TENTATIVE PROGRAM

58th ANNUAL SAFE SYMPOSIUM
NOVEMBER 30 – DECEMBER 4, 2020
VIRTUAL

The SAFE Board of Directors extends a cordial invitation for you to join us at the 58th Annual SAFE Symposium being held virtually. This year's symposium continues our tradition of being the premier forum for professionals, academics, engineers, and industry leaders who join together with the goal of advancing personal safety and protection in air, land, space, and marine environments worldwide.

The Annual SAFE Symposium remains a powerful platform for innovation, education, networking, and strengthening the disciplines of the personal safety and protection community. The knowledge shared, and relationships created among participants are conduits for continued learning, exploration, and innovation.

This year's program includes dynamic presentations, a large number of technical sessions, our Annual General Membership Meeting and Presentation of the 2020 SAFE Awards. The 2020 symposium will provide a valuable opportunity to share ideas on an international basis with participants from around the world. Attendees will also have the opportunity to explore the technological advancements and innovations in safety and life-sustaining equipment by visiting our virtual exhibition hall that will feature many members of industry who will have their products and services displayed for attendees to browse 24/7, beginning November 23, 2020.

The Symposium Committee and the SAFE Board of Directors would like to thank all Symposium participants and exhibitors. We would also like to offer a special thanks to our individual and corporate sustaining members for their commitment and dedication to the SAFE Association.

Any changes to this tentative program will be posted on the SAFE website at www.safeassociation.com under the Symposium link, so check periodically for the latest information!

REGISTRATION INFORMATION & RATES

SAFE Member:

$10.00

Member registration does not include dues.

Non-Member:

$30.00

Non-Member registration does not include membership dues to the SAFE Association.

All U.S. personnel assigned to a military organization/installation holding a valid Active Duty Military, Department of Defense I.D/CAC card and the U.S. Coast Guard:

FREE

All foreign military active duty personnel:

FREE

For registration and payment, please visit the SAFE website!

Attendee Registration Form
https://eventify.io/events/safe2020/tickets

Registration will gain you access to all virtual events, including the exhibit hall!!

GENERAL POLICIES

All attendees must complete an Attendee Registration Form and make applicable payment: https://eventify.io/events/safe2020/tickets

SAFE accepts Visa, Master Card, and American Express.

A receipt is generated by the system when you register and pay on-line regardless of the credit method used. You are welcome to e-mail the SAFE office (admin@safeassociation.com) to verify receipt of your registration.

Payment using the website does not require a personal account to use.

Chapter membership does not entitle registration at the SAFE member rate. You must be a member of the SAFE Association to obtain the member rate.

While pre-registration is not required and you may register at any time, it is strongly encouraged to register prior to the start of the symposium to prevent any technological issues occurring that could prevent you from attending any of the symposium events.

Registered attendees will have access to virtual exhibit booths beginning the week of November 23, 2020. Exhibit booths will be active 24/7. SAFE Association recommends browsing exhibit booths during this week and requesting virtual meetings with exhibitors during the next week of the symposium. This will allow both the attendee and exhibitor to make plans at a convenient time, with a compatible online meeting platform, ensuring a productive and efficient meeting is held.

SAFE Association scheduled events, such as keynote speaker presentation and technical presentations, will be streamed Eastern Standard Time.

Dues, contributions and/or gifts to the SAFE Association are not deductible as charitable contributions for federal or state tax purposes

EXHIBIT HALL HOURS & TENTATIVE TIMELINE OF EVENTS

EXHIBIT HALL HOURS

Monday, November 23 through Friday, December 4
9am EST booths will be accessible online and remain active 24/7 until close of the symposium

The Virtual Symposium will officially begin the morning of Monday, November 30

- The 2020 SAFE Awards Presentation will be held on Monday morning immediately following the Special Presentation Speakers remarks.
- The 2020 General Membership Meeting will be held Wednesday morning immediately following US Air Force and US Navy Safety presentations
- Wednesday and Thursday will feature virtual social events. The SAFE Association will host fun, friendly competitive events and you will also get to learn more about our social event sponsors.
- Industry Day events will be held Friday

Detailed Tentative Timeline continues on next page

VIRTUAL EXHIBIT HALL HOURS & TENTATIVE TIMELINE OF EVENTS

NOTE: ALL EVENTS ARE SCHEDULED IN EASTERN STANDARD TIME

MONDAY, NOVEMBER 23rd

9:00 AM	Virtual Exhibit Booths Active

MONDAY, NOVEMBER 30th

9:00 AM	SAFE Virtual Symposium start
9:10 AM	SAFE 2020 President Welcome Presentation
9:30 AM	Keynote Speaker Presentation
10:45 AM	Special Speaker Presentation
11:30 AM	SAFE 2020 Awards Presentation
12:00 PM	Break
1:00 PM	Technical Sessions begin
3:00 PM	End of day broadcast

TUESDAY, DECEMBER 1st

9:00 AM	Sign on/Welcome Message
9:30 AM	Technical Sessions begin
11:30 AM	Special Speaker Presentation
12:30 PM	Break
1:00 PM	Technical Sessions begin
3:00 PM	End of day broadcast

WEDNESDAY, DECEMBER 2nd

9:00 AM	Sign on/Welcome Message
9:30 AM	2021 SAFE Symposium Preview
10:00 AM	USAF Safety Presentation
10:30 AM	USN Safety Presentation
11:00 AM	SAFE General Membership Meeting
11:30 AM	Virtual Social Event
12:30 PM	Break
1:00 PM	Technical Sessions begin
3:30 PM	End of day broadcast

THURSDAY, DECEMBER 3rd

9:00 AM	Sign on/Welcome Message
9:30 AM	Technical Sessions begin
11:30 AM	Virtual Social Event
12:30 PM	Break
1:00 PM	Technical Sessions begin
3:00 PM	End of day broadcast

FRIDAY, DECEMBER 4th

9:00 AM	Sign on/Welcome Message
9:30 AM	Joint Services Acquisitions and Sustainment briefings begin
1:00 PM	End of day broadcast

NOTE: ALL EVENTS AND TIMES ARE SUBJECT TO CHANGE

2020 VIRTUAL SYMPOSIUM EXHIBITORS

Air Force Research Laboratory
Capewell Aerial Systems
Cobham Missions Systems
Collins Aerospace
Diversified Technical Systems, Inc.
East/West Industries, Inc.
Elemance, LLC
Essex Industries
General Dynamics Mission Systems
Insta ILS OY
Life Support International, Inc.
Martin-Baker Aircraft Company, Ltd.
Massif
Visit Mobile Alabama
Mustang Survival/The Patten Companies – Part of the Wing Group of Companies
Omni Medical Systems, Inc.
SAFE Association
See/Rescue Corporation
Stratus Systems, Inc.
Survitec Group, Ltd.
Switlik Survival Products
TIAX, LLC.
Virginia Beach Convention and Visitors Bureau

MONDAY, NOVEMBER 23rd

MONDAY – 9:00 AM
VIRTUAL EXHIBIT BOOTHS ACTIVE FOR ATTENDEES TO BROWSE

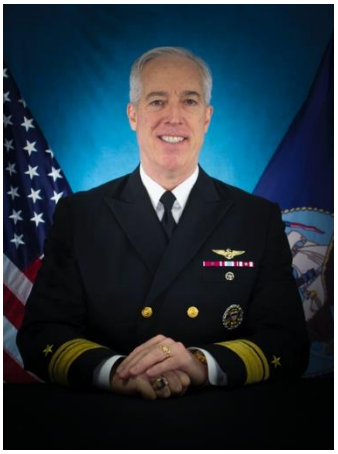
MONDAY, NOVEMBER 30th

MONDAY - 9:00 AM – 9:05 AM
ATTENDEE SIGN-ON

MONDAY – 9:05 AM – 9:10 AM
DIAMOND SPONSOR MESSAGE, COLLINS AEROSPACE
LOCATION: CHANNEL 1 & 2

MONDAY – 9:15 AM – 9:30 AM
2020 SAFE PRESIDENT WELCOME PRESENTATION
LOCATION: CHANNEL 1 & 2

MONDAY – 9:30 AM – 10:30 AM
KEYNOTE SPEAKER PRESENTATION
LOCATION: CHANNEL 1 & 2



KEYNOTE SPEAKER PRESENTATION

Rear Admiral John F. Meier
Commander, Naval Air Force Atlantic

Rear Adm. John F. Meier, a native of Export, Pennsylvania, graduated from the United States Naval Academy in 1986 with a Bachelor of Science in General Engineering. He completed flight training in Beeville, Texas, and was "winged" as a Naval Aviator in August 1988.
Meier's operational assignments include Electronic Attack Squadron-141 (VAQ-141), Carrier Air Wing Two (CVW-2), VAQ-128, and executive officer onboard USS Harry S. Truman (CVN-75), during which the command was recognized with the 2008, 2009 & 2010 Battle "E" and the 2009 Safety "S." Command tours include VAQ-136, earning the Safety "S" and Battle "E" in 2004 as well as the 2005 Retention Excellence award; USS Gunston Hall (LSD-44), earning the 2011 Battle "E"; and Precommissioning Unit Gerald R. Ford (CVN-78) earning the 2014 &2015 Retention Excellence awards. Meier most recently commanded Carrier Strike Group Ten (CSG-10) earning the Humanitarian Service award.
Meier's shore assignments include tours at VAQ-129, where he was recognized as Instructor Pilot of the Year in 1995; EA-6B placement officer at Navy Personnel Command; senior operations officer and emergency actions officer on the Chairman of the Joint Chiefs of Staff in the National Military Command Center; requirements officer for EA-18G at the Office of the Chief of Naval Operations

(OPNAV) N88; assistant chief of staff force readiness officer at Commander, Naval Air Forces; assistant commander, Navy Personnel Command for Career Management (PERS-4); and commander, Navy Warfare Development Command.

Meier has participated in operations around the world since Desert Storm, lead Southern Partnership Station and built the crew and culture of USS Gerald R. Ford (CVN-78) as her first commanding officer. He has accumulated over 4,000 flight hours and 675 carrier landings.
Meier assumed command of Naval Air Force Atlantic on May 1, 2020.
His decorations include the Legion of Merit and various other personal and unit level awards.

MONDAY – 10:45 AM –11:30 AM
SPECIAL SPEAKER PRESENTATION
LOCATION: CHANNEL 1 & 2

SPECIAL SPEAKER PRESENTATION
DR. DAVE PRAKASH

Dr. Dave Prakash was a physician but left his medical career to join the US Air Force. He omitted the fact that he was a doctor in his application to ensure he went straight to pilot training. He went on to fly as an operational test pilot in the B-52 where he tested new weapons, tactics and system upgrades. Dave also convinced the Air Force to let him work as a flight surgeon, becoming one of ten pilot-physicians in the entire service. Dave combined his perspectives as a pilot and a doctor to improve combat capabilities and aircrew safety in bomber aircraft. In 2017, he left the Air Force after 13 years of service to attend Stanford University and pursue degrees in business and public policy.

Today, Dave works for a Fortune 50 company in Palo Alto, CA where he develops artificial intelligence-based solutions to transform healthcare delivery. He also consults for Northrop Grumman, advises health tech startups, and serves on the Executive Leadership Committee for the National Kidney Foundation.

Organizational Resistance to Upgrading Legacy Systems.
The B-52H operates the oldest ejection system in the Air Force. The good news is that the seat still works just as well as it did when it was new 60 years ago. The bad news is that it only works as well as it did when it was new. The suggestion of replacing or improving legacy systems is often met with great institutional resistance. Dave Prakash will share his experience leading an effort to improve the B-52 ejection system and the lessons he learned on driving change and influencing large institutions.

MONDAY – 11:30 AM – 12:00 PM
SAFE 2020 AWARDS PRESENTATION (*SPONSOR EAST/WEST INDUSTRIES)*
LOCATION: CHANNEL 1 & 2

MONDAY – 12:00 PM – 1:00 PM
SYMPSOIUM BREAK (*SPONSOR SURVITEC GROUP)*
LOCATION: CHANNEL 1 & 2

MONDAY: 1:00 P.M. – 3:00 P.M.
AEROSPACE PHYSIOLOGY
LOCATION: Channel 1
MODERATOR: Mr. John Plaga, AFRL/711TH HPW

BRIEFING: SPYDR: Integrated Human Performance Sensing - Program Updates - Dr. Brian Bradke[1]

[1]*Spotlight Labs, Haddonfield, NJ*

INTRODUCTION:
Human error has been identified as the most common cause of preventable aviation mishaps and is responsible for most fatalities which occur in commercial, military, and general aviation. While "human error" itself is a vague term with no singular root cause, one of the largest contributing factors in the error chain is the pilot's mental and physiological condition. The recent surge in physiological episodes has concerned both pilots and commanders, since reduced human performance represents a serious and avoidable risk to airborne operations.

METHODS:
SPYDR was created to monitor, analyze, and warn operators of performance decrements and impending incapacitation. The original concept for a form-fit, functional replacement for the earcups in a flyer's helmet has since evolved into a multi-modal, open-architecture, standalone system. SPYDR's capabilities have expanded dramatically, incorporating multiple sensor data streams in real-time, collecting and assessing physiological data from both the cardiovascular and respiratory systems. SPYDR has the ability to warn of hypoxia, hypo/hypercapnia, cockpit CO2 levels, and OBOGS contamination. With more than 300 sorties and 600 hours of data from over 60 different subjects, SPYDR has been proven to reliably capture clinical-grade data while remaining transparent and unobtrusive the wearer. This briefing will present findings from operational test, as well as a technology road map, program risks and development timelines.

RESULTS & DISCUSSION:
The human operator has long been recognized as the weakest link in modern weapons systems. Until recently, there has been no objective system for augmenting the brain in evaluating the status of the human system. For the first time, physiological and environmental data can be gathered from all flights, providing key information for pilots, commanders, physicians, and scientists attempting to maximize human performance while mitigating the risks from physiological degradation. With the option of including multiple sensors, SPYDR is a proven, scalable, integrated cockpit sensing platform ready for operational deployment.

BRIEFING: **Updates on Clinical Field Trials of Pharmacologic Motion Sickness Countermeasures -** Commander Matthew Doubrava[1]

[1]*Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH*

INTRODUCTION:
Briefing on the status of the clinical field trial of intranasal scopolamine being performed by the Naval Aerospace Medical Research Laboratory(NAMRL) at the Naval Medical Research Unit- Dayton (NAMRU-D) in conjunction with its industry partner, Defender Pharmaceuticals, Inc (DEFENDER).

METHODS:
As part of the FDA's criteria for approval for military forces, INSCOP is to be evaluated under operational conditions with the greatest possible fidelity. INSCOP is currently under evaluation comparing its efficacy, pharmacokinetics and safety to current standard of care, the transdermal scopolamine patch and oral dimenhydrinate. Clinical field trials in operational conditions have proved challenging with active military forces. DEFENDER has conducted a civilian version of the military protocol to run parallel with the military efforts to serve as a surrogate study.

RESULTS & DISCUSSION:
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operational conditions have proved challenging with active military forces. DEFENDER has conducted a civilian version of the military protocol to run parallel with the military efforts to serve as a surrogate study. Discussion will focus on project status, testing and evaluation protocols being used and under development. In addition, future research plans and a roadmap for possible acquisition will be briefed. This is a prime example of research and development being transitioned to a test and evaluation environment with a possibility for succeeding in acquisition to fulfill an operational gap to improve human performance in a provocative environment.

BRIEFING: **Guidelines for Physiologic Monitoring System Warning Levels Based on Objective and Subjective Responses to Moderate Hypobaric Hypoxia -** Dr. Barry Shender[1], Mr. Eric Joyce[2], Ms. Jessica Anderson[2], Dr. Phillip Whitley[3], Dr. Jeremy Beer[4]

[1]Naval Air Warfare Center Aircraft Division, Patuxent River, MD; [2]Athena GTX, Inc.; [3]Criterion Analysis, Inc.; [4]KBR Science & Mission Solutions Group

INTRODUCTION:
To detect and predict "physiological episodes" occurrence, NAVAIR and NAWCAD are developing a monitoring/warning system to estimate aircrew vital signs and cognitive status.

METHODS:
Thirteen volunteers (32±6 yr.) gave their informed consent and received a hypobaric exposure in the KBR Brooks City-Base, TX altitude chamber facility. The profile included 5,000 ft/min transitions to 10,000ft and 14,000ft 10-min plateaus, and 20-min at 17,500ft (17.5K) while breathing 21% O_2. Symptoms were reported using a 0-10 scale (10=maximal).

The Holistic Modular Aircrew Physiologic Status (HMAPS) Monitoring System was used to measure SpO_2, PR, and pressure. A cognitive impairment index (CI) estimates cerebral cognitive reserve and relates it to SpO_2 and multi-task performance. A Summary State (SS) index fuses vital signs to estimate overall status. CI and SS have 5-point scales (5=highest degradation). Mask CO_2 pressure, respiration rate (RR), and cerebral tissue oximetry (rSO_2) were also measured. Data are presented as mean ±1 standard deviation change from ground level during the last two-min of exposure. Vitals were aligned in time with subjective ratings. A two-tailed t-test compared differences between responses of subjects who completed the 17.5K vs. those who did not ($p \leq 0.05$).

RESULTS & DISCUSSION:
Ten subjects completed 17.5K; three without reporting symptoms. The three subjects ending their exposure early ranged from 5:20 to 18:22 minutes. The results were:

	PR change (bpm)	SpO_2 change (%)	rSO_2 change	SS	CI	RR (bpm)	CO_2 (mmHg)
Terminated Early	20.8±2.2	-28.8±3.2	-21.7±3.3	2.8±0.4	4.1±0.3	0.9±2.1	-1.3±2.0
Completed	14.4±8.5	-23.5±5.2	-16.1±4.7	2.7±0.4	3.6±1.1	-0.4±1.6	-3.2±0.5
No Symptoms	8.2±8.8	-20.2±10.1	-16.9±13.5	1.8±1.1	2.8±1.8	-2.3±1.3	-2.9±1.1

Mean change in SpO_2, PR, rSO_2, and SS between symptomatic subjects who completed 17.5K and those who did not were significantly different ($p<0.001$).

Preliminary warning guidelines were created using a corridor of symptomatic subject responses who completed 17.5K and those who could not. These corridors are: 22-30% SpO_2 fall, 12-23 bpm PR increase, 16-27 point rSO_2 fall, SS ≥ 3, and CI ≥4, which provides a span from initial to critical warnings.

BRIEFING: **HYDRATION AND BLADDER RELIEF IN MICROGRAVITY -** Dr. Mark Plante[1]

[1]University of Vermont Medical Center, Burlington , VT

INTRODUCTION:
Maintenance and optimization of aircrews' physiologic state remain of paramount importance both in military and space theatre. Given both technological advances and demographic evolution, both the requirements and the diversity of the aircrews have expanded. Hydration, and in turn, management of bladder evacuation, are well known to be very important and central themes to ensure optimal human performance.

METHODS:
Homeostasis, as it relates to one's absolute need to remain normally hydrated, has the resultant consequence of normal renal blood flow and urine production. Efforts to reduce or eliminate urine production by way of dehydration are doomed to fail given renal blood flow and urine production are maintained in all but more severe hypovolemic states. Also, well established, by way of controlled trials, is that both mild and moderate degrees of dehydration can measurably reduce G-force tolerance and overall performance. Adding to this is the fact that both military and space aircrew diversity and the flight times required of them have increased significantly. The maintenance of high function in theatre dictates that the physiologic life support community be left to address pilot needs for hydration both before and during flight as well as the need for management of the resultant urinary production and, in turn, the need for its evacuation.

RESULTS & DISCUSSION:
Increasing integration of mechanistic solutions for pilot hydration in theatre as well as bladder waste management has seen a paradigm shift in recent years with the advent of important technological advances. Related to urinary evacuation, personalized urinary collection garments, self-priming automated pumps, and secure connectors to allow for safe and reliable transmittal of fluids across the closed suit environment to the exterior represents some of the important advances central to ensuring optimization of aircrew comfort and safety.

MONDAY: 1:00 P.M. – 3:00 P.M.
TRAINING/INJURY
LOCATION: Channel 2
MODERATOR: Dr. Casey Pirnstill, AFRL/711TH HPW

BRIEFING: **Assessment of the ability of RCAF fast jet aircrew to survive extreme cold exposure in the Canadian Arctic while awaiting rescue following an ejection -** Dr. Fethi Bouak[1], Mr. Vaughn Cosman[2], Ms. Wendy Sullivan-Kwantes[3], Mr. Kevin Hofer[3], Ms. Ingrid Smith[3], Ms. Adrienne Sy[3]

[1]Defence Research and Development Canada – Toronto Research Centre, Toronto; [2]ADM(S&T), Directorate Science and Technology Air; [3]Defence Research and Development Canada – Toronto Research Centre

INTRODUCTION:
In the event of an ejection over the Arctic, aircrew become exposed to extreme cold. Clothing and Aviation Life Support Equipment (ALSE: LPSV and Seat Pack) may not provide sufficient thermal protection to avoid life threatening cold weather injuries (CWI) while awaiting rescue. A field trial was conducted in Tuktoyaktuk (Canada) to monitor physiological and subjective responses of fast jet aircrew during a simulated ejection in extreme cold, and to assess their ability to survive, given their issued clothing, ALSE and training, until rescue.

METHODS:
Ten RCAF aircrew (9 males, 1 female; 26.3±1.4 yr) from the fast jet community completed field testing (exposure duration: 2-4 h; outdoor temperature: -9 to -18°C) over three days, involving cold survival that included physical activities. Skin (pinky fingers and big toes) and core temperatures were continuously monitored. Participants gave subjective ratings for thermal comfort and mood, completed surveys on clothing and ALSE, and took part in semi-structured interviews regarding their experience using the equipment.

RESULTS & DISCUSSION:
Toe and finger skin temperatures dropped below 15°C with continued cold exposure and reached levels as low as 5°C for some participants, leading to numbness and increased risks of serious CWI. In addition to the skin temperature changes, decreases of both thermal comfort and positive affect ratings suggest the importance of preventing cooling of the fingers and toes. Findings showed that some of the clothing, such as footwear and handwear, were inadequate for Arctic temperatures, and that certain items of ALSE equipment were identified as being highly important but

requiring improvement. The participants' knowledge of ALSE contents and their ability to adequately use them in cold conditions was found to be unsatisfactory. Thermal comfort and mood ratings, and more generally the ability to cope with cold stress, showed that participants who received Arctic survival training had a clear advantage.

BRIEFING: **Responses of Royal Canadian Air Force aircrew to a simulated crash scenario under extreme cold stress -** Dr. Fethi Bouak[1], Ms. Wendy Sullivan-Kwantes[1], Dr. Matthew Cramer[1], Mr. Kevin Hofer[1], Ms. Olivia Paserin[1], Ms. Katy Moes[1]

[1]Defence Research and Development Canada – Toronto Research Centre, Toronto

INTRODUCTION:
If an air disaster were to occur in the Arctic extreme cold conditions, military aircrew from crewed aircraft may not be sufficiently protected by their issued clothing and the on-board Aviation Life Support Equipment (ALSE) to avoid life threatening or career impacting cold weather injuries (CWI) until rescue. A field trial was conducted in Resolute Bay (Canada) to identify performance gaps in clothing and ALSE in operational setting, and assess the ability of aircrew to work as a team and survive in temperatures at or below -40°C following a simulated crash.

METHODS:
Fifteen RCAF aircrew (13 males, 2 females; 32.0±9.6 yr) from three crewed aircraft were divided into two groups (Gr1: N=11; Gr2: N=4) and exposed to air temperatures of -37 to -45°C (windchill: -50°C). They were instructed to use on-board ALSE (i.e., Basic and Arctic Survival Kits) to survive for 24-48h (estimated domestic SAR response), given their training and issued clothing. Big toes and pinky fingers skin and core temperatures, heart rate and physical activity were continuously measured. Participants subjectively rated their thermal comfort and mood, answered surveys on clothing and ALSE, and completed semi-structured interviews.

RESULTS & DISCUSSION:
Finger and toe temperatures gradually dropped to as low as 5°C, indicating greater CWI risk. Despite equivalent environmental conditions, Gr1 withstood less than 12h of cold exposure duration compared to 23h for Gr2. Thermal discomfort and cold stress appeared similar between both groups for the first 8h. Given their previous training, Gr2 had more cold weather experience and significantly more knowledge of ALSE contents with increased ability and confidence to use it, which may have led to positive group dynamic and ability to withstand the extreme cold temperatures for a longer duration. With proper Arctic survival training, it may be possible for aircrew to survive the harsh Canadian Arctic until rescue.

BRIEFING: **Virtual Reality Parachute Simulation Training for Ejection and Bailout -** Dr. Chi Liang[1], Russ Lascink[1], Cecy Pelz[1]

[1]Systems Technology Inc., Hawthorne, CA

INTRODUCTION:
Parachuting is the primary method of escape for pilots and aircrew when unrecoverable emergencies occur. In most cases, aviators do not have any parachuting experience prior to emergency egress. To ensure their safety and prepare them for emergencies, they must be trained to handle such situations. Simulation training provides an effective solution for pilots and aircrew to practice emergency egress procedures safely on the ground, within the classroom environment.

METHODS:
The preferred solution lies in a Virtual-Reality training system originally developed for Forest Service smokejumpers, to establish canopy flight skills for extremely difficult terrain and unsafe conditions. The simulation system provides training for emergency procedures, altitude awareness, malfunctions identification/correction, canopy control, over water or land, in various weather conditions.

The simulator's success is rooted in real-world canopy dynamics and accurate visual models of the various parachutes and potential malfunctions. Recent parachute additions include the GQ6000 canopy for the F35 ejection seat and the BA30 bailout harness/canopy for airlift platforms. Incorporation of VBS wargaming engine and new

high resolution VR goggles attached to a standard aircrew helmet have greatly increased simulation fidelity providing a more realistic training experience. Existing systems can be upgraded with a motorized lift to increase throughput and practice proper body position at landing. The trainee can be fully equipped with helmet, visor, oxygen mask, flight gloves, LPUs, ripcords, seat kit and other equipment for IROK procedure training.

RESULTS & DISCUSSION:
Simulation training using real-world equipment is the optimal method to develop a positive transfer of knowledge and skills from the appropriate instructor. Canopy flight control, proper procedural actions, and a wide variety of training scenarios allow these life-saving skills to be reinforced in a safe but realistic environment. PARASIM continues to enhance the muscle memory skills, equipment familiarity, and life-saving parachute descent skills to survive a very dangerous emergency egress situation.

BRIEFING: **Aviation Ejection Assessment Scenarios: A Tool for Parachute Descent Emergency Procedure Training -** Ms. Kaylin Strong[1], Ms. Cayla Hartley[1], Mr. Matthew Pierce[2], Ms. Beth Wheeler Atkinson[3], Dr. Steven Kass[4]

[1]University of West Florida, Pensacola, FL; [2]Naval Air Warfare Center Training Systems Division; [3]NAWCTSD, Training Systems RDT&E Department; [4]University of West Florida

INTRODUCTION:
Assessment scenarios, or event-based training, introduce realistic events within training exercises and allow opportunities to observe behaviors of interest (Dwyer et al., 1998). For assessment scenarios to be successful, they must be appropriate to the trainee's current level of knowledge, provide a reasonable amount of challenge, and allow for the practice of previously taught skills (Cannon-Bowers et al., 2013). This paper details assessment scenarios developed to support the Naval Aviation Survival Training Program (NASTP) parachute descent emergency procedure training evaluations and highlights the benefits of their use to training.

METHODS:
Several sources were used to create assessment scenarios. In addition to keyword searches of databases, the research team conducted a Google search to locate news articles with relevant information. This search led to the United States Parachute Association webpage, which provides incident and accident reports related to recreational jumps. Additional information was collected from Martin-Baker, a company that manufactures ejection seats for the Department of Defense. Finally, the most robust source of information was from interviews with pilots who had previously ejected from an aircraft.

RESULTS & DISCUSSION:
A total of seven assessment scenarios were developed, all of which are based on real events that arose from various pilots' experiences post ejection. Each scenario includes several variables including date, aircraft type, weather conditions, geography, cause for ejection, altitude upon ejection, parachute malfunction, training procedures used, landing obstacles, injuries, oscillation, parachute landing fall (PLF) strategies, and total descent time. The variables associated with each assessment scenario provide data for initial conditions to support scenario development. These scenarios, with relevant performance measures, will serve as a basis for evaluating two distinct simulation trainers. Additionally, these scenarios could also serve as a valuable instructional tool for emergency parachute descent procedures, which can save lives.

MONDAY – 3:00 PM – 3:30 PM
END OF DAY BROADCAST
LOCATION: CHANNEL 1 & 2

TUESDAY, DECEMBER 1st

TUESDAY - 9:00 AM – 9:30 AM
SIGN-ON/WELCOME MESSAGE
LOCATION: CHANNEL 1 & 2

TUESDAY: 9:30 AM – 11:30 AM
OXYGEN/CONTAMINANTS/HEALTH I
LOCATION: Channel 1
MODERATOR: Mr. John Plaga, AFRL/711TH HPW

BRIEFING: **Sieve Bed Rig Development for Contamination Testing of the OBOGS Concentrator -** Dr. Krisiam Ortiz-Martinez[1], Ms. Ashley Ziur[1], Dr. Leah Eller[1]

[1]NAVAIR, Patuxent River, MD

INTRODUCTION:
Currently, there is no standardized test method for assessing the chemical protection performance of On-Board Oxygen Generating System (OBOGS) concentrators and validating that these breathing system components provide the required chemical protection as specified in MIL-STD-3050. In an effort to close these gaps, a molecular sieve test rig was developed as an initial contamination test setup intended to correlate with full-concentrator testing. Molecular sieves are the heart of the OBOGS concentrator; therefore, better understanding how individual chemical contaminants interact with the sieves will shed light on how the concentrator handles chemicals and how to predict the fate of the chemical compounds when they reach the OBOGS.

METHODS:
Design and build of the test rig were developed to evaluate the adsorption and desorption performance of the molecular sieves with regard to filtering out chemical contaminants from the air at relevant conditions within a controlled laboratory environment. The setup was designed to inject chemicals and purge gas into a bed filled with molecular sieve using a remote interface of mass-flow controllers and multi-port valves at the bed inlet and outlet, respectively, to simulate pressure swing. 13X molecular sieves were tested against target contaminants to represent generic compound species relevant to MIL-STD-3050. The effects of temperature, flow rate, chemical concentration, and humidity on the removal of contaminants were also studied. A mass spectrometer assessed the performance of the sieves at the outlet of the bed, and target chemicals were quantified to determine breakthrough behaviors.

RESULTS & DISCUSSION:
Through these testing, breakthrough curves were obtained for each chemical system. Adsorption capacities, breakthrough times, and breakthrough parameters were also measured. The parameters were used to model the adsorption profiles and predict the fate of contaminants in OBOGS concentrators. These findings seek to define optimal test setup and test method for future verification of chemical contaminant testing for OBOGS concentrators.

BRIEFING: **Method Development for Chemical Testing of Oxygen Concentrators: A Review of Chemical Targets -** Dr. Leah Eller[1], Ms. Ashley Ziur[1], Dr. Krisiam Ortiz-Martinez[1]

[1]Naval Air Warfare Center Aircraft Division, Patuxent River, MD

INTRODUCTION:
With the publication of MIL-STD-3050 in 2015, a new chemical protection requirement was added to the performance requirements of On-Board Oxygen Generating Systems (OBOGS) oxygen concentrators. Currently, there is no standardized method to test oxygen concentrators against the new chemical protection requirement. Scientists and engineers at the Naval Air Warfare Center Aircraft Division (NAWCAD) have undertaken a multiyear effort to dissect the requirement as written in the military standard and to develop a reliable and repeatable test method. One of the first milestones in this effort was to review the chemicals listed for assessment in MIL-STD-3050 in the context of their chemical and physical properties and determine useful strategies for the detecting and quantifying those materials.

METHODS:
A paper study was conducted to examine the chemical and physical properties of the specific chemicals listed in MIL-STD-3050, published in 2015. This study supported a subsequent analysis of alternatives, AoA, regarding potential detection systems and other details of a test rig setup for a future standardized test method. Volatility, vaporization, stability and reactivity, sensitivity towards various types of spectroscopy, ionization potential, etc. were all considered. Accuracy, reliability, cost, and safety were all considerations.

RESULTS & DISCUSSION:
The chemical targets, as listed in MIL-STD-3050, were prioritized to support component-level testing with the molecular sieve material, the results of which will inform future oxygen concentrator testing. Suitable detection systems were identified for each chemical, with commentary on the safety and feasibility of vapor phase testing. These findings support the long-term goal of developing a platform-agnostic standardized test method for future verification of chemical contaminant protection in OBOGS.

BRIEFING: **Method Development for Chemical Testing of Oxygen Concentrators: An Approach Overview -** Dr. Leah Eller[1], Ms. Ashley Ziur[1], Dr. Krisiam Ortiz-Martinez[1]

[1]Naval Air Warfare Center Aircraft Division, Patuxent River, MD

INTRODUCTION:
With the publication of MIL-STD-3050 in 2015, a new chemical protection requirement was added to the performance requirements of On-Board Oxygen Generating Systems (OBOGS) oxygen concentrators. Currently, there is no standardized method to test oxygen concentrators against the new chemical protection requirement. Scientists and engineers at the Naval Air Warfare Center Aircraft Division (NAWCAD) have undertaken a multi-year effort to dissect the requirement as written in the military standard and to develop a reliable and repeatable test method against the chemical protection requirement in MIL-STD-3050. This brief outlines the overall approach to this multi-year effort to develop a standardized testing strategy.

METHODS:
A bottom-up strategy was employed, whereby the history of the new requirement and the properties of the identified target chemicals were first examined. This information supported the design and development of component-level tests, which in turn, will support the design and development of oxygen concentrator testing. It is anticipated that after each phase, the chemical target list will be refined; all changes will be documented and traceable to specific data.

RESULTS & DISCUSSION:
The background paper studies are completed, and component-level test rigs have been developed and used to address issues of material compatibility and safety. Chemical behavior modelling is in progress. Two additional presentations at SAFE 2020 address the results of those efforts. The concentrator test rig is currently being assembled and validated. Results of concentrator testing will be reported on at SAFE 2021.

BRIEFING: **A Model Based Systems Engineering (MBSE) approach to designing the Next Generation of Pilot Flight Equipment –** Mr. Kevin Peters[1]

[1]Survitec Group, NPD, Technology & Future Capability Manager

INTRODUCTION:
The Safety, Survival and Escape Equipment industry typically has applied a very traditional document-based approach to the design and development of products. The process of conception through to being market ready, often requires a large amount of testing to gather the necessary evidence to prove that when needed, the product will function as intended. This traditional approach follows a systems engineering approach of verification and validation (V&V) through physical testing and documented records.

METHODS:
Survitec are evolving the traditional document-based approaches to a model-based approach. Survitec have begun to introduce tools and systems that enable a Model Based Systems Engineering (MBSE) approach to design and development for Safety, Survival and Escape Equipment. MBSE enhances the ability to capture, analyse,

share, and manage the information associated with the specification of a product in real-time, and results in the following benefits:

- Improved communications among the design and development stakeholders (e.g., the customer, program management, systems engineers, testing team, and specialty engineering disciplines).
- Increased ability to manage system complexity by enabling a system model to be viewed from multiple perspectives and to analyse the impact of changes.
- Enhanced knowledge and data capture and reuse of the information by capturing it in more standardized ways and leveraging built-in abstraction mechanisms inherent in model-driven approaches. This in turn can result in reduced cycle time, likelihood of error and capture latent mistakes, and leading to lower maintenance costs to modify the design (agile design).
- Improved ability to teach and learn SE fundamentals by providing a clear and unambiguous representation of the concepts.

RESULTS & DISCUSSION:
The biggest challenge to overcome is the move away from traditional document base approach. The fabric and technical textile materials used in the construction of our products requires specialist software to enable the analysis and simulation to produce useful and informed results. Until now, this has been not easily been possible. We strive to be at the forefront of this technology and by incorporating into our design process, will allow us greater freedoms to validate concepts far earlier in the development process.

TUESDAY: 9:30 AM – 11:30 AM
EJECTION SYSTEMS/SAFETY I
LOCATION: Channel 2
MODERATOR: Dr. Casey Pirnstill, AFRL/711TH HPW

BRIEFING: **History of Martin-Baker Sequencer Development –** Mr. Mark Elson[1]

[1]Martin-Baker Aircraft Co Ltd (MBA), Higher Denham, UK

INTRODUCTION:
History of the development of electronic sequencers for Martin-Baker ejection seats.

METHODS:
Martin-Baker has been involved in the development of electronic sequencers since the first digital microprocessor-controlled sequencer for NACES in the 1990s through to the third incarnation of that sequencer underway today. Martin-Baker sub-contracted much of the design and development to start with but since 2007 developed their own.

RESULTS & DISCUSSION:
The history and lessons learned along the way will be discussed.

BRIEFING: **Pressure Packing for a Safer Ejection -** Mr Robin Saaristo[1]

[1]Martin-Baker Aircraft Co Ltd, Near Uxbridge

INTRODUCTION:
Recovery parachutes for ejection seats can be hand packed or pressure packed. Hand packing allows the operator to inspect and repack parachutes, whereas pressure packing allows reduction of the container size and an optimization of the parachute's useable life, thereby reducing life cycle cost and preventing maintainer-induced errors. This paper will analyze the difference between the two packing methods and the requirements behind them, as well as demonstrate that pressure packing can result in a safer ejection.

METHODS:
Differences between the two methods need to be considered in all of the states that the parachute is found.

Firstly, we need to consider the impact on aircrew, with the parachute packed in its container and installed in the cockpit, by analyzing the volumetric packing efficiency and considering its effect on the field of view. Secondly, we need to consider the impact on maintenance, both in terms of the work required and the risk for errors to occur. Thirdly, we need to consider the most important factor, the performance during an ejection. This is the effect of the two packing methods on extraction, inflation, descent rate and injury risk.

RESULTS & DISCUSSION:
The volumetric packing efficiency is shown to be greater for a pressure packed parachute container, therefore a better field of view can be achieved for a given parachute. Repacking can result in errors that endanger safety and novel inspection procedures can allow operators to verify the correct packing by the supplier. Extraction times are shown to be identical and inflation times to be independent of packing method. Considering the volumetric packing efficiency, a larger parachute with a lower descent rate can be packed in a parachute container of the same size. This is shown to result in a safer ejection by assessing the associated risk of injury provided by historical risk curves.

BRIEFING: **Myth Busters: MIL-HDBK-516C Change Notice 5 -** Mr. John Hampton[1]

[1]*Collins Aerospace, Colorado Springs, CO*

INTRODUCTION:
Although the HDBK change notice was published 3 years ago, there is still confusion in the minds of some about what it means, to whom it applies, and whether it can be reliably demonstrated.

METHODS:
This presentation explains the updated injury criteria and airworthiness standards to which DoD platforms must comply. The briefing reviews why injury criteria evolved, and correlates the injury criteria to the widely-accepted industry standard: the Abbreviated Injury Scale (AIS). The ACES 5 seat reliably meets the criteria of <5% probability of an AIS level 2 injury assuring aircrew a high likelihood of being able to walk away from demanding ejections. Many ejection seat aircraft fly in combat, so aircrew must be able to escape and evade during hostile territory ejections. Even if in non-hostile territory, aircrew are often hours from rescue or medical attention, and must be able to climb into a raft, seek shelter, or otherwise effect their own survival. This is why reducing the potential for spinal and other injuries throughout the ejection sequence, within a large operational flight envelope, and to an expanded aircrew accommodation range is highly desired.

RESULTS & DISCUSSION:
Collins was given permission to share data from the 2018 USAF-funded Egress Feasibility Study. This data formed part of the basis of the USAF's decision, announced in the 2019 Justification and Authorization, to sole-source the Next Generation Ejection Seat Program to Collins. 40 years of ACES II ejection data and 15 years of ACES 5 testing support the claims of <1% chance of a spinal injury; and ACES 5 meets the AIS-2 injury criteria in the gold-seal of airworthiness standards: The MIL-HDBK-516C. No myth. Real data.

BRIEFING: **Evaluation of a 4-Tether Harness System and Head Support Panel on a NACES Platform -** Mr. Edward J. Custer[1], Mr. Glenn R. Paskoff[1]

[1]*Naval Air Warfare Center - Aircraft Division, Patuxent River, MD*

INTRODUCTION:
The NACES ejection envelope is primarily limited by excessive head and neck loads on small aircrew during the parachute opening shock phase of ejection. To mitigate this risk, the current NACES seat could leverage modern aircrew protection technologies to improve survivability.

METHODS:
NAWCAD's Parachute Opening Shock Emulator (POSE) test fixture was used on the Horizontal Accelerator to evaluate the potential benefit a 4-tether system coupled with a head support panel could provide ejecting lightweight aircrew. Two different lightweight anthropomorphic test devices (103 lbs. 5th female and 136 lbs. 5th male) in two harness configurations (legacy PCU-56/P torso harness and 4-tether harness with higher torso attachment

points and an integrated head support panel) were tested. Both configurations were equipped with a mass and center of gravity representative Joint Helmet Mounting Cueing System mock-up. Twelve Horizontal Accelerator tests were completed in this test series. The test series was conducted primarily with the manikin in a single orientation because: 1) it represented the worst case from a neck loading perspective, and 2) it allowed quantification of the maximum benefit that could be obtained from the 4-tether harness with the head support panel. Current neck injury metrics were used to compare the results of the new configuration to legacy performance.

RESULTS & DISCUSSION:
The Z-force and Y-moment were the primary data channels analyzed, as they are the data most relevant to neck injury. Injury metrics including Nij (a combined tension/compression and neck bending criteria), load duration, and Neck Moment Index were calculated and compared. The results indicated the potential for neck load reduction is substantial. The axial forces experienced in both the upper and lower neck were reduced. The Y-axis moment was also reduced. Neck load durations saw marginal improvement, however, the Nij in both the upper and lower neck were reduced by as much as 400%.

TUESDAY – 12:30 PM – 1:00 PM
SYMPOSIUM BREAK
LOCATION: CHANNEL 1 & 2

TUESDAY: 1:00 PM – 3:00 PM
OXYGEN/CONTAMINANTS/HEALTH II
LOCATION: Channel 1
MODERATOR: Mr. Kevin Divers, SAFE Secretary

BRIEFING: **Particle Emission and Control Evaluation for Aircraft Crash Recovery Operations** - Ms. Ariel Parker[1], Mr. Jerimiah Jackson[1], Dr. David Black[2], Dr. Sarah Burke[3], Mr. Aaron Ramert[3], Dr. Christin Duran[4]

[1]UES, Inc., Dayton, OH; [2]Henry M. Jackson Foundation; [3]Scientific Test & Analysis Techniques Center of Excellence; [4]711th Human Performance Wing, Air Force Research Laboratory

INTRODUCTION:
Advanced composite materials (ACM), incorporated into high performance aircraft flown by Air Force pilots, are desirably lightweight yet durable and strong. The exposure hazards associated with these increasingly complex materials require investigation. Studies investigating possible exposure risks first responders encounter indicated hazardous particulate and gaseous emissions during ACM burn phase(s). However, limited data address particulate hazards recovery operators handling burnt ACM experience. Technical Order 00-105E-9 includes guidance to minimize hazardous particulate exposure, but these recommendations lack experimental data. We investigated common recovery operations on burnt ACM coupons and characterized particulate emissions.

METHODS:
In a randomized study design, burnt coupons with different base polymer composition, fuel content, and surface treatments (water, diluted floor wax) for hazard control were key factors. Real-world composite coupons were cut or impacted in an enclosed glovebox, from which air was sampled before, during, and after each destructive process (~10 minutes). Aerosol size distribution, concentration, and lung-deposited surface area (LDSA) was measured in real-time using an Electrical Low Pressure Impactor, Aerodynamic Particle Sizer, and electrometer. Air samples were collected onto matched-weight mixed cellulose ester filters to measure respirable dust. Microscopy samples were collected onto polycarbonate filters and electron microscopy grids.

RESULTS & DISCUSSION:
Cut coupons produced significantly more particulate (4E5 particles/cm3) than impacted coupons (2E3 particles/cm3). A similar difference was observed between cut and impacted samples for LDSA measurements (9E4 vs 1E2 µm2/cm3) and gravimetric analysis (39 mg/m3 vs 5 mg/m3 or less). Surface treatment and composite base type also had an effect on particulate concentrations. On average, water decreased emissions by 41-49% compared to wax or none.

These results will impact Air Force personnel and Technical Orders advising recovery operations post-aircraft mishap. Follow-on work will characterize particulate emissions of composites smoldered at different heat rates. Understanding crash recovery exposure hazards will enable safer recovery operation.

BRIEFING: **Design and Development of a New USAF Life Support Systems Scientific Test, Analysis, and Qualification Lab -** Mr. John Plaga[1], Mr. Andrew Klein[2]

[1]711 HPW/RHBFD, WPAFB, OH; [2]AFLCMC/WNU

INTRODUCTION:
Beginning in 2013, there was a significant increase in reports of hypoxia-like symptoms such as shortness of breath, confusion, and wheezing by USAF and USN aircrew. Examination of these Unexplained Physiological Incidents (UPEs) revealed that there were several possible contributors, including the On-Board Oxygen Generation System (OBOGS), regulators, and aircrew equipment that may be causing these dangerous effects. The UPEs jeopardized the health and life of our aircrew, threatened loss of expensive aircraft valuable to national security, and have even resulted in grounded air fleets, compromising real-life DoD objectives and mission readiness. Congress reacted by providing a $5M plus-up to determine root causes of the UPEs and to develop methods to better identify and mitigate/stop these occurrences.

METHODS:
The Air Force responded by ensuring critical mass is applied to solve hypoxia issues with the current fleet as well as head off any issues with new aircraft. The focus was to address issues with on-board oxygen generation and delivery to pilot by building an OBOGS laboratory for the Life Cycle Management Center to test and validate Oxygen generation and delivery related equipment, freeing the current lab to conduct R&D.

RESULTS & DISCUSSION:
The new lab design was baselined from the current OBOGS research laboratory and modified as a result of experience and specific mission requirements from LCMC. A 3200 square foot facility was identified and modified for the lab. A two-phase approach to achieving Full Operational Capability resulted in unique 3 chamber facility: a 64 cubic foot cabin chamber and a 300 cubic foot aircraft/accumulator chamber in Phase 1, and an additional 128 cubic foot environmental chamber in Phase 2, all of which were rectangular for easy setup. The vacuum is provided by two 30 HP pumps, connected to each chamber via a pipe main and independently controlled valves. IOC is planned for October 2020.

BRIEFING: **Aviation Light Duty Respirator (ALDR) –** Dr. Mohamed Mughal[1] and Mr. William Strang[2]

[1]Air Force Life Cycle Management Center (AFLCMC), Human Systems Division, Wright-Patterson Air Force Base, Ohio; [2]United States Navy, Naval Air Systems Command (NAVAIR), PMA 202, Patuxent River Naval Base, Maryland.

INTRODUCTION:
Department of Defense (DoD) aircrew have been tasked with many non-traditional missions to include transport of Ebola patients; evacuations in nuclear contaminated environments during Operation Tomodachi; and movement of military/civilian COVID-19 patients. These non-traditional operations highlight a capability gap in personal protective equipment (PPE). Current Chemical, Biological, Radiological and Nuclear (CBRN) PPE are designed to protect against battlefield warfare agents. Such PPE are grossly overdesigned for non-traditional operations. More importantly, they add unnecessary bulk and thermal burden which reduce aircrew effectiveness, safety and endurance during potentially protracted emergency operations.

In short, DoD aircrew have a PPE capability gap when supporting non-traditional emergency operations involving infectious diseases, low-level radioactive materials and/or moderately toxic industrial chemicals and materials. We have drafted a system requirement for an Aviation Light Duty Respirator (ALDR) to fill this gap.

METHODS:
Our draft requirement statement is being coordinated and finalized through the CBRN Integrated Concept Team (ICT) of the Joint Requirements Office.

RESULTS:
The ALDR will be scalable to mission needs, shall be capable of being donned/doffed in flight, and shall include a CBRN hardened oronasal mask, ocular protection, and cranial/temple wrap. Subassemblies shall be independent of each other so aircrew can wear combinations as needed. The solution(s) will be effective with existing aircrew gear including helmets, communication systems, life support systems, vision correction devices, laser eye protection, vests, life preservers, night vision goggles, and torso harnesses.

DISCUSSION:
Through this presentation, the SAFE community will learn the Air Force and the Navy's approach to filling a critical capability gap. We seek feedback from operational aircrew, Industry, and fellow Military Services regarding (1) our overall approach to defining and coordinating the requirement, (2) potential materiel and/or operational solutions, and (3) challenges to consider as we move to fill this important, real-world need.

BRIEFING: **COVID-19 Patient Transport on U.S. Military Aircraft -** Captain Alexis Todaro[1]

[1]USAF AFMC AFLCMC/WN AF CBRN Defense Systems, WPAFB, OH

INTRODUCTION:
With the COVID-19 pandemic ongoing, the US Air Force was faced with the challenge of moving infected individuals for treatment or quarantine without jeopardizing protection to the aircrew and aircraft. In response, USTRANSCOM JUON TC-003 for the ability to move large number of COVID-19 infected personnel from worldwide locations to CONUS and OCONUS locations was released. JUON TC-003 looked for both non-materiel and materiel solutions which offered a better risk profile than open air transportation. Open air transportation is a complex problem set which requires consideration of aircrew and caregivers' safety, decontamination of the aircraft, and increased mission down time. With such, focus turned to the potential of modifying an existing structure into a negatively pressurized system for safe transport of individuals while allowing continued care and attention by medical teams.

METHODS:
As a rapid acquisition, a pre-fabricated forty-foot CONEX container was modified for greater structural integrity and outfitted with HEPA filters and negative pressure blower systems. The system is designed to pull air from the aircraft fuselage through a set of HEPA filters, across a potentially contaminated space, and through HEPA filters once again to be recirculated into the aircraft environment. The following primary objectives were tested to determine operational functionality of the system:

1. System will maintain a negative pressure environment
2. System will prevent the passage of particles greater than 0.3 microns at 99.97% efficiency
3. System will provide a minimum of 12 air exchanges per hour

RESULTS & DISCUSSION:
Testing has been performed resulting in the system passing and receiving approval for operational flight. Further analysis of results needs to be conducted to inform proper egress procedures to mitigate the escape of contamination once patient doors have been opened, evaluate the most cost effective method by which to purify inbound and outbound air, and create a repeatable process to check filter efficiency and biocontainment.

TUESDAY: 1:00 PM – 3:00 PM
EJECTION SYSTEMS/SAFETY II
LOCATION: Channel 2
MODERATOR: Mr. Glenn Paskoff, NAVAIR

BRIEFING: **Accelerator-Based Neutron Radiography to Support CAD/PAD Supply Chain -** Mr. Brad Bloomquist[1], Dr. Evan Sengbusch[1], Mr. Dan Michalek[2], Mr. Glenn Campbell[2]

[1]Phoenix Neutron Imaging, LLC, Madison, WI; [2]Naval Surface Warfare Center IHEODTD

INTRODUCTION:
Neutron radiography (N-ray) is a critical nondestructive inspection technique used to complement X-ray. N-ray and X-ray are used to detect defects and proper assembly of a variety of items in industry including Cartridge and Propellant

Actuated Devices (CAD/PADs). When utilized properly, these quality control measures can help ensure the safety and effectiveness of these lifesaving devices. Historically, nuclear reactors have been the only sources of sufficient neutron flux to perform high quality, high throughput neutron radiography. The CAD/PAD supply chain has been heavily reliant on a single commercial nuclear reactor that has been operating since the 1950s with closure imminent.

METHODS:
Phoenix has designed and manufactured particle accelerator-based neutron imaging systems for over a decade. The latest generation neutron generator has a measured strength over 10^13 neutrons/second. That high flux neutron generator, in concert with an innovative radiography system and process design, are utilized at the Phoenix Neutron Imaging Center (PNIC).

RESULTS & DISCUSSION:
It has been quantitatively and qualitatively demonstrated that this first of a kind system and facility can meet the highest image quality standards measured by ASTM and match the typical N-ray throughput of nuclear reactor based N-ray facilities. PNIC has been utilized to demonstrate the viability of utilizing this technology for supporting the CAD/PAD supply chain to the Navy's CAD/PAD Joint Program Office. The JPO has issued a letter to industry stating that the Phoenix accelerator-based N-ray approach is a commercially viable alternative and recommending industry secure the short term and long-term N-ray capacity they need in order to mitigate supply chain disruptions. The use of accelerator-based N-ray will enable facilities to be located across the country to mitigate a major supply chain risk for the entire aerospace and defense industry.

BRIEFING: **Limb Restraints for Crew Escape Safety -** Dr Camille Bilger[1]

[1]*Martin-Baker Aircraft Co Ltd, Near Uxbridge*

INTRODUCTION:
High speed fighter aircraft introduce extreme aerodynamic exposure and inertial forces during open-seat ejections, which can injure unrestrained limbs, as a result of excessive joint motion or impact with the seat structure. The challenge for crew escape system manufacturers is developing a limb restraint design which will safely restrain the limbs while conforming to design constraints which arise from aircraft and escape system requirements, as well as human integration expectations from aircrew's comfort, safety and survivability, to total system performance and reliability.

METHODS:
The challenge of protecting aircrew from limb injuries during high-speed ejections is described. Studies of the Martin-Baker ejection database have shown that flail injuries to the upper limbs are aggravated at high speeds when no arm restraint system is in place. A risk from flail injuries is survivability in the immediate post ejection period. The possibility of an arm injury preventing prompt release of the parachute, resulting in the aircrew being dragged over terrain in high wind conditions, and as a result compromising survivability is explored. Several variants of arm and leg restraint systems are presented for consideration.

RESULTS & DISCUSSION:
Current crew escape system requirements call for limb restraint systems in aircraft capable of speeds above 300 KEAS with leg restraints designed to prevent movement of the legs laterally beyond the sides of the seat, and arm restraints designed to prevent movement of arms rearward beyond the seat back tangent line. However, success criteria have yet to be developed that would allow limb restraint systems to be designed and assessed with physiological limits in mind, in accordance with injuries identified as part of the analysis of ejection accident data. In the absence of quantitative injury metrics, the evaluation of limb restraint systems, for their different merits in preventing injuries, must be performed qualitatively.

BRIEFING: **CAD/PAD Engineering Investigations -** Mr Nicholas Schombs[1]

[1]*NSWC IHEODTD CAD/PAD, Indian Head, MD*

INTRODUCTION:
CAD/PAD is used on Navy, Marine Corps, Air Force, Army, Coast Guard, NASA, foreign military egress systems,

fire suppression, stores, and survival equipment. Engineering Investigations for CAD/PAD devices are processed on fleet deficiencies to determine cause, effect and to minimize risk.

METHODS:
Process for engineering investigations will be discussed as well as engineering methods.

RESULTS & DISCUSSION:
Provides a summary of recent engineering investigations that were supported for United States Navy and United States Marine Corps aviation by the CAD/PAD In-Service Engineering Department for the past year. Status and key findings will be identified to support root cause analysis of the investigations.

BRIEFING: **FEA Simulation -** Mr. Steve Kana Mbazo[1]

[1]Collins Aerospace, Colorado Springs, CO

INTRODUCTION:
Collins Aerospace crash simulation research has culminated in the ability to accurately model crash event with close correlation to actual test data. The briefing will review the analysis completed to simulate crash dynamic testing conducted on a pilot seat as a means of validating design changes from a certification perspective.

METHODS:
The pilot seat received TSO-C127a approval in 1999. Recently, the seats have developed fatigue cracks. For the safety of the occupant, a repair kit is being designed to address the cracking issue. The goal is to substantiate the changes using FEA thus avoiding another round of certification tests. An FEA model, the baseline, is to be correlated to the actual test following the guidelines highlighted in AC 20-146A and ARP 5765A pertaining to certification by analysis. The FEA model set up and meshing are completed using Hypermesh while the analysis is completed using LS-DYNA v9.1 and a MADYMO dummy. Both 16G and 14G crash simulations were analyzed.

RESULTS & DISCUSSION:
The safety of the occupant being the priority, AC20-146A and ARP 5765A recommend the primary channels to correlate within 10% for peak error and curve shape error. Most primary channels were correlated within 10% of the actual test. More analysis and testing (cushion testing) are being conducted in an effort to correlate the remaining primary channels.

TUESDAY – 3:00 PM – 3:30 PM
END OF DAY BROADCAST
LOCATION: CHANNEL 1 & 2

WEDNESDAY, DECEMBER 2nd

WEDNESDAY - 9:00 AM – 9:30 AM
SIGN-ON/WELCOME MESSAGE
LOCATION: CHANNEL 1 & 2

WEDNESDAY - 9:30 AM – 10:00 AM
2021 SAFE SYMPOSIUM PREVIEW
LOCATION: CHANNEL 1 & 2

WEDNESDAY: 10:00 AM – 11:00 AM
U.S. AIR FORCE & U.S. NAVY SAFETY Presentations
LOCATION: Channel 1 & 2
MODERATOR: Dr. Casey Pirnstill, AFRL/711TH HPW, WPAFB

INTRODUCTION: This panel provides an update from the Air Force and Navy Safety Centers on current trends in aviation mishaps and projections for future strategies to protect the aviator. A question and answer session will follow

after each Service presentation. Presenters include:

UNITED STATES AIR FORCE – MR. MARK RUDDELL, U.S. Air Force Safety Center

Mr. Ruddell has worked for 15 years as an Aerospace Engineer at the Headquarters, Air Force Safety Center, investigating mishaps for all types of aircraft flown by the US Air Force. Mark focuses in the areas of structures and mechanical systems, with special emphasis on escape systems, crashworthiness, and survivability.

Prior to working for the Air Force, Mark worked for 17 years for the US Navy providing engineering support for Depot level aircraft maintenance and sustainment. Mr. Ruddell holds a B.S. degree in Aircraft Maintenance Engineering from Parks College of St. Louis University.

UNITED STATES NAVY – TBD

WEDNESDAY - 11:00 AM – 11:30 AM
SAFE ASSOCIATION GENERAL MEMBERSHIP MEETING
LOCATION: CHANNEL 1 & 2

WEDNESDAY - 11:30 AM – 12:30 PM
SAFE VIRTUAL SOCIAL EVENT (*SPONSOR MASSIF)*
LOCATION: CHANNEL 1 & 2
*The symposium committee has a fun, friendly competitive event planned. There will be an announced winner of the event and the SAFE Association will make a donation to the charity of their choice. Details will be released closer to the symposium – keep a look out!

WEDNESDAY - 12:30 PM – 1:00 PM
SYMPOSIUM BREAK
LOCATION: CHANNEL 1 & 2

WEDNESDAY: 1:00 PM – 3:00 PM
ANTHROPOMETRY I
LOCATION: Channel 1
MODERATOR: Mr. John Plaga, AFRL/711TH HPW

BRIEFING: **Female Body Armor: Estimation of Size Tariffs Using Various Size Prediction Models -** Dr. Jeffrey Hudson[1], Jennifer Whitestone[2]

[1]Solutions Through Innovative Technologies, Inc., Fairborn, OH; [2]AFMC AFLCMC/WNU Airmen Accommodation Lab (AAL)

INTRODUCTION:
New acquisition of clothing or equipment with multiple sizes requires an accurate estimation of how many of each size to purchase. An inaccurate estimation results in a shortage or excess of sizes as well as wasted funds. A recent female body armor acquisition program required a tariff, or percentage of each size to purchase, in order to efficiently accommodate the female user population. Each vendor builds a size roll to a particular set of anthropometric dimensions (one or more). However, an extensive fit mapping study often demonstrates discrepancies between the size predicted by the vendor size roll for an individual and the size that actually fits best. Data from a recent USAF armor fit mapping study were used to explore the impact on tariff estimation given various size prediction models.

METHODS:
A recent fit mapping study (n=67 USAF women) had traditional anthropometry measured and were fit with armor

to determine the best fitting armor size (XS, S, M, L, XL). Using the anthropometry of a general USAF female database (n=1,013), three different approaches were used to offer a tariff by database overlay given the following size rolls: 1) original vendor defined size roll, 2) predicted best fit using multiple (ordinal) regression, and 3) predicted best fit using a discriminant function analysis.

RESULTS & DISCUSSION:
The resulting tariff percentages for the multiple regression approach were not that different from that offered by the vendor size roll. However, the size roll offered by the discriminant function approach dramatically increased the percentage of extra size small (XS) and reduced that of size large (L). If for example, we can find data from the Defense Logistics Agency that XS small armor runs out quicker for women, this method of tariff determination may be more accurate.

BRIEFING: **Rapid Evaluation of Commercially Available Body Armor for USAF Female Security Forces -**
Dr. Daniel Mountjoy[1], Ms. Jennifer Whitestone[1], Ms. Casserly Mullenger[2], Ms. Diana Whilding[3]

[1]AFLCMC/WNU, Wright-Patterson AFB, OH; [2]STI-TEC; [3]AFLCMC/WNU

INTRODUCTION:
The historic use of "unisex" body armor systems for female security forces has led to a high incidence of musculoskeletal injury, ill-fitting equipment, and subsequent performance-degradation. In response to these deficiencies, the Air Force Security Forces Center generated a requirement for the acquisition of a modular body armor system that better meets the physical characteristics of female security forces. This presentation addresses the approach taken by the AFLCMC Human Systems Division to identify, evaluate and procure a commercially-available, female-specific body armor system. The contract vehicle known as "Try, Decide, Buy" (TDB) was utilized in order to fill the capability gap in an accelerated manner.

METHODS:
A three-phased approach was taken to identify and evaluate prospective systems before making a procurement recommendation: proposal evaluation, quantitative lab assessments, and qualitative field assessments. The proposal evaluation phase narrowed an initial set of eight prospective systems down to five. These five systems were then subjected to quantitative assessments in the Human Systems Division's Airmen Accommodation Laboratory. Lab evaluations included collection of traditional anthropometry and range of motion, 3D scan data, pressure mapping and heat mitigation, as well as demonstrations of other performance requirements such as quick release activation and buddy system removal. Analysis of lab assessment data resulted in two viable systems to be further examined during field assessments. Field assessments were conducted at three Air Force bases, and provided an opportunity for female defenders to provide their feedback via surveys after wearing each system for their respective mission sets.

RESULTS & DISCUSSION:
Results of the lab and field assessments were compiled for each of the final two competing systems. While most lab-based measures were similar when comparing the two, field assessment results clearly indicated the preferred system. The entire process, from proposal request to final contract award, was completed in nine months.

BRIEFING: **Airmen Accommodation Laboratory Capabilities for the USAF Life Cycle Management Center -** Jennifer Whitestone[1], Dr. Jeffrey Hudson[2], Casserly Mullenger[2], Max Grattan[2]

[1]USAF AFMC AFLCMC/WNU Airmen Accommodation Laboratory, WPAFB, OH; [2]Solutions Through Innovative Technologies, Inc.

INTRODUCTION:
Advanced capabilities offered by the AFLCMC/WNU Airmen Accommodation Laboratory (AAL) support body size related issues for acquisition programs. The AAL conducts Test and Evaluation for aircraft programs, defining anthropometric accommodation envelopes for new cockpits as well as modifications to existing aircraft. Additionally,

the AAL is an integral part of programs developing and improving Aircrew Flight Equipment (AFE), uniforms, and other Personal Protection Equipment (PPE). Overall, the AAL is an integrated contractor and government team that supports Human Systems and USAF acquisitions, developing specifications, test plans and protocols, conducting tests, performing data collection and analyses, designing integrated models, software, databases, and recommendations, emphasizing safety and performance given Airmen body size.

METHODS:
The AAL routinely collects, prepares, and analyzes human subject data; evaluates results of (or response to) process; and summarizes data. The AAL approach employs traditional anthropometric methods as well as state-of-the-art high-resolution surface scanning and sensor technologies. For aircraft accommodation evaluations, the mission tasks are determined and used to script test participants through a set of tasks while seated in the cockpit and fully equipped in AFE, ultimately determining who can perform the mission given body size proportions.

RESULTS & DISCUSSION:
In FY20, the AAL has successfully supported multiple programs including the anthropometric accommodation evaluations of the Crew Rescue Helicopter (CRH), UH1-N replacement helicopter, the current T-7 mock-up, and fielded multiple CSAF and AETC General's tasker on the WebPASS (Web-based Pilot Accommodation Screening Software). AAL also supported Security Forces Female Body Armor Assessment, and provided support for AFRL's neck strength study. AAL worked with WNU to derive specifications for the head gear acquisition efforts, including developing and implementing verification methods. Multiple other programs will be briefed to demonstrated the capabilities and successful programs implemented using the AAL.

BRIEFING: **Female Bladder Relief System Development Efforts for USAF and NAVY Pilots -** Lt. Erika Cardinale[1], Lt. Abraham Louisma[1]

[1]USAF AFMC AFLCMC/WNU, WPAFB, OH

INTRODUCTION:
Current mission profiles and the ability for mid-air refueling have led to longer flight times for aircrew who need to be able to urinate multiple times during flight without removal of restraint systems and life support equipment. An in-flight bladder relief system (IBRS) is required to provide female aircrew with the capability of bladder relief during flight without interfering with operations or compromising their safety. Often, female aircrew, in order to prevent the need to evacuate will dehydrate which can result in a variety of medical problems, including reduced physical and cognitive performance, decreased situational awareness, intense headaches and altered vision. Longer-term physiological effects include the development of kidney stones, recurring skin irritations and urinary tract infections. The USAF/NAVY effort to develop an improved IBRS will enhance the overall quality of life for female aviators on and off the job by leading to fewer health issues.

METHODS:
The USAF and NAVY have implemented multiple development and contracting efforts to quickly and effectively develop options for the IBRS for female aircrew. Requirements were developed to detail the specifications needed to deploy an IBRS that successfully fits all female aircrew and performs adequately for long sorties. Commercially available IBRS, prototype systems offered under NAVY efforts, and working with AFWERX to benefit from agile acquisition processes, a variety of IBRS systems have assessed to determine the optimum way forward for USAF aircrew.

RESULTS & DISCUSSION:
Candidate IBRS components have been assessed by USAF and NAVY female aircrew, including survey results of the Human Interface components as well as functional performance of the system as a whole. Development of the IBRS using a multi-front approach including traditional contracting efforts, SBIRs, and AFWERX, the USAF and NAVY are working to develop a bladder relief system.

BRIEFING: **Female Accommodation Roadmap: Current Efforts to Improve Flight Gear for Women -** Ms. Tara M. Capecci[1], Major Saily Rodriguez[2]

[1]Aircrew and Flight Deck Clothing (NAWCAD Human Systems Department 4.6), Naval Air Station Patuxent River MD; [2]Human Systems Division (AFMC AFLCMC/WNU), Wright Patterson AFB, Dayton OH

INTRODUCTION:
The requirements for female flight gear between the US military services have many more similarities than differences. The program managers have recognized this and are supporting joint efforts between the services. The efforts currently in development include changes to flight suit materials, a standardized 2 piece flight suit design, maternity fit for flight suits, body armor and alternative bladder relief solutions. A roadmap of the joint efforts will be provided and the opportunity to talk with the developers about the progress and challenges to identify new solutions.

METHODS:
The number of female aircrew across the services has been increasing steadily and now constitutes approximately 10% of the total number of aircrew. Obtaining feedback on issues from a group at one time can be difficult due to geographic dispersed locations. The Navy and USAF held a joint "FITMENT" event to bring aircrew together from both services to conduct fit checks on flight suits, brief them on bladder relief devices and hold sessions to gain insight into issues and challenges with flight equipment.

RESULTS & DISCUSSION:
Improving flight gear for female aircrew is being tackled through numerous efforts. The FITMENT event reinforced the commonality in the requirements across services for capabilities, performance, integration and fit as well as concerns with long term sustainability. The development of changes is being conducted with a multi-service team and a roadmap will be presented.

WEDNESDAY: 1:00 PM – 3:00 PM
Biomechanics
LOCATION: Channel 2
MODERATOR: Mr. Chris Dooley, AFRL/711TH HPW

BRIEFING: **Test and Simulation of a Fokker F28 Crash Landing -** Mr. Jacob Putnam[1], Dr. Justin Littell[1], Dr. Karen Jackson[2]

[1]NASA Langley Research Center, Hampton, VA; [2]National Institute of Aerospace

INTRODUCTION:
In June of 2019, the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) conducted a full-scale crash test of a Fokker F28 MK1000 aircraft. Aircraft crashworthiness is typically evaluated through component level tests (i.e. vertical drops of fuselage subsections or isolated seat tests). Finite Element Models (FEMs) are also used to bridge the gap between component testing and full-scale crash prediction. The full-scale crash test performed in conjunction with previous subsection testing of a Fokker F28 fuselage provided the opportunity to evaluate differences in crashworthiness predictions between full- and sub-scale testing and to quantify the predictive capability of FEMs in the aerospace crash environment.

METHODS:
In this study vehicle crashworthiness was quantified through anthropometric test devices (ATDs) included in both the full-scale crash test as well as fuselage section drop tests previously performed at NASA LaRC. A FEM of the Fokker F28 aircraft was developed and simulated within the tested environment. Vehicle and ATD response predictions were compared between test and simulation. The International Organization for Standardization ISO/TR 16250 curve comparison methodology was used to provide a quantitative assessment of predictive accuracy for both the vehicle and ATD FEMs. Determination of aircraft crashworthiness made between the three evaluations methodologies (full-vehicle crash test, component test, and FEM simulation) were then compared.

RESULTS & DISCUSSION:
Structural differences as well as the more complex loading environment achieved within the full-vehicle test resulted in increased injury risk compared to that predicted within the component level tests. The FEM simulations

were found to produce a more realistic prediction of injury risk within the full-vehicle crash environment than the component level testing. Limitations of both component testing and FEM simulation within aerospace crash environment were identified.

BRIEFING: **Lunar Sustained Translational Acceleration Requirements -** Mr. Jeffrey Somers[1], Dr. James Pattarini[2], Dr. Jacqueline Charvat[3], Ms. Devan Petersen[3], Dr. Stuart Lee[3], Mr. Nate Newby[3]

[1]KBR, Houston, TX; [2]NASA; [3]KBR

INTRODUCTION:
Current sustained-translational-acceleration requirements are applicable only to crewmembers in a seated posture and, thus, are inadequate to address human tolerance in non-seated configurations. Artemis mission timelines will be longer than the longest Apollo mission, which may present significant cardiovascular challenges to crew in landers without seats. New sustained-translational-acceleration limits were developed to address this risk.

METHODS:
Limits were derived from: evaluations of Apollo biomedical and flight profile data during lunar descent and ascent operations, Soyuz and Space Shuttle flight profile and post-landing biomedical data, and analogue bed rest data on orthostatic intolerance.

RESULTS & DISCUSSION:
Based on a review of these data sources, new sustained-translational-acceleration limits were derived for architectures without seats. The -Gz (eyeballs up) limit is 0 m/s2 for sustained accelerations based on mitigation of symptoms associated with Spaceflight-Associated Neuro-ocular Syndrome (SANS). Limits in +Gz (eyeballs down) vary based on whether a lower body compression garment is used and mission duration. For long-duration (> 30 days) missions, the acceleration limit decreases. The use of a compression garment allows for higher acceleration limits based on NASA's flight experience with such countermeasures.

Many assumptions must be met to apply these new limits. These include accounting for spaceflight deconditioning of the cardiovascular system, future astronaut corps composition, maintaining capability of piloting under all mission phases, ensuring suit mass borne by the crewmember is no more than 20% of the crewmember's shirtsleeve mass, and using adequate restraint systems. Adequate restraints for the purposes of sustained-translational-acceleration limits are defined as devices sufficient to arrest motion between the occupant and vehicle interior by applying counterforce. Restraints also must prevent contact between the crewmember and rigid elements of the spacesuit, while facilitating continual access to, and operation of, vehicle displays and controls.

BRIEFING: **Development of a THOR Anthropometric Test Device Lumbar Spine Injury Risk Function -** Mr. Nate Newby[1], Ms. Jessica Wells[2], Mr. Brian Blette[3], Mr. Jeffrey Somers[4], Mr. Preston Greenhalgh[5], Ms. Teresa Reiber[5]

[1]KBR, Houston, TX; [2]Leidos; [3]UNC; [4]NASA; [5]KBR

INTRODUCTION:
Currently, the Brinkley Dynamic Response Criteria (BDRC) is used to assess the risk of thoraco-lumbar spinal injury for astronauts. The BDRC has been validated for predicting injury in military aircraft ejections (Brinkley, 1968; Brinkley and Schaffer, 1971). The objective of this study was to use the injurious data behind the BDRC and sub-injurious human-volunteer data to develop an injury risk function for the Test device for Human Occupant Restraint (THOR) to predict probability of thoraco-lumbar spine injury during space vehicle landings.

METHODS:
Sub-injurious human data included z-axis testing performed at the Wright Patterson Air Force Research Laboratory (WPAFRL) between 1981 and 2004. Injurious human data included operational aircraft ejections reported in Brinkley, 1968, and Brinkley and Schaffer, 1971.

THOR data included match-pair testing to a subset of the sub-injurious WPAFRL cases using either the THOR, the THOR finite element model (FEM) or both.

Linear and logistic regression models were used to convert Dynamic Response Index (DRI) to lumbar force and predict probability of injury from lumbar force.

RESULTS & DISCUSSION:
Per the Definition of Acceptable Risk Memo (Somers et. al, 2015), at least 95% of all spacecraft dynamic events must have <4% risk of an AIS1 injury; the remaining dynamic events must have <23% risk of AIS1 injury.

The calculated injury risk function for the THOR estimates a 4% risk of injury for a lumbar spine force of 1983 lbf, with the 95% confidence interval ranging between 1886 to 2039 lbf.

The 23% risk of lumbar injury corresponds to a force of 2248 lbf, with the 95% confidence interval ranging between 2200 and 2324 lbf.

Additional THOR ATD testing or FEM simulations in the range of the injurious human data set could help refine the upper spectrum of the injury risk curve for thoraco-lumbar spine injury for the THOR.

BRIEFING: **Lunar Transient Acceleration Requirements -** Jeffrey Somers[1], Teresa Reiber[1], Dr. James Pattarini[2], Nathaniel Newby[3], Preston Greenhalgh[3]

[1]KBR, Houston, TX; [2]NASA; [3]KBR

INTRODUCTION:
Current NASA requirements for crew injury resulting from impact loads are based on crew being secured in a seat with a 5-point restraint system. For lunar landings, Apollo crews landed in a standing orientation and no known injuries occurred. However, the acceleration data have not been found and the landing suit planned for future lunar missions is significantly heavier than the Apollo suit. A subject matter expert (SME) panel was convened and data were drawn from multiple sources to develop new standing acceleration limits.

METHODS:
Several data sources were examined to inform crew tolerance to impact loading in the vertical, +Gz axis. Using touchdown conditions from each Apollo landing, acceleration pulses for each landing were estimated. Added to this data set are Apollo landing gear tests. Ground-reaction forces measured during treadmill running on the International Space Station were used to assess forces that are well tolerated by deconditioned astronauts. Postflight voluntary jump data collected from long-duration astronauts also were reviewed. Finally, lower extremity injury data from automotive impacts (Kuppa, 2001) and from vertical loading of the foot (Pintar, 2016) were reviewed.

RESULTS & DISCUSSION:
A model, similar to the current seated Brinkley Dynamic Response Criterion (BDRC), was fit to the relevant data sources in the +Gz axis. A spaceflight deconditioning factor of 0.75 was applied yielding a new dynamic response limit of 2.0. For off-axis loads while standing, the same scaling factor used to decrement the +Gz axis was applied to the ±Gx and ±Gy axes. The -Gz limits are set to zero. The SME panel concluded that suit mass borne by the astronaut should be limited to no more than 20% of the crewmember's shirtsleeve mass.

Limitations of these new standards include a small dataset, suit interactions, applicability of BDRC model parameters to standing, and unknown effects of deconditioning.

BRIEFING: Advances in Miniature Measurement Solutions - Mr. Mike Beckage[1] and Mr. Kyvory Henderson[1]

[1]Diversified Technical Systems (DTS), Seal Beach, CA

INTRODUCTION:
Collecting accurate, high-speed data from multiple sensors has historically been a cumbersome process often requiring large data acquisition systems, yards of cabling, and massive power sources. As Moore's Law has predicted, these systems have become more efficient and effective over the years and they continue to shrink in size.

Recent advances in sensors and electronics have made it possible to unobtrusively collect data from flight and ordinance testing, automotive testing, medical research, sports research, and occupant protection systems in ways

that were not possible just a few years ago. This briefing will provide an overview of new sensing technologies and data recording methods, and touch on several real-world applications for person-worn recorders, crash data recording, and flight testing in real-time.

METHODS:
Mr. Beckage has spent a large portion of his career designing advanced measurement solutions for person-worn 6DOF sensors, automotive & aerospace crashworthiness testing, and various other safety-related and defense applications. The primary concept throughout has been to identify and apply the latest miniaturized sensors and data recording electronics in new and innovative ways to meet the needs of a more data-driven industry.

RESULTS & DISCUSSION:
Selected projects will be highlighted starting with a head-worn accelerometer array and telemetry system developed in the late 1980s and continuing through current projects. Active development programs are resulting in practical, person-worn sensors to better understand human dynamic exposure in military and civilian life. Miniature data loggers have been developed to allow researchers to localize sensors to virtually any point of interest. These programs are all working toward the goal of improving test and evaluation systems and enhancing occupant protection.

WEDNESDAY – 3:30 PM – 4:00 PM
END OF DAY BROADCAST
LOCATION: CHANNEL 1 & 2

THURSDAY, DECEMBER 3rd

THURSDAY – 9:00 AM – 9:30 AM
SING-ON/WELCOME MESSAGE
LOCATION: CHANNEL 1 & 2

THURSDAY: 9:30 AM – 10:00 AM
ANTHROPOMETRY II
LOCATION: Channel 1
MODERATOR: Mr. John Plaga, AFRL/711TH HPW

BRIEFING: **A mobile phone app for automated and accurate sizing of respirator masks -** Dr. Paulien Roos[1], Ms. Katherine Marschner[1], Dr. Laszlo Jeni[2], Mr. Rohith Pillai[2], Dr. Vincent Harrand[3]

[1]CFD Research Corporation, Huntsville, AL; [2]Carnegie Mellon University; [3]CFD Research Corporation

INTRODUCTION:
Typical procedures for respirator mask sizing and protective fit testing are time-consuming and user-intensive. Detailed measurements are often needed requiring significant expertise. Followed by quantitative fit testing using specialized testing equipment to verify a proper seal is achieved. Any changes to wearer's weight or face may affect mask size, necessitating repeated sizing and testing. Therefore, a mobile phone app was developed that can quickly, accurately, and automatically perform respirator mask sizing and predict protective fit.

METHODS:
A mobile phone app has been developed that uses time-locked high-speed video and inertial measurement data captured by the phone to reconstruct a metric 3D representation of the face. The method was trained on a dataset of high-resolution 3D face scans covering a diverse population. The app automatically identifies facial features on the 3D facial representation and calculates best fit mask size. The app was tested on 20 subjects, facial features were compared to manual measurements and a 3D face scan. A quantitative mask fit was performed on the predicted mask size for 13 subjects.

RESULTS & DISCUSSION:
The app estimated facial features closer to manual measurements than facial scans did. Mean error of predictions by the app were below 4mm for all facial features, with mean percentage errors below 5.4%. Quantitative mask fitting showed predicted mask sizes by the app resulted in a good fit for all subjects.

It was demonstrated that a cell phone app can accurately predict facial features and mask size for the Avon M50 mask. The app has been developed with the Avon M50 mask as a first target, but can be customized for any respirator or other mask. The tool can be used both in the military, health, and industrial sectors for fast and accurate mask sizing without needing any user expertise.

Support was provided by the US Army Contracting Command (W911SR-17-C-0060).

BRIEFING: **Alternative Night Vision Goggles Mounting Systems FOV (Alt NVG Mount) -** Max Grattan[1], Casserly Mullenger[1], Dr. Jeffrey Hudson[1], Jennifer Whitestone[2]

[1]Solutions Through Innovative Technologies, Inc., Fairborn, OH; [2]USAF AFMC AFLCMC/WNU Airmen Accommodation Lab

INTRODUCTION:
NVGs (Night Vision Goggles) have been used by all military branches over the years. The AN/AVS-9, also known as ANVIS-9 (Aviation Night Vision System) is the standard night-flying system for the USAF and Navy, and is in-service in more than 60 countries. It is commonly used in conjunction with the HGU-55/p helmet. With newly developed helmet technologies, aircrew still require a capability to mount ANVIS-9 NVGs, without sacrificing function. The Airmen Accommodation Laboratory (AAL) built a device to measure how alternative equipment configurations, particularly ANVIS-9 mounts, might affect aircrew field-of-view (FOV).

METHODS:
Subjects of varying head shapes, face proportions, and interpupillary distance (IPD) were used as test participants examining various NVG mount configurations for stability, fit, comfort, and FOV. In order to test each of the six configurations, participants donned a helmet/NVG configuration to gather FOV data. While standing at the chin stabilization rig and positioned towards the FOV rig 72" away, they were asked to aim a helmet mounted laser in the middle of the FOV rig on a target horizontal with their viewing angle. While keeping the helmet-mounted laser centered, the TP pointed portable lasers to mark the left and right edges of their FOV through the NVGs. Edge locations were marked, distances from center were measured, and the FOV angle determined. Fit, comfort, and stability of the various systems were recorded.

RESULTS & DISCUSSION:
Data collection was completed with 22 test participants (including civilians and active duty aircrew). By measuring the performance of the helmet/NVG mount systems offered by the vendors, we will be able to contrast their effectiveness with that offered by the baseline system currently in use. This type of setup could be used moving forward to test how additional equipment variations affect FOV.

BRIEFING: **Neck Muscle Fatigue Resulting from Prolonged Wear of Weighted Helmets – Basic 1 G Version -** Casserly Mullenger[1], Dr. Edward Eveland[2], Charles Goodyear[3]

[1]Solutions Through Innovative Technologies, Inc., Fairborn, OH; [2]USAF AFMC 711 HPW/RHBNB; [3]Infoscitex

INTRODUCTION:
The United States Air Force (USAF) Airmen Accommodation Laboratory (AAL) recently collaborated with AFRL's Biodynamics Branch to investigate human performance differences that may develop after prolonged wear of helmet systems. This study used a combination of cognitive and physical tasks to compare the amount of fatigue resulting from six different configurations of varying weight and center of gravity. The helmet and seat angle configurations represent the F-35 helmet and the HGU/55P (with and without the ANVIS-9 night vision goggles), which are frequently utilized in high performance aircraft.

METHODS:
Participants were asked to come in the lab one day a week for 6 weeks, in order to test each of the six configurations. Each visit, they wore a helmet over the course of the day (approximately 7 hours) while sitting in an

ejection seat. They were asked to perform a series of tasks every 1.5 hours; including maximum voluntary contractions (MVCs), a neck muscle endurance pull, visual searches, and target acquisition. Data were also collected with electromyography (EMG), 3D scanning, surveys of exertion and discomfort, and a time-lapse camera.

RESULTS & DISCUSSION:
Fourteen active duty USAF Airmen (9 women and 5 men) completed 76 days of testing. When analyzing data taken over the course of each day, we observed decreasing MVCs, but no change in endurance time. Participants also reported an increased level of discomfort while maintaining the same level of perceived exertion. For the target acquisition task and visual search tasks, we saw little difference and an improvement in scores, respectively. Men had significantly stronger MVCs than women. EMG data is currently being analyzed. We intend to further investigate the role demographic and anthropometric variables, including neck size, have on fatigue and performance. Data collection and analysis is ongoing, but preliminary results will be presented.

BRIEFING: **Naval Air Warfare Center Aircraft Division (NAWCAD) Digital Human Modeling (DHM) and Research for Ergonomic, Anthropometric, and Medical applications & 3D Scanning (DREAMS) Lab: Expanding Digital Human Modeling Capabilities and Research -** Lori Brattin Basham[1], Andrew Koch[1], Bethany L. Shivers[2], Anusha Bhattacharya[2], Jeffrey A. Hudson[3,4], Jennifer Whitestone[3], Ronald Richardson[5], Max Grattan[3,4]

[1]DREAMS Lab (NAWCAD Human Systems Engineering), Naval Air Station Patuxent River MD; [2]Crashworthiness and Escape Systems (NAWCAD Human Systems Engineering), Naval Air Station Patuxent River MD; [3]Airmen Accommodation Lab, (AFMC AFLCMC/WNU), Wright Patterson AFB, Dayton OH; [4]Sti-Tec, Dayton OH; [5]AFLCMC/EZ-FC, Wright Patterson AFB, Dayton, OH.

INTRODUCTION:
The NAWCAD DREAMS Lab was established in 2019 to expand NAWCAD's DHM capability as well as to focus on research efforts to address aircrew and maintainer safety-related topics such as anthropometric accommodation and musculoskeletal pain/injury. While FY20 has provided challenges, it has also yielded opportunities.

METHODS:
The lab received significant funding to purchase additional hardware and software including Artec Ray and Leo scanners, Size Stream body scanner, Geomagic Design X, Human Solutions RAMSIS, NexGen Ergonomics HumanCAD, the Anybody Modeling System (AMS), C-Motion 3D Visual Pro, the Xsens motion capture system, and a variety of other hardware and software upgrades.

RESULTS & DISCUSSION:
Research has included an ongoing collaborative effort with AFLCMC/WNU to obtain empirical data for DHM seat posture modeling purposes and the start of a project utilizing fiber optic technology to collect spinal posture data and evaluate aircrew postures in DHM tools. The lab also supported a number of 3D scanning and modeling efforts including MH-139A cockpit/cabin/aircrew, scanning of participants for an Office of Naval Research (ONR) TechSolutions body scanning project, scanning of a historic US Navy owned home, and a cabin scan of the E-2D has been funded for September 2020. Several collaborative program support and research efforts, as well as rotations are planned with anthropometry, ergonomic, and/or biomechanical subject matter experts from other organizations in FY21-FY23. These activities will be described in the panel brief as well.

THURSDAY: 9:30 AM – 11:30 AM
HELMET PROTECTION
LOCATION: Channel 2
MODERATOR: Mr. Tim DeWitt, AFRL/711TH HPW

BRIEFING: **Designing speech intelligibility requirements and determining the appropriate ambient noise environment for the measurements -** Mrs. Hilary Gallagher[1], Mr. Billy Swayne[2], Dr. Eric Thompson[3]

[1]Air Force Research Laboratory, Wright-Patterson Air Force Base, OH; [2]Ball Aerospace and Technologies Corporation; [3]Air Force Research Laboratory

INTRODUCTION:
A flight helmet is a critical piece of equipment for most aircrew. Flight helmets serve many purposes, but from an acoustic perspective, the helmet provides hearing protection and the ability to communicate. Product specification documents are developed to inform designers and manufacturers of the necessary requirements. Each requirement defines the measurement threshold and objectives as well as the necessary test method(s). For speech intelligibility (SI), measurements shall be conducted in accordance with the American National Standards Institute (ANSI) S3.2, which allows flexibility for the user to define the communication system, including the appropriate ambient noise environment. Since a flight helmet may be used on multiple aircraft platforms, a full test matrix for SI in every noise environment quickly becomes unwieldy. This study was conducted to inform the development of the requirements document with a narrower test matrix for a new flight helmet.

METHODS:
SI performance measurements were conducted in the Voice Communication Research and Evaluation System (VOCRES) at WPAFB. Data were collected in accordance with ANSI S3.2 to measure the SI performance of the Aircrew Ballistic Helmet (ABH-2). The ABH-2 was designed for rotary wing aircrew. Therefore, the measurements were conducted in various ambient environments consisting of recordings made inside a rotary wing platform: UH-60 cockpit, UH-60 cargo area, and generic pink noise.

RESULTS & DISCUSSION:
The results indicate that SI scores did not vary as a function of the specific noise environment in which the measurements were conducted. Due to these results, measurements need not be made in each environment in order to adequately predict communication performance across a broad range of expected environments. It was recommended that the specification document require SI measurements be conducted in a generic pink noise environment.

BRIEFING: **Helmet Characterization of the HGU 55/P -** Mr. Benjamin Steinhauer[1]

[1]711th HPW/RHB, WPAFB, OH

INTRODUCTION:
The HGU 55/P is the primary fixed wing helmet for the Air Force and has gone through many changes over the years as far as outfitting the helmet with various HMDs. This typically requires a modifications to interface the HMDs with the helmet, usually involving drilling into the shell. AFLCMC is concerned at the modifications effecting the impact characteristics of the helmet. 711th HPW/RHB is working in collaboration with AFLCMC to characterize the individual components of the helmet to help address future risk, while collecting data to prove the effectiveness of the individual components.

METHODS:
Utilizing the HGU 55/P, brand new helmets will be used and taken apart to their component levels and drop from a set drop height onto a rubber programming service. Various comfort liners will be used to address if any comfort liners have an advantage over the other from an impact perspective. The shell and Energy Absorbing Liner (EAL) will also be impacted by themselves. Combinations will be utilized to understand any combined characteristics. Remaining shell assets will be drilled at fixed widths and distances from each other to understand the effects of how this may effect impact attenuation when making modifications.

RESULTS & DISCUSSION:
Data is still being collected at this time and results of the study will be displayed at the conference.

BRIEFING: **What Hearing Protection Do I Need for My Noise Environment? -** Ms. Michelle Collier[1], Mr. Brian Fowler[1]

[1]Gentex Corporation, Manchester, NH

INTRODUCTION:
Many military missions often have extreme noise environments, and tinnitus and hearing loss are the number one and number two disabilities impacting our warfighters, with over 2.2 million servicemembers receiving

compensation for the two disabilities at the close of fiscal year 2014 according to the VA. Further, blast exposure has been linked to auditory processing disorder, where veterans are audiologically normal, but have trouble understanding speech.

What should you consider when selecting hearing protection to improve mission effectiveness, maintain situational awareness, and reduce long term hearing loss for aircrew personnel? Gentex Corporation will present some things to consider and provide several integrated solutions/approaches to address this issue including:

METHODS:
What should you consider when selecting hearing protection to improve mission effectiveness, maintain situational awareness, and reduce long term hearing loss for aircrew personnel? Gentex Corporation will present some things to consider and provide several integrated solutions/approaches to address this issue including:

RESULTS & DISCUSSION:
Things to consider when selecting Hearing Protection and Communications solutions: Airframe noise spectrum, presence of impulse threats, mission duration, effects of rapid decompression, and Total Daily Exposure (TDE).

Technologies and Systems: Which products are best suited for the aircraft type or ground application. Solutions to be considered include: passive and active, single and double hearing protection, hear-through for face to face communications and situational awareness, and communications stripping for improved hearing protection and speech intelligibility.

Hearing Protection by Noise Environment Spectrum: Different noise fields have different frequency content that can pose different levels of risk for hearing loss.

Where are the high levels of noise in the spectrum of the operational environment you need to protect against?

BRIEFING: **Advancements in Aircrew Head Protection -** Mr. Mike Stump[1]

[1]*GENTEX Corporation, Rancho Cucamonga, CA*

INTRODUCTION:
The design and requirements for flight helmets has remained largely unchanged for 25+ years, however, the physical and physiological demands on aircrew continues to increase as mission durations are extended and head-borne equipment becomes more advanced and commonplace; coupled with an expanding anthropometric range of aircrew with increasing numbers of female aircrew has exacerbated the need for a fresh look at how a flight helmet should perform, its architecture, design, and sizing to meet the needs of the current and future Aircrew population. This presentation will provide insight into the performance and design improvements and benefits that can be expected in the Next Generation Fixed Wing Helmet. Specific emphasis will be provided for the critical performance characteristics of:

1. Stability
2. Equipment Compatibility (Current and Future)
3. Weight. Center of Gravity, Moment of Inertia
4. Anthropometric Accommodation
5. Comfort
6. User Functionality

METHODS: N/A

RESULTS & DISCUSSION: N/A

THURSDAY - 11:30 AM – 12:30 PM
SAFE VIRTUAL SOCIAL EVENT (*SPONSOR COBHAM MISSION SYSTEMS)*
LOCATION: CHANNEL 1 & 2
*The symposium committee has a fun, friendly competitive event planned. There will be an announced winner of the event and the SAFE Association will make a donation to the charity of their choice. Details to be released closer to the symposium – keep a look out!

THURSDAY - 12:30 PM – 1:00 PM
SYMPOSIUM BREAK
LOCATION: CHANNEL 1 & 2

THURSDAY: 1:00 PM – 3:00 PM
PANEL ON PHYSIOLOGIC EVENTS
LOCATION: Channel 1
MODERATOR: Mr. Glenn Paskoff, NAVAIR

BRIEFING: **Physiological Episodes in U.S. Navy Aircraft: Root Cause and Corrective Action Analysis -**
CDR Adrian Jope[1], Mr. Ed Gassie[2]**,** Mr. Don Salamon[3]**,** CAPT Russell Linderman[4]**,** CDR Allen Hoffman[5]

[1]Physiological Episodes Action Team Lead (PEAT); [2]Chief Engineer, T-45 and T-6 Program Office (PMA-273), Naval Air Systems Command; [3]Systems Engineer, F/A-18 and EA-18 Program Office (PMA-265), Naval Air Systems Command; [4]Physiological Episodes Action Team Aeromedical Safety Officer (AMSO); [5]Physiological Episodes Action Team Flight Surgeon / BUMED Aeromedical Action Team Lead (AMAT)

INTRODUCTION:
A sharp increase in aircrew self-reported Physiological Events (PE) while flying FA-18/EA-18G, T-45, and T-6 aircraft in 2017 significantly affected Naval Aviation operations and training. Evidence, at the time, suggested aircrew were suffering from hypoxia due to either insidious failure of the aircraft's oxygen system or from noxious contaminants within the breathing oxygen. Furthermore, the FA-18/EA-18G community saw a significant rise in reported pressure events as a result of issues related to the aircraft Environmental Control System (ECS). A loss of confidence in the safety of both aircraft was wide spread across the fleet and significant enough in the T-45 to force a fleet-wide operational pause in March 2017.

METHODS:
NAVAIR initiated a number of in-house and independent reviews to investigate the causes of these events. Ultimately, the most successful approach was a Root Cause Corrective Action (RCCA) approach involving a collaborative effort between NAVAIR and industry partner subject matter experts. This comprehensive and deliberate approach considered all aspects of the man-machine interface and the subsequent physiological impact of system design, maintenance, failure modes, training, and normal and abnormal operations. The investigation involved more than 100 personnel across more than 30 organizations and nearly three years of effort, ultimately producing more than 8000 pages of technical documentation and 567 recommendations.

RESULTS & DISCUSSION:
While no single root cause was identified, it has been determined that physiological events are complex and multifactorial. The RCCA analysis identified key factors that can synergistically combine to cause physiological events in the aircraft. Focus areas included Aviation Life Support Systems (ALSS) and flight equipment, the Environmental Control System (ECS), training, operations, and the human. PEs were also categorized into two distinct categories, pressure and non-pressure, based on resultant symptomology. To date, a number of changes and improvements have been adopted leading to an overall reduction in FA-18/EA-18G and T-45 PEs by 74% and 94% since their respective peaks in 2017. For example, the development of the Hornet Health Assessment and Readiness Tool (HhART) for the FA-18/EA-18G aircraft has driven down pressure-related PEs significantly due to the predictive maintenance capability that it provides. On the non-pressure side, hypoxia caused by inadequate oxygen levels and breathing gas contamination, long thought to be the primary causes of Aircraft Oxygen System (non-pressure) type PEs, were found to be non-factors and more likely due to other causes. This panel session will highlight key RCCA findings as well as NAVAIR's flight path to recovery consisting of aircraft modifications,

aircrew gear accommodations, aircrew physiology, operator and maintainer training, changes to emergency procedures, and the roll of "big data" in yesterday's investigation and tomorrow's state-of-the-art maintenance practices.

THURSDAY - 3:00 PM – 3:30 PM
END OF DAY BROADCAST
LOCATION: CHANNEL 1 & 2

FRIDAY, DECEMBER 4TH

FRIDAY – 9:00 AM – 9:30 AM
SIGN-ON/WELCOME MESSAGE
LOCATION: CHANNEL 1 & 2

FRIDAY – 9:30 AM – 11:30 AM
Acquisitions and Sustainment Briefings
LOCATION: CHANNEL 1 & 2
*An Industry Day event has been planned again this year. Briefings will take place on Friday following the symposium events. Planning is in the early stages so please look out for more information to follow.

FRIDAY – 11:30 AM – 12:00 PM
END OF DAY BROADCAST
LOCATION: CHANNEL 1 & 2

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