TENTATIVE PROGRAM

57th ANNUAL SAFE SYMPOSIUM
OCTOBER 14 – 16, 2019
GRAND SIERRA RESORT AND CASINO
RENO, NEVADA

The SAFE Board of Directors extends a cordial invitation for you to join us at the 57th Annual SAFE Symposium being held at the Grand Sierra Resort and Casino in Reno, Nevada. 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 including featured panels, our Annual General Membership Meeting and Presentation of the 2019 SAFE Awards. The 2019 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 with the many members of industry who will be exhibiting at this year's symposium.

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! The final program will be provided on-site.

REGISTRATION INFORMATION & RATES

SAFE Member:

$500.00 - Pre-registration
$600.00 - At-the-door

Member registration does not include dues.

Non-Member:

$600.00 - Pre-registration
$750.00 - At-the-door

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 - $150.00

Covers all three (3) days of the Symposium. I.D. will be checked.

All foreign military active duty personnel:
$150.00

Covers all three (3) days of the Symposium. I.D. will be checked.

One Day Registration $300.00 per day. If an attendee wishes to register for more than one day, they will be required to re-register each day and cannot pay for and pick up both badges on their first registration.

One Day Student Registration - $75.00
I.D. will be checked.

Spouse Registration:

$150.00 – This fee covers all activities open to general attendees for all three days of the symposium.

Pre-registration deadline: October 9th.
This date applies to all registrations.

Full refunds are issued in the event you are unable to attend.

2019 Golf Tournament
See page 74 for complete information.

5k Runner 2019
See page 76 for complete information.

For registration and payment, please visit the SAFE website!

Attendee Registration Form
https://www.safeassociation.com/index.cfm/events/eventregistrationform

Exhibit Booth Personnel Registration Form
https://www.safeassociation.com/index.cfm/events/exhibitorPersonnelForm2

REGISTER NOW - MAKE PLANS NOW TO ATTEND!!

GENERAL POLICIES

All attendees must complete an Attendee registration Form and make applicable payment:
https://www.safeassociation.com/index.cfm/events/eventregistrationform

All exhibitors must complete an Exhibit Booth Personnel Registration Form and make applicable payment:
https://www.safeassociation.com/index.cfm/events/exhibitorPersonnelForm2

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. If duplicates are needed, a general receipt card will be available at the registration desk, along with program materials, including attendee badge. You are welcome to e-mail the SAFE office (safe@peak.org) to verify receipt of your registration.

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

One day registration will be $300.00 and will be accepted in advance and/or at-the-door.

One Day Badge Pick-Up Policy: If an attendee wishes to register for more than one day, they will be required to re-register each day. Attendees cannot pay for and pick up both badges on their first day of registration.

International visitors registering by check or money order must provide payment in U.S. funds. No bank transfers are accepted.

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.

PRE-REGISTRATION

To qualify for the pre-registration rate, registrants must complete a registration form and pay in advance on or before **October 9, 2019.**

Registrations received after the pre-registration deadline of October 9, 2019, will be charged the at-the-door rate.

AT-THE-DOOR REGISTRATION

At-the-door registration is available by credit card, check or cash. At-the-door registration fees are shown on Page 2.

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

SIDE MEETINGS & HOSPITALITY SUITES FOR SAFE CORPORATE MEMBERS, CO-LOCATION GROUPS AND EXHIBITORS

Did you know that if you are planning any side meetings or a hospitality event during the 2019 Symposium, you can complete a Side Meeting/Hospitality Event Room Reservation Form online to reserve the space from the SAFE room block and you won't be charged room rental? SAFE will also advise the hotel that the room(s) have been taken from the SAFE block and are complimentary. Then, your primary Point of Contact (POC) will be turned over to the appropriate person for you to arrange, at your costs, for any additional needs such as food, beverage, additional audiovisual equipment not provided by SAFE, and so forth. SAFE will only provide the following:

-The meeting or hospitality event room space
-Basic audiovisual equipment such as a projector and a screen, if needed.
-Tables and chairs
-Free WIFI

If you are interested in this service, please follow the link and complete reservation form www.safeassociation.com/index.cfm/hospitalityEvents/form.

EXHIBITOR EDUCATION IN THE HALL

You won't want to miss a **new** opportunity to highlight your company's capabilities and products.

For the first time, we are offering our 2019 exhibitors, on a first-come; first-served basis, the opportunity to educate attendees on the latest products, capabilities, and services available in the safety and survival community while enjoying a morning or afternoon refreshment in the exhibit hall.

Education in the Hall opportunities are will be available to our 2019 symposium exhibitors with the following provisions and limitations:

- Symposium exhibitors will be limited to a 10-minute in-booth demonstration or briefing during one of the morning or afternoon exhibit hall refreshment breaks only.
- Due to space and time limitations, only two (2) morning and two afternoon (2) opportunities are available per day on Monday, Tuesday and Wednesday - AM ONLY on a first-come; first-served basis.
- Interested exhibitors must contact the SAFE Administrator at safe@peak.org no later than October 1, 2019, to reserve one of ten (10) opportunities.

Again, Exhibitor Education in the Hall opportunities are being offered on a **first come; first served basis** so reserve your opportunity now!

SLEEPING ROOM RESERVATIONS & HOTEL INFORMATION

GRAND SIERRA RESORT AND CASINO

2500 EAST 2ND STREET RENO, NEVADA 89502

Sleeping Room Reservations: Attendees should book their sleeping room reservations at the following 2019 SAFE Symposium host hotel: Grand Sierra Resort and Casino, 2500 East 2nd Street, Reno, Nevada 89502.

2019 SAFE Symposium Dates/Location: October 14 – October 16, 2019 at the Grand Sierra Resort and Casino in Reno, Nevada.

When calling the Grand Sierra Resort for reservations, please identify yourself with SAFE Association Symposium and use the code SAFE19 to receive the group rate.

Group Reservation Phone Number: (800) 501-2651 **Grand Sierra Main Line:** (775) 789-2000

2019 SAFE Symposium Group Code: **SAFE19**

Non-Government & Government attendees can book sleeping room reservations on-line at:

Booking Website: https://book.passkey.com/e/49807770

Call (800) 501-2651 and identify yourself as an attendee or member of the military/government (if applicable) attending the 2019 SAFE Association Symposium and provide the group code - **SAFE19**.

Standard Summit King / Queen Rooms: $99.00
Standard "A" Level King / Queen Rooms: $119.00
SAFE holds the room block for Non-Government and Government attendees from October 11-17, 2019.

Government per diem rate sleeping rooms are available at the prevailing government rate and are subject to change. Government employees and members of the military should advise the hotel reservation clerk (or include when reserving online) of their government affiliation. Provide the 2019 SAFE Association Symposium group code - **SAFE19**.

Room Reservation Deadline Cut-Off is Midnight, September 10, 2019, to be able to receive the 2019 SAFE negotiated sleeping room rates.

Payment Options: You can access all payment options on our website (www.safeassociation.com) including PayPal (requires no personal account to use) and the secure shopping cart. Use the **Symposium** link at the top of the page and then the appropriate dropdown to register for the symposium, register for social events, reserve an exhibit space, and pay the associated fees.

Cancellation Policy: The hotel requires a one night's room deposit, per room, to guarantee accommodations. The hotel accepts all major credit cards for deposit, which is refundable if cancellation is made 48 hours before arrival. The deposit secures the sleeping room until 12:00 Midnight on the scheduled arrival date. If the guest plans to arrive after midnight, they **must call** to assure their accommodation is secured.

Discounted Rooms: Contact by companies offering to provide individual rooms or small room blocks at less than SAFE contracted rates, please do not do business with them. While the SAFE room rate may be a few dollars more than the rates quoted by these companies, this is because SAFE negotiates directly with the hotel to obtain the best price and amenities for our attendees.

SAFE's Financial Responsibility: SAFE is financially liable for **all** contracted rooms whether the hotel sells them or not. This policy is why we ask that you always book your rooms under the SAFE block. We work diligently to give all attendees the best overall experience at our annual symposium and we thank you for your continued support.

HOUSING SCAM – 2019 SAFE SYMPOSIUM

If you are contacted by "Exhibition Housing Company," "Global Housing" or any other company claiming they are the "official" housing service for the 2019 SAFE Symposium, and that they are able to obtain significant reductions for you on rooms, **please do not do business with them**. SAFE has made no arrangement, nor does it plan to, for the utilization of a 2019 sleeping room housing service.

Management at the Grand Sierra Hotel were advised and, unfortunately, they reported this is becoming more of an issue across the country each year. They have also advised that these types of operations get as much money as they can, close up shop, and move. They will take your deposit and run! SAFE's official published statement regarding sleeping rooms follows…

Special Note: We understand that companies offering to provide individual rooms or small room blocks at less than SAFE contracted rates have been in contact with several of our corporate members and exhibitors. While the SAFE room rate may be a few dollars more than the rates quoted by these companies, this is due to the fact that SAFE negotiates with the hotel to obtain no rental fees for our meeting and exhibit space. This negotiation results in a huge savings which is passed along to our SAFE attendees in the form of lower registration and exhibit space rates. The hotel recovers a small percentage of this rental by adding a few dollars to the negotiated room rate.

It is important to understand that this slight room increase does not come close to covering the astronomical per square foot per day rates the hotel normally charges for meeting room and exhibit space rental.

SAFE is financially liable for all contracted rooms, whether the hotel sells them or not. This is why we ask that you always book your rooms under the SAFE block. We work diligently to give all attendees the best overall experience at our annual Symposium and ask for your continued support."

Please pass this along to anyone you think may benefit!

EXHIBIT HALL HOURS & TENTATIVE TIMELINE OF EVENTS

EXHIBIT HALL HOURS

Sunday, October 13	7:00 PM – 9:00 PM
Monday, October 14	11:30 AM – 7:00 PM
Tuesday, October 15	9:30 AM – 7:00 PM
Wednesday, October 16	9:30 AM – 1:30 PM

- The Get-Acquainted Reception on Sunday, October 13, at 7:00 pm will be a SAFE/Hotel hosted reception will held be in the exhibit hall. Exhibits will be open and manned.
- The 2019 SAFE Awards Ceremony will be held on Monday morning immediately following the Special Presentation Speakers remarks.
- The 2019 SAFE Awardee Lunch - Complimentary for all attendees on Monday, 14 October, at 11:30 AM in the Exhibit Hall.
- Complimentary Networking Lunches for all attendees will be provided on Tuesday and Wednesday in the Exhibit Hall.
- Monday and Tuesday End-of-Day Networking Receptions will be held in the Exhibit Hall 5:00 PM – 7:00 PM. Complementary Beverage Tickets will be provided and available for purchase. Monday Night Football will be aired during the Monday Networking Reception.
- On the last day, Wednesday, 16 October at 1:30 PM, the Exhibit Hall will close. **No booth removal/dismantle can take place before 3:00 PM as other events will be in progress.**
- On Wednesday at 1:15 PM, the Tri-Services Acquisition Program Manager (PM) Briefing will take place.
- The presentation of the Presidents Award and Industry Awards will take place immediately following the Tri-Service Acquisition PM Briefing.
- WIFI and a Symposium APP will be available to all attendees and exhibitors at no cost.
- We welcome exhibitor sponsored special or hospitality events at their booths during the Get-Acquainted and Networking Receptions - a great way to highlight your company and help make the end of day activities fun and enjoyable.

Tentative Timeline continues on next page

EXHIBIT HALL HOURS & TENTATIVE TIMELINE OF EVENTS

SATURDAY, OCTOBER 13th

Noon – 5:30PM	Exhibitor Move-In

SUNDAY, OCTOBER 13th

7:00 AM – 4:00 PM	Exhibitor Move-In
8:30 AM (Start Time)	SAFE Golf Tournament
Noon – 6:00 PM	Registration Open
3:00 PM (Start Time)	SAFE 5k Runner
7:00 PM – 9:00 PM	Get-Acquainted Reception in Exhibit Hall

MONDAY, OCTOBER 14th

7:00 AM – 4:00 PM	Registration Open
8:00 AM – 8:30 AM	Symposium Opening & Welcome
8:30 AM – 10:00 AM	Special Presentation Speaker and SAFE Awards
10:00 AM – 10:30 AM	AM Refreshment Break (Exhibit Hall)
10:00 AM – 5:00 PM	Co-location/Industry
10:30 AM – 11:15 PM	General Membership Meeting
11:15 AM– 11:45 AM	Author's Coordination Briefing
11:30 PM – 7:00 PM	Exhibit Hall Opens
11:30 AM – 1:00 PM	SAFE Awardee Luncheon (Exhibit Hall)
1:00 PM – 2:30 PM	Technical Sessions
2:30 PM – 3:00 PM	PM Refreshment Break (Exhibit Hall)
3:00 PM – 4:30 PM	Technical Sessions
5:00 PM – 7:00 PM	Networking Reception (Exhibit Hall)

TUESDAY, OCTOBER 15TH

7:00 AM – 4:00 PM	Registration Open
8:00 AM – 9:30 AM	Technical Sessions
9:30 AM – 4:30 PM	Co-Location/Industry
9:30 AM – 7:00 PM	Exhibit Hall Opens
9:30 AM – 10:00 AM	AM Refreshment Break (Exhibit Hall)
10:00 AM – 11:30 AM	Technical Sessions
11:30 AM – 1:00 PM	Networking Lunch (Exhibit Hall)
1:00 PM – 2:30 PM	Technical Sessions
2:30 PM – 3:00 PM	PM Refreshment Break (Exhibit Hall)
3:00 PM – 4:30 PM	Technical Sessions
5:00 PM – 7:00 PM	Networking Reception (Exhibit Hall)

WEDNESDAY, OCTOBER 16TH

8:00 AM – 3:30 PM	Registration Open
8:00 AM – 9:30 AM	Technical Sessions
9:30 AM – 3:30 PM	Co-Location/Industry
9:30 AM –1:30 PM	Exhibit Hall Opens
9:30 AM – 10:00 AM	AM Refreshment Break (Exhibit Hall)
10:00 AM – 11:00 AM	Technical Sessions
11:15 AM – 11:45 PM	USAF Safety Center Briefing
11:45 PM – 1:15 PM	Networking Lunch (Exhibit Hall)
1:15 PM – 2:45 PM	Tri-Service Acq. PM Briefing
2:45 PM – 3:00 PM	Industry/Presidents Awards
3:00 PM – 8:00 PM	Exhibitor Move-Out

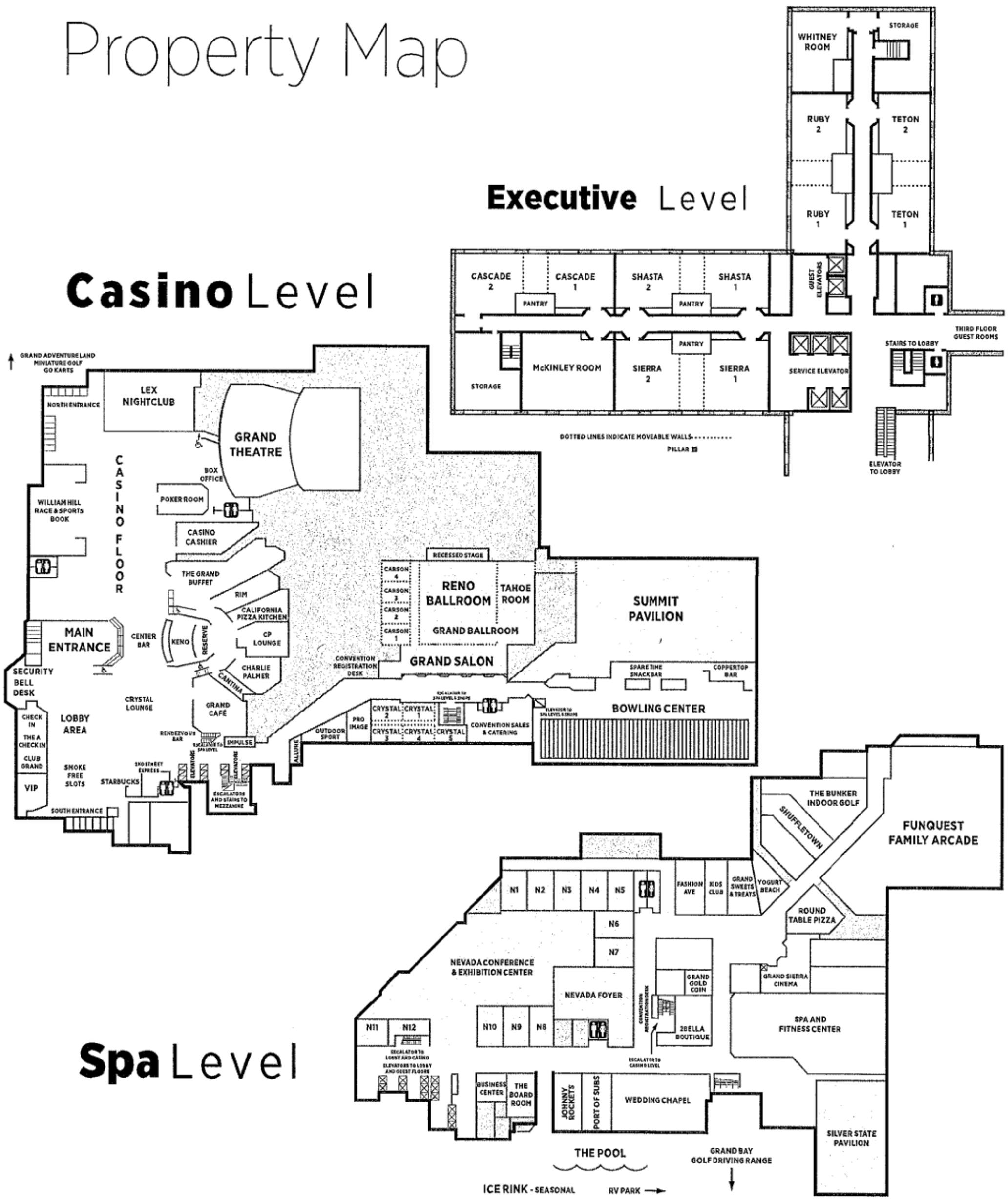
JOINT SERVICES AIRCREW SYSTEMS INDUSTRY DAYS

THURSDAY, OCTOBER 17TH
8:00 AM – 6:00 PM

FRIDAY, OCTOBER 18TH
8:00 AM – 6:00 PM

NOTE: ALL EVENTS AND TIMES ARE SUBJECT TO CHANGE

Property Map



775.789.2000
GrandSierraResort.com

GSR GRAND
SIERRA RESORT AND CASINO

EXHIBIT AREA ACCESS POLICY, SET-UP AND TEAR-DOWN TIMES

The Symposium Committee has developed the exhibit area set-up and access policies to protect the exhibitors and their products from unauthorized access and theft. We appreciate your cooperation and understanding in this matter.

Set-up for exhibitors will be Saturday, October 12th from Noon to 5:30 PM and Sunday, October 13th from 7:00 AM – 4:00 PM. We urge you to have your exhibit set early in order that you are able to enjoy the Get-Acquainted Reception being held in the Exhibit Hall that evening. During move-in, persons who are not setting booths cannot be in the exhibit area and security will be enforced for the protection of our exhibitors.

Dismantle for exhibitors will be Wednesday, October 16th beginning at 3:00 PM. Dismantle of exhibits must be completed by 8:00 PM on Wednesday evening. **We ask that you not commence your tear-down prior to 3:00 PM as we will still have association events taking place that everyone will want to attend.**

GET-ACQUAINTED RECEPTION

Our 2019 Get-Acquainted Reception will be held on Sunday, October 13th, from 7:00 PM – 9:00 PM and is complementary to all symposium attendees. The reception is a SAFE and Hotel-Hosted event. Food and beverages will be available as well as beverages for purchase. Come out and meet your outgoing 2019 and incoming 2020 SAFE Board of Directors, our special guest, as well as network with other symposium exhibitors and other attendees.

The Exhibit Hall will be open and exhibits manned during this time.

2019 SAFE AWARDS CEREMONY AND GENERALMEMBERSHIP MEETING

The SAFE Awards Ceremony will be held on Monday, October 14 at 9:30 AM immediately following the Special Presentation Speakers remark.

The 2019 SAFE General Membership Meeting will be held Monday, October 14 at 10:30 AM.

SAFE 2019 AWARDEE LUNCHEON

Our 2019 Awardees Luncheon will be held on Monday, October 14, at 11:30 AM in the exhibit hall and is complementary to all symposium attendees. We ask that you join us in congratulating our 2019 SAFE Association Awardees.

JOINT SERVICES AIRCEW SYSTEMS INDUSTRY DAYS

This event will take place on the Thursday and Friday following the symposium. Details are available on the SAFE website at www.safeassociation.com

SAFE PHOTOGRAPHY POLICY

No in-session photography is permitted except photos taken by the official SAFE photographer.

The taking of photographs inside the Exhibit Hall IS NOT permitted except by those photographing their own booth, booth visitors, and displays after the Exhibit Hall opens on Monday. To photograph anything inside the Exhibit Hall or area other than previously explained, you must receive prior informed consent of the individual and/or owner of the subject matter. Photographs may only be taken during normal exhibit hours with the consenting individual present at the time the photographs are taken.

No photography is permitted in the Exhibit Hall or area prior to opening and after closing. All attendees are expected to comply.

Official SAFE photos will be taken by an authorized photography service which is sanctioned and controlled by the Symposium Committee. If you see any suspicious photography-related activity, please report it immediately.

DEADLINES REMINDER

Grand Sierra Room Reservation Deadline – Wednesday, September 11th

Golf Tournament Sign-Up Deadline – Friday, September 27th

Booth Payment Balance Deadline – Tuesday, October 1st

Exhibitor Education in the Hall Sign-Up Deadline – Tuesday, October 1st

Pre-Registration Deadline – Wednesday, October 9th

5k Runner Sign-Up Deadline – Wednesday, October 9th

EXHIBIT SPACE RESERVATION FORM
57h ANNUAL SAFE SYMPOSIUM
OCTOBER 14 – 16, 2019
GRAND SIERRA RESORT AND CASINO
RENO, NEVADA

ONLINE BOOTH REGISTRATION AVAILABLE – WWW.SAFEASSOCIATION.COM

Exhibit booths are 10 x 10. The exhibit fee includes, 24-hour security, draping, booth identification sign, and clean-up.

Four guest passes per exhibitor (not per booth) per day will be available at the registration desk. These passes are for visiting customers of the exhibitor; **not** spouses, friends, employees or consultants or anyone else employed by that exhibitor. Use of guest passes will be monitored.

No exhibit space will be assigned unless the reservation form is accompanied by a fifty percent (50%) deposit per booth space.

Cost of each 10' x 10' Booth Space:

( ) SAFE Corporate Members $1,500.00
( ) University Organizations $750.00
( ) Military Organizations $750.00
( ) All Others $2,500.00

Number of 10' X 10' spaces required? ________

From the attached floor plan, please indicate your first four choices of exhibit space numbers below. If all indicated choices have been reserved prior to receipt of this application, we will call you regarding an assignment.

______ 1st choice ______ 2nd choice

______ 3rd choice ______ 4th choice

Return completed application to:

SAFE Association
Post Office Box 130
Creswell, OR 97426-0130
(541) 895-3012
FAX: (541) 895-3014

Final booth balance due on or before **October 1, 2019**.

Exhibit Booth Space Reservation and Payment can be made online:
https://www.safeassociation.com/index.cfm/events/exhibitorcontractform

Company Name: ______________________________

Postal Mailing Address of person in charge of all future exhibit-related mailings – can be different than the person filling out this form: ____________

____

____

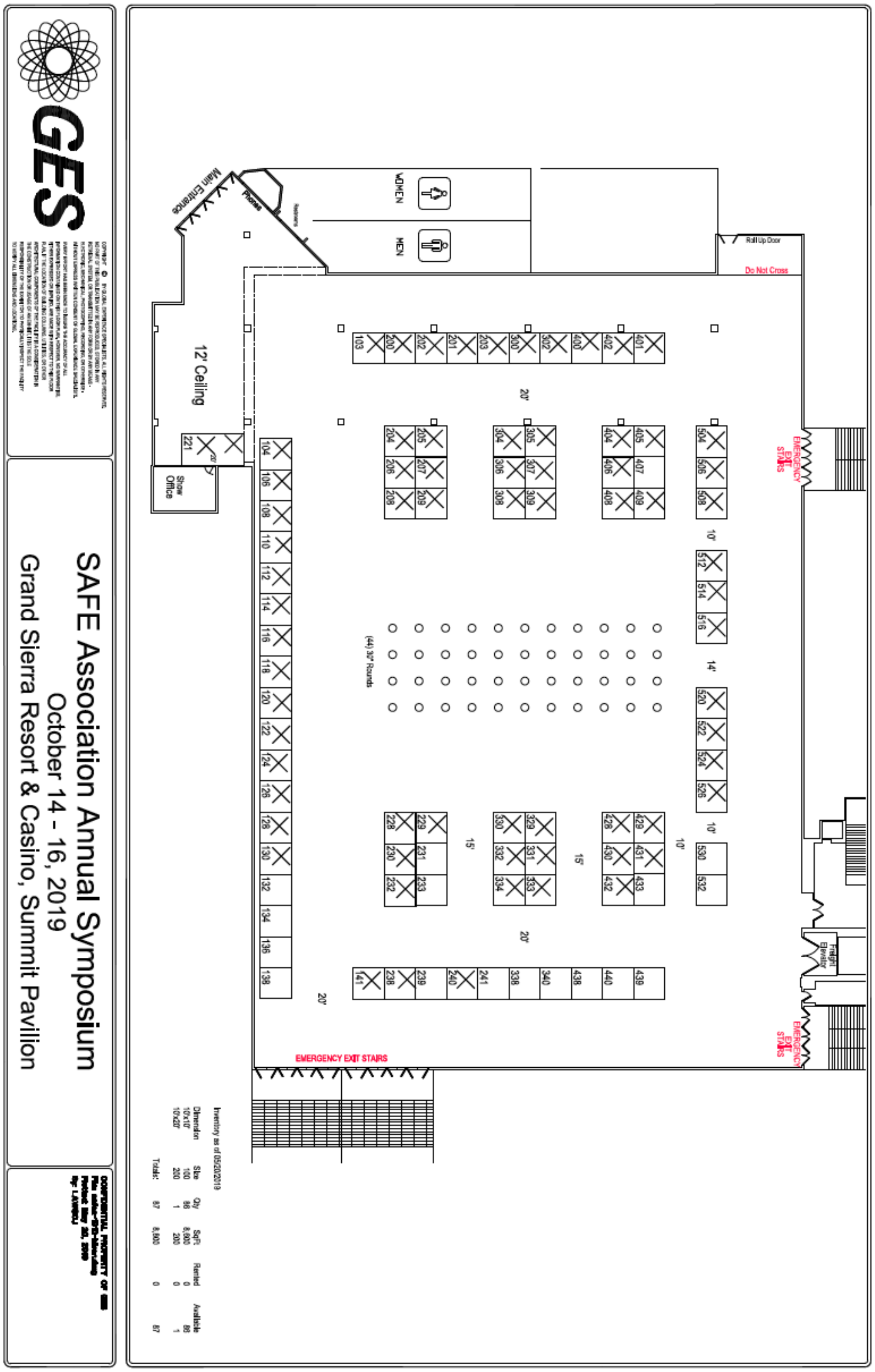
City, State, Zip, Postal Code, Country ______________________________

Individual to contact regarding application: ______________________________

Signed ______________________________ Date: ______________

In addition to the Exhibit Space Reservation Form, **all booth personnel must register for the 2019 SAFE Symposium** using the form online https://www.safeassociation.com/index.cfm/events/exhibitorPersonnelForm2
There are no complementary Registration tied to the cost of a booth.

EXHIBIT HALL FLOOR PLAN



2019 SYMPOSIUM EXHIBITORS

ADS, Inc.	302
Applied Energy Technology	409
Aqua Innovations, Ltd.	203
Autoflug GmbH	118
Bally Ribbon Mills	204
Biomedtech Australia Pty Ltd	110
Bose Corporation	431
Butler Parachute Systems, Inc	428
Capewell	228, 230 & 232
Cartridge Actuated Devices, Inc.	405
Cobham	306 & 308
Collins Aerospace	104 & 106
Dayton T. Brown, Inc.	429
DRIFIRE	300
East/West Industries, Inc.	508, 512,514, & 516
Elbit Systems C41 and Cyber	229
Essex Industries	305
First-Light USA	202
FXC Corporation	120 & 122
Gentex Corporation	205, 207 & 209
Insta ILS Oy	112
Integrated Procurement Technologies (IPT)	406 & 408
Life Support International	401 & 402
Martin-Baker Aircraft Company, Ltd.	520 & 522
Massif	200
NASA Armstrong Flight Research Center	201
Networks Electronic Company	304
Omni Defense Technologies Corp.	504
Pacific Scientific Energetic Materials Company	524 & 526
Per Vivo Labs, Inc.	404
RINI Technologies, Inc.	240
SAFE Chapters	221
SECUMAR Bernhardt Apparatