cognitive reserve, and genetic factors. A variety of interventions have been tested to combat CRCI. Currently cognitive training has the best evidence base. **APPLICATION:** Patients need to be advised of the risks of CRCI along with other potential side effects from treatment in order to make informed decisions. The cognitive functioning of cancer survivors should be carefully assessed in the aerospace context.

RESOURCES:

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2. Janelins MC, Heckler CE, Peppone LJ, et al. Cognitive complaints in survivors of breast cancer after chemotherapy compared with age-matched controls: An analysis from a nationwide, multicenter, prospective longitudinal study. *JCO*. 2016; 35(5):506-514. doi:10.1200/JCO.2016.68.5826.
3. Von Ah D. Cognitive Changes Associated with Cancer and Cancer Treatment: State of the Science. *Clin J Oncol Nurs*. 2015; 19(1):1-10. doi:10.1188/15.CJON.19-01AP.

Learning Objectives:

1. The audience will learn about key advances in the study of cancer-related cognitive impairment (CRCI).
2. The audience will learn about the risks of cancer-related cognitive impairment and its potential impact on aerospace personnel.

[82] GASTROINTESTINAL ONCOLOGY: CURRENT ADVANCES IN COLORECTAL CANCER RELEVANT TO AEROMEDICAL CERTIFICATIONJoyce Pastore*Federal Aviation Administration, Washington, DC, USA**(Education - Tutorial Proposal)*

INTRODUCTION: Tumor stage, grade, nodal status, spread and metastases are the traditional basis for risk assessment in pilots with

colorectal cancer (CRC). This presentation will review the current epidemiology, advances in tumor biology, genomics and embryology, and the diagnosis, treatment and outcomes of colorectal cancers, with the goal of identifying factors important to risk assessment in pilots.

TOPIC: CRCs account for 7-9% of new cancer cases and 8% of deaths. Sporadic (non-familial) tumors take 30-50 years to initiate and 10-20 years to progress to frank carcinoma (6% risk, mean age 68 years). However, numerous lines of research are advancing the understanding CRC risks and prognosis. Cases and deaths are declining in patients over 50 but are increasing in 20-49 year olds. Survival rates are highest with early diagnosis (90%) but decrease with regional (70+%) and distant (12-14%) spread, and the probability of disease-free survival after treatment also declines by stage. Longer treatment results in higher rates and severity of neurosensory side effects, but shorter treatment (3 months) has been found non-inferior to 6-months protocols. Right-sided tumors have worse prognosis compared to left-sided tumors, relating to embryologic origin and biological complexity of the colon. This reflects in the "continuum hypothesis": high risk markers (CIMP-high, MSI-high, BRAF mutation) increase proportionally from rectum to cecum, and inversely correlate to therapeutic outcome. Inherited CRC syndromes (familial adenomatous polyposis (FAP; Lynch) have known accelerated progression and carcinoma risk. Mismatch repair status (deficient vs. proficient), HER2 copy number, and BRAF mutation status correlate to survival and treatment efficacy, and aid in treatment choice (e.g., pembrolizumab, ipilimumab, dual HER2-blockade). A 5-factor risk score system based on liver metastases predicts tumor recurrence and 5-year survival.

APPLICATION: Advances in multiple research lines provide new clinical tools useful for risk assessment in pilots. Prognosis for a pilot with "no evident disease" is significantly affected by tumor type, location, genetics, markers and therapy. These new research findings are directly applicable to risk-based aeromedical decision-making for medical certification and follow-up surveillance requirements.

Learning Objectives:

1. The audience will learn about the baseline risks for developing CRC, and the overall likelihood for survival following treatment based on standard published staging and clinical guidelines.
2. The audience will learn about new developments in understanding of CRC, including tumor side, the "continuum hypothesis," distribution of high risk markers, and inherited CRC syndromes.
3. The audience will learn about advances in therapeutics, correlation of tumor markers to treatment success, and factors affecting prognosis for treatment side effects and disease-free survival.

[83] Updates in Therapy For Advanced Melanoma

April Salama

Duke University, Durham, NC, USA

(Education - Tutorial Proposal)

INTRODUCTION: Immune checkpoint inhibitors and targeted therapies have revolutionized melanoma treatment in recent years. Studies have demonstrated the significant impact of these new therapies compared with standard of care on patient outcomes, including durable response and extended survival. **TOPIC:** Historically, the median overall survival of metastatic melanoma patients was less than 1 year and long-term survivors were rare. Advances in immune modulators, including cytotoxic T-lymphocyte antigen 4 (CTLA-4) and programmed death-1 (PD-1) based treatments, have been an integral part of this shift. Recent data suggests now that more than half of patients are still alive at 4 years when they receive these new agents. The toxicity profile of these agents is unique, termed collectively immune related adverse events (irAEs). irAEs require specific and sometimes highly specialized management, and in rare cases can be life-threatening. Additionally, advances in molecularly targeted therapies have shown great promise in the treatment of advanced melanoma. *BRAF* mutations are present in over half of metastatic melanomas, with the most common activating mutations being V600E and V600K. Metastatic melanoma patients whose tumor harbor a *BRAF* mutation have been shown to respond to the selective *BRAF* and MEK inhibitors has resulted in improved response rates and in some studies overall survival when compared to *BRAF* inhibitor monotherapy. Dual inhibition now represents a standard of care option for patients with *BRAF* mutated melanoma. More recently, these therapies have now demonstrated clinical benefit adjuvant setting, increasing the potential number of

patients likely to be treated with systemic therapy. Despite remarkable progress, however, many challenges remain. Many melanomas ultimately develop resistance to either targeted or immune therapies and additional therapeutic options are needed. **APPLICATION:** The revolutionary advances in therapy for melanoma mean that patients with previously incurable cancer are now living years with continued control of their disease. This shift in clinical outcomes has implications for aerospace medicine and directly impacts decisions regarding the medical fitness of those diagnosed with melanoma.

Learning Objectives:

1. The audience will learn about new developments in immunotherapy for melanoma.
2. The audience will learn about new developments in targeted therapy for melanoma.

Monday, 05/06/2019

4:00 PM

Brasilia 7

[S-19] PANEL: ADVANCING FUTURE SPACE EXPLORATION MEDICAL SYSTEM DESIGN

Chair: Kris Lehnhardt

PANEL OVERVIEW: INTRODUCTION: NASA and its International Partners are rapidly developing new space exploration missions beyond low Earth orbit (LEO). These missions to cis-lunar space, the lunar surface, and the vicinity of Mars will generate new challenges for maintaining human health and performance in space. **TOPIC:** The Exploration Medical Capability (ExMC) Element of the NASA Human Research program is charged with addressing these challenges and to this end, ExMC has developed an interdisciplinary team focused on using engineering principles to advance the medical system design process and improve risk-informed decision making for future exploration missions. This effort involves clinicians, engineers, scientists, and others who are working to develop an evidence-based, traceable, and repeatable systematic approach to medical system design that can identify, define, and prioritize medical capabilities based upon key mission parameters. These parameters include mission constraints that will inevitably limit the potential scope of a medical system (such as mass, power, volume, etc.), all of which must be accounted for in the design process. The end state of ExMC's work will be a medical system design process that can be applied to any given space exploration mission in the future. Each time the process is executed, the intended output will be a recommended medical system design scoped appropriately to mission constraints that reduces medical risk and improves human health and performance in space.

APPLICATION: This panel will outline the key steps in this space exploration medical system design process and how this effort can be used to better communicate medical risks and needs to inform space vehicle and system design.

[84] CHANGING NATURE OF MEDICAL RISK IN EXPLORATION SPACEFLIGHT

Erik Antonsen¹, Michael Canga², Eric Kerstman³, Jerry Myers⁴, Kris Lehnhardt¹

¹NASA Johnson Space Center / Baylor College of Medicine, Houston, TX, USA; ²NASA Johnson Space Center, Houston, TX, USA; ³University of Texas Medical Branch, Galveston, TX, USA; ⁴NASA Glenn Research Center, Cleveland, OH, USA

(Original Research)

INTRODUCTION: It is possible to provide a quantitative estimate of the relative medical risks expected for human space exploration missions using NASA's Integrated Medical Model (IMM). This is performed through simulation that relies on evidence from human spaceflight and terrestrial medicine as well as resource utilization in an ISS-like mission context. **METHODS:** Medical risk was quantified via the IMM for five NASA design reference missions. The missions modeled include: 1) 21 days with 4 crew (early Orion missions); 2) 42 days with 4 crew (Orion/Gateway missions); 3) 365 days with 4 crew (deep space mission as preparation for a Mars mission); 4) 730 days with 4 crew (Mars flyby

mission); and, finally, 5) 1195 days with 4 crew (Mars planetary mission). Three sub-cases were considered: MedCap - use of the ISS medical kit without resupply; Treated - use of the ISS medical kit with resupply; and Untreated - ineffective medical kit. **RESULTS:** Total medical events predicted range from tens of events up to approximately 400, depending upon the mission duration. The likelihood of considering evacuation due to medical issues for at least one crewmembers ranges in the Untreated cases from 0.140 [21 days] (CI 0.138 – 0.142) to 0.984 [1195 days] (CI 0.983 – 0.985), and in the Treated cases from 0.0026 [21 days] (CI 0.0023 – 0.0029) to 0.143 [1195 days] (CI 0.142 – 0.146). The likelihood of loss of crew life due to medical issues ranges in the Untreated cases from 0.0015 [21 days] (CI 0.0013 – 0.0018) to 0.057 [1195 days] (CI 0.056 – 0.059), and in the Treated cases from 0.0003 [21 days] (CI 0.0002 – 0.0005) to 0.021 [1195 days] (CI 0.020 – 0.022). Crew Health Index ranged in the Untreated cases from 90.23 [21 days] (CI 69.75 – 96.89) to 14.82 [1195 days] (CI 8.64 – 20.52) and in the Treated cases from 96.99 [21 days] (CI 92.95 – 98.84) to 86.87 [1195 days] (CI 67.72 – 95.75). **DISCUSSION:** These probabilistic risk analysis estimates seek to provide a reasonable quantitative bounding of the risk that crews are likely to encounter by calculating both time and resource estimates of mission relevant parameters. While these are not predictive estimates, this information will assist risk managers and mission designers to perform the best possible trade space analyses that will ultimately help to mitigate future mission risks.

Learning Objective:

1. The audience will learn about how NASA's Integrated Medical Model was used to provide medical risk estimates for human space exploration missions.

[85] ADDRESSING NASA STANDARDS IN FUTURE MEDICAL SYSTEM DESIGN

Kerry McGuire

NASA Johnson Space Center, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: Future exploration beyond low Earth orbit will require a change in the way medicine is practiced in space. Progressively Earth-independent advanced levels of care will be necessary, with a greater focus on in-flight diagnosis, treatment, and rehabilitation compared to current space-flight operations today. **TOPIC:** The Exploration Medical Capability element (ExMC) is using a Systems Engineering (SE) approach to define, develop, validate, and manage the medical system design for exploration missions. During the first phase in this process, documentation was obtained that informed the SE team of stakeholder concerns and needs. A key driving document in this phase was the NASA Standard 3001, volume 1. Within this document, NASA medical care standards are established and levels of care are defined. To ensure consistency of interpretation of the levels of care within this standard, ExMC developed and defined actions for each of level of care. Content from this interpretation was then used to inform multiple Concept of Operations (ConOps) documents that outline the capabilities required to ensure appropriate medical care for the crew during exploration missions. The SE team worked with NASA aerospace medicine experts to generate representative medical scenarios that captured the day-in-the-life of future crewmembers who are either providing or receiving care. From these scenarios, the ExMC SE team was able to identify functions and requirements for a future medical system. **APPLICATION:** This presentation will provide an overview of the Systems Engineering (SE) approach taken by ExMC. The interpretation of the NASA levels of care will be presented, followed by how this content was used to inform medical system concept of operations, functions, and requirements.

Learning Objective:

1. The audience will learn about the Systems Engineering approach to developing a medical system and the resources needed to accomplish this task.

[86] DEVELOPMENT OF AN ACCEPTED MEDICAL CONDITION LIST FOR MEDICAL SYSTEM SCOPING

Derek Nusbaum¹, Rebecca Blue², Erik Antonsen³

¹University of Texas Medical Branch, Galveston, TX, USA; ²GeoControl Systems, Inc., Houston, TX, USA; ³Baylor College of Medicine, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: The Accepted Medical Condition List (AMCL) is a list of identified potential medical conditions for deep-space missions that can be used for scoping the medical capability needs for future design reference missions (DRMs), including a Mars Transit DRM and a Cis-Lunar DRM. The development of a baseline AMCL by the Exploration Medical Capability (ExMC) Element will assist the effort to identify high priority medical capabilities for inclusion in mission and vehicle planning and provide traceable and documented clinical needs to the Systems Engineering teams tasked with requirements development. **TOPIC:** To provide a traceable understanding of the drivers for a clinical capability for future DRMs, including both for Mars Transit and Cis-Lunar missions, the ExMC Clinician's group developed a means to identify potential medical conditions that a medical capability should plan to address during these DRMs. This was done by starting with the Exploration Medical Condition List (EMCL), derived from the International Space Station (ISS) Integrated Medical Group (IMG) Medical Checklist (JSC-48522), the Flight Data File Medical Checklist (JSC-48031), in-flight medical incidence data in the Lifetime Surveillance of Astronaut Health (LSAH) repository, and NASA Flight Surgeon subject matter expertise. From there, probabilities of occurrence of the medical conditions in the EMCL were determined using the Integrated Medical Model (run SR-20170306-376) to model the medical events of a deep-space mission. These condition probabilities, coupled with metrics for management complexity and treatment futility, were combined to give an assessment of the probability and severity of the different conditions on the EMCL. With this, the conditions could then be quantitatively and objectively ordered in relation to one another. This final list was reviewed by a panel of space medicine subject matter experts to ensure agreement with the results and then codified to form the AMCL. **APPLICATION:** Defining an AMCL allows ExMC to better scope a potential exploration medical capability and identify the necessary resources for inclusion aboard future exploration vehicles within the context of known conditions, desired treatment capabilities, and limitations of vehicle design. This presentation explores the methodology used in pilot efforts towards development of the AMCL, as well as lessons learned that can be used for future refinement of the AMCL, and modifications to accommodate future DRMs.

Learning Objective:

1. The audience will learn about pilot efforts to define a traceable, repeatable process that can be used to identify potential medical conditions that influence scoping of an exploration spaceflight system.

[87] INFORMING THE MEDICAL SYSTEM MODEL ARCHITECTURE

Melinda Hailey¹, Kris Lehnhardt²

¹KBRwyle, Houston, TX, USA; ²Baylor College of Medicine, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: The identification of prioritized medical capabilities and associated resources needed during exploration spaceflight provides robust content that informs system designers and allows for a more complete evaluation of both medical and overall mission risk. **TOPIC:** Medical systems supporting exploration-class missions to cislunar space, the lunar surface, and the vicinity of Mars will require a change in medical capability from today's low Earth orbit centric paradigm. This change will be driven by prolonged mission duration, significant distance from earth, and the realities of orbital mechanics. The medical system (which includes the crewmembers) is expected to be able to diagnose, treat, and manage a defined list of medical conditions (Accepted Medical Conditions List or AMCL). The system is also expected to support planned medical activities that promote the health and performance of the crew. This list of conditions, along with the planned medical activities, drives the selection of prioritized capabilities and resources for the system. Traceability between conditions, activities, capabilities, and resources provides context that informs the development of medical system functional requirements. All of this content and its associated traceability also enable risk-informed decision making when considering any system design trades. ExMC clinicians, working with systems engineers populated a Model-Based Systems Engineering (MBSE) architecture built in Systems Modeling language (SysML) with this clinical content to capture the traces between capabilities, conditions,

activities, and resources. Use of the SysML model with this large dataset allows for efficiency in content manipulation, provides appropriate configuration management, and enables the team to produce visual products that help system stakeholders assess clinical content.

APPLICATION: This presentation will share the approach taken by the ExMC clinician community to identify key medical capabilities and resources needed to populate the medical system model. Visual representations of model content will be shared, demonstrating the utility of MBSE tools to help with communication of medical risks and needs to system and vehicle engineers.

Learning Objective:

1. The participant will be able to recognize the value of defining clinical capabilities required within a desired medical system and tracing these capabilities to required resources, as well as recognize the merits of modelling this content within a SysML environment.

[88] USING TOOLS TO INFORM MEDICAL SYSTEM TRADE SPACE DECISIONS

Jennifer Mindock

KBRwyle, Houston, TX, USA

(Education - Tutorial Proposal)

INTRODUCTION: When making programmatic and technical decisions about the scope of medical care to provide on exploration missions, decision makers need to be informed of the impacts due to the various options. **TOPIC:** In the case of a spaceflight medical system, the trades must consider aspects from a program's risk posture, space medical policy, the goals of the envisioned system, and the technical implementation benefits and challenges of the options to implement the envisioned system. These aspects, as addressed in the previous topics in the panel, define a trade space for exploration medical systems. ExMC is currently developing a suite of tools in an integrated way to provide quantitative and repeatable characterizations of medical system options to inform decision makers. The connections among the tools allow for traceability and consistency in characterizing medical system options in terms important to programmatic and technical decisions makers, e.g. risk metrics, standards met, requirements met, mass, power, and volume.

APPLICATION: This topic will discuss the current state of the suite of trade space analysis tools, including the coordinated use of a Systems Modeling Language (SysML) model capturing medical conditions to address, capabilities to provide, and requirements to meet; a Probabilistic Risk Analysis tool providing risk metrics based on evidence; and a database capturing medical equipment options and specifications. Examples of pilot trade activities will be provided, along with the development of team processes to make recommendations based on trade characterizations. The topic will also describe the next steps in achieving ExMC's goal of a repeatable process to recommend medical system implementations for future exploration missions.

Learning Objective:

1. Awareness of tools and processes in development to recommend medical systems for exploration missions.

Monday, 05/06/2019

4:00 PM

Miranda 5/7

[S-20] SLIDE: SPATIAL DISORIENTATION & PERFORMANCE

Chair: Fred Bonato

Co-Chair: David Schroeder

4:00 PM

[89] THE KRACKEN UNLEASHED: CREATING THE ENVIRONMENT FOR THE FIRST RESEARCH STUDY IN THE DISORIENTATION RESEARCH DEVICE (DRD)

Richard Folga¹, Kyle Ellis², Charles Powell¹, Peter Le¹, Cortland Etgen¹

¹Naval Medical Research Unit Dayton, Dayton, OH, USA; ²NASA Langley Research Center, Hampton, VA, USA

(Education - Program / Process Review Proposal)

BACKGROUND: The Disorientation Research Device (DRD) also known as the Kraken, is the Navy's newest, largest and most powerful aerospace medicine research device. Designed as a basic research device, the DRD is being developed for use in an applied manner in the study of pilot spatial disorientation (SD) and aviation mishap prevention. The first official use of the DRD was in support of the NASA Advanced Flight Deck Countermeasures - 4 (AFDC-4) project to test safety enhancements to prevent loss of energy state awareness in commercial aviation. This presentation will describe the significant challenges in creating the unique software, hardware, network applications and interfaces required to complete the AFDC-4 project.

OVERVIEW: The DRD was required to be configured to accommodate two crew members simulating a modern commercial aircraft flight deck using side stick controls and precise duplication of head down display design eye reference points. Construction of the flight deck itself will be described briefly, to include anthropometric accommodation, internal safety certification testing and joint NASA/NAMRU capsule man rating. A custom data acquisition network architecture was created to support the integrated recording of precision eye tracking, stick inputs, motion and flight data to include display and instruments. Control of the flight scenarios was accomplished through the development of a custom instructor operator station and multiple graphical user interface applications. Detailed description of the flight model, motion washout algorithm development and subject qualitative feedback will be presented separately. All subjects were part of Institutional Review Board approved human use research protocols. **DISCUSSION:** Upon completion of man rating and joint institutional review board process, data collection officially began in and was completed in July 2018. Twenty non-military trained regional airline pilots (flying as singles and pairs) completed the AFDC-4 protocol. Significant technical challenges were overcome with the development of six custom software applications that included resolving network architecture congestion, code development for the flight controls and high speed synchronous remote communication for in capsule and in control room PCs.

Learning Objective:

1. The audience will learn about the development of the first research configuration for the Disorientation Research Device capsule and the network architecture to support man in the loop study of advanced flight deck countermeasures to loss of energy state awareness.

4:15 PM

[90] CONTROLLING THE KRACKEN: THE FIRST APPLICATION OF MOTION WASHOUT AND FLIGHT MODEL INTEGRATION FOR RESEARCH IN THE DISORIENTATION RESEARCH DEVICE (DRD)

Cortland Etgen¹, Torin Clark², Jordan Dixon², Dain Horning¹, Richard Folga¹, Kyle Ellis³

¹Naval Medical Research Unit Dayton, Dayton, OH, USA; ²University of Colorado at Boulder, Boulder, CO, USA; ³NASA Langley Research Center, Hampton, VA, USA

(Original Research)

INTRODUCTION: The Disorientation Research Device (DRD), AKA the 'Kraken', is the Navy's newest and most powerful aerospace medicine research device. Designed for basic research, NAMRU-Dayton has established an applied research program centered on the Kraken to address pilot spatial disorientation (SD). This is a significant challenge for the Kraken team: harness the raw power and dexterity of the DRD and develop elegant, authentic flight motion usable to SD researchers for man in the loop (MITL) control. **METHODS:** Relying on limited published research using six degree of freedom (DOF) motion control and washout, the DRD team began to explore models and conventions applied to similar 'flying' devices throughout history. The first DRD MITL flight scenarios were tested using a three DOF model in the fall of 2016. The progression of motion control concepts was applied jointly with NASA in July 2018 to the first human subjects in the Kraken. Commercial carrier pilots were exposed to 'Big Stewart' (6-DOF) and 'Gx Centrifuge' (1-DOF) DRD motion conventions. 'Big Stewart' was used for upset and recovery (UAR) and plane following tasks, and 'Gx Centrifuge'

for takeoff scenarios to induce the somatogravic illusion. All subjects were part of Institutional Review Board approved human use research protocols. **RESULTS:** Expert feedback and intense refinement of mathematical motion washout models resulted in scenarios with positive subject experience ratings. The UAR series was judged "very good" with a mean rating of 4.45 ($\sigma = 0.541$) and somatogravic illusion scenarios were rated "excellent" 4.60 ($\sigma = 0.134$) on five-point Likert scales. Self-reported motion sickness scores were below 1.0 on a ten-point scale for all scenarios. **DISCUSSION:** The DRD team has demonstrated readiness to study human perception of complex motions, to include the applied work of MITL pilot SD. Further applications of the newly developed flight motion washout solutions were also used for a later joint SD modeling study investigating control reversal error in experienced pilots.

Learning Objective:

1. The audience will learn about the development of motion washout algorithms used for the first applied research study executed in the Disorientation Research Device.

4:30 PM

[91] PERCEPTION THRESHOLD OF THE VESTIBULAR CORIOLIS ILLUSION

Eric Groen¹, Arjan Meskers², Mark Houben¹, Jelte Bos¹

¹TNO, Soesterberg, Netherlands; ²TNO, Delft, Netherlands

(Original Research)

BACKGROUND: The vestibular Coriolis illusion results from cross-coupled stimulation of the semicircular canals by making a head rotation about one axis during constant body rotation about another axis. This gives an illusion of self-tilt about an axis perpendicular to the two stimulus axes. The Coriolis illusion is often mentioned in aerospace medicine literature for its nauseogenic and disorienting effect. However, little is known about the minimum angular velocity needed to produce the illusion. The current paper describes an experimental study to determine the perception threshold of the Coriolis illusion.

METHODS: Nineteen subjects gave verbal judgements of their perceived self-rotation, while making a standardized head movement during constant body rotation about an Earth-vertical axis. The head movement consisted of pitching down (chin-to-chest), followed by pitching up back to upright when all sensations had disappeared. Each subject experienced ten stimuli of constant yaw rotation, ranging from 5 to 50 °/s, in semi-random order and alternating direction. Yaw acceleration and deceleration was always 0.7 °/s². The yaw stimuli were produced by a moving base flight simulator with an additional continuous yaw drive. Although only yaw motion was used, before the experiment the subjects watched the simulator also move about the pitch and roll axes, to make such (illusory) Coriolis sensations more plausible. **RESULTS:** A psychometric curve fit to the individual data showed that, on average, a Coriolis illusion was only perceived at yaw stimuli higher than 12 °/s. This yaw rate applies to the pitching movement performed by our subjects, which had an average amplitude of 40 ° and peak velocity of 55 °/s. We calculated that, at a yaw rate of 12 °/s, this head motion yields an (internal) response of the semicircular canals of 7 °/s. Based on this it can be predicted that, in theory, the Coriolis illusion does not occur at yaw stimuli below 5 °/s, even with more extreme head movements. By comparison, a rate one turn of an airplane is 3 °/s. **DISCUSSION:** We conclude that the minimum angular velocity to produce a Coriolis illusion (5 °/s) is higher than the perception threshold for the semicircular canals (1-2 °/s). Maybe the rather complex Coriolis illusion is difficult to distinguish from the head motion itself. Our results may be taken into account in accident investigations where the Coriolis illusion is suspected to be a contributing factor.

Learning Objectives:

1. The audience will learn about the psychophysical mechanism and modeling of the Coriolis illusion.
2. The audience will learn that the disorienting effect of the so-called Coriolis illusion in-flight only occurs at turn rates above a certain perception threshold.
3. The audience will learn that previous studies on the Coriolis illusion were primarily concerned with the nauseogenic effects, requiring rotation stimuli far above the perception threshold.

4:45 PM

[92] THE ROLE OF VISUAL INPUTS ON VESTIBULAR CROSS-COUPLING STIMULUS

Denis Bron¹, Romano Fausto², Dominik Straumann², Giovanni Bertolini³

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(Original Research)

Vestibular cross-coupling (CC) stimulus occurs when an individual tilts his head during an ongoing rotation in darkness. It induces tumbling sensation and motion sickness. Our aim was to investigate whether visual information decreases CC sensation by preserving the rotational sensation. Eleven healthy subjects were rotated (30°/s and 60°/s) around an earth-vertical yaw axis. CC stimulus was induced by an active head tilt of 45°. Such trial was executed four times: 1) in darkness; 2) in light, staring (not fixating) at a static optokinetic (OK) drum; 3) in light, staring at an OK drum rotating in the opposite direction; 4) in darkness. After each head tilt, subject scored (0-20) the strength of the CC sensation respect to the first trial (defined as score=10). Visual information reduced the CC sensation in all subjects. With static OK drum, CC sensation score was half at 30°/s, while 2/3 at 60°/s. Increase of OK velocity did not induce a further decrease CC sensation in 6/11 subjects (both at 30°/s and 60°/s). Our findings suggest: 1) vection induced by OK drum partially decreases the CC sensation; 2) the reduction of CC by vection is less effective with stronger vestibular stimulations; 3) vection twice as strong as the vestibular stimuli cause no further decrease in CC sensation in certain subjects, suggesting a possible saturation effect.

Learning Objective:

1. Introducing newest vestibular ocular research results.

5:00 PM

[93] EVALUATION OF A SIMULATED SPATIAL DISORIENTATION SCENARIO BY MEANS OF PILOT CONTROL AND GAZE BEHAVIOR

Wietse Ledegang, Eric Groen

TNO, Soesterberg, Netherlands

(Original Research)

INTRODUCTION: The Royal Netherlands Air Force uses a spatial disorientation (SD) simulator to improve SD awareness of pilots by self-experiencing common illusions. Typically, pre-programmed SD illusions are presented in separate maneuvers. The objective of this study was to integrate several SD illusions into one actively flown scenario, and to investigate the effectiveness by measuring the pilots' control and gaze behavior. **METHODS:** Ten male novice pilots were asked to fly three circuits in a continuous session in a simulated Pilatus PC-7 aircraft. Unmentioned to the pilots, the final circuit contained one visual and four vestibular SD illusions: (1) Cloud leans, (2) Somatogravic, (3) Coriolis, (4) Post-rotatory, and (5) Vestibular Leans. Control inputs, flight performance, simulator motion, and the pilots' visual behavior were recorded. Afterwards, pilots were asked to report any unexpected events they had noticed. The experiment was conducted with approval of the institutional ethics committee. **RESULTS:** The Post-rotatory illusion and Vestibular Leans did not produce any noticeable effects and were not recognized by the pilots. The other three SD events did produce significant effects on pilots' control and gaze behavior. The Cloud leans, reported by half of the pilots, induced an unintended roll rate when pilots were looking outside, followed by a correction when looking at the attitude indicator. The Coriolis illusion, reported by all pilots, caused a delay in the first glance to the attitude indicator as well as an unintended roll during the coordinated turn. Finally, the Somatogravic illusion, reported by four pilots, significantly affected the pitch input, but seemed to be confounded by a time delay in the simulator pitch response. **DISCUSSION:** The results of the Coriolis illusion and Cloud leans provide experimental evidence for a relation between SD, control input and gaze behavior, and shows that flight performance was

affected even when the pilots did not recognize the illusion ("Type-1"). Although the other illusions can be effectively demonstrated in single maneuvers, the maneuvers flown in our active scenario did not induce adequate simulator motion response. Also, whereas the illusions are normally pointed out by the instructor, in our scenario pilots were oblivious to the SD events. In conclusion, different SD events can be combined in an active scenario, but it requires appropriate illusions and simulator motion.

Learning Objectives:

1. The audience will learn that adequate SD simulation requires appropriate illusions and simulator motion.
2. The audience will learn that there is a relation between SD, control input and gaze behavior.

5:15 PM

[94] FINGER TAPPING TEST FOR ASSESSMENT OF PSYCHOMOTOR FUNCTION ON EXTENDED STAY AT HIGH ALTITUDE

Munna Khan¹, Ashok Salhan², Sanjeev Sharma², Taru Tevatia³, Sudhir Rao⁴

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(Original Research)

INTRODUCTION: Acute decrement in psychomotor performances is common at high altitude but is not as well understood as the physiological adaptation. Objective is to assess psychomotor functions on a short duration exposure to high altitude (HA) and during extended stay using simple Finger Tapping Test (FTT). Effectiveness of supplementation of glutamic acid has also been assessed during both stays. **METHODS:** The PBG probe of BIOPAC MP30 system was used to record signals from the finger of human subjects at sea level (SL), just reaching high altitude of 10700 feet (HA1) and extended stay of one month at same altitude (HA2). Total 30 healthy, young, right-hand dominant volunteers aged between 24 to 28 years were studied. They were randomly divided into two groups. The 15 subjects were administered oral glutamic acid and designated as supplemented group (SG) and rest were designated as the control group (CG). The signal was acquired from tapping movement of index finger for 30 seconds. Total time taken for first 10 taps and last 10 taps was calculated from the recordings. **RESULTS:** The CG took average 1.99 seconds (sec) for first 10 taps and 2.27 sec for last 10 taps at SL while corresponding values for SG were 2.13 and 2.37 sec respectively. At HA1, average δT for start and end taps was 2.12 and 2.49 sec for CG and 2.31 and 2.63 sec for SG. At HA2, average δT was 1.98 and 2.35 sec for CG and 2.08 and 2.45 sec for SG for start and end taps respectively. The FTT resulted percentage change average area (PCAA) at SL as 29.37 and 23.70 for CG and SG respectively. The PCAA at HA1 was found to be 17.71 and 15.28 for CG and SG respectively. The PCAA at HA2 was 24.18 and 27.06 for CG and SG respectively.

DISCUSSION: The δT for start and end 10 taps for both groups was highly significantly increased in 30 sec ($P < 0.0001$) signifying slowing of finger taps at HA1 and HA2. Tap Index was created by dividing the area by δT and found significantly different ($P < 0.05$) in both groups at SL. The FTT proved significant for both phases. There was a significant slowing in the initial and highly significant slowing in the final 10 seconds at high altitude. The FTT can clearly show a deteriorating psychomotor function at high altitude and easy fatigue on muscular effort and also the effect of Glutamic acid supplementation at high altitude.

Learning Objectives:

1. How Finger Tapping Test can be utilized for short and long duration at high altitude.
2. How supplementation of glutamic acid affects small muscle performances.
3. How Finger Tapping Test is useful for assessment of psycho-motor function at high altitude.

TUESDAY, MAY 7, 2019

Tuesday, 05/07/2019

8:00 AM

6TH ANNUAL REINARTZ LECTURE

Prof. dr. Floris Wuyts, Ph.D.

"The Impact of Microgravity and Hypergravity on the Human Brain Studied with Advanced MRI Methods"

Tuesday, 05/07/2019

10:30 AM

Brasilia 1

[S-21] PANEL: CHANGES OF PARADIGMS IN MODERN DENTISTRY

Sponsored by International Association of Aerospace Dentistry (IAAD)

Chair: Jose Luis Mompell

Co-Chair: Juan Lara Chao

PANEL OVERVIEW: Dentistry has developed considerably within the last few decades, many of these developments have come from the computer aided systems that were already present in Aviation in the late 80s, This Aviation Dentistry panel will be focused on many aspects where aviation and dentistry merge. X-Ray interpretation from an AME or flight surgeon's point of view will be also discussed. How may dentistry help an AME/Flight Surgeon to prevent in flight complications? From the CAD/CAM systems to the human factors. Every single field of specialization in dentistry is experiencing a huge change in the way it was previously conceived. Technology developed from aviation is taking a main role in dentistry in daily practice. Short implants are also a huge revolution in implant dentistry allowing shorter periods of recovery and therefore less complication for inflight tripulations in compare to bone grafting procedures. Also, the relation between microgravity and dental health will be discussed. A very interesting topic in relation to future aerospace missions.

[95] THE PANORAMIC XRAY AS A DIAGNOSTIC SCREENING TOOL

Juan Lara Chao¹, Jose Luis Mompell², Ramon Mompell², Daniel Robles Cantero³

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(Education - Program / Process Review Proposal)

Radiographs are an essential part of the examination process. They serve as a diagnostic tool for baseline reference, aid in the diagnosis of disease, detection of asymmetries, as well as other anomalies. Panoramic x-rays play a special role in the diagnostic arsenal by allowing the clinician to see a broad area on one image, thus allowing the clinician to screen and detect multiple pathologies on the same. This presentation will look at some of the different pathologies that may be detected during the examination with a panoramic radiograph, discuss the risk-benefits of acquiring the image, radiation protocols, and the appropriate frequency for taking the panoramic radiograph.

Learning Objective:

1. To gain a basic understanding of the benefits of utilizing the panoramic x-ray in the examination process.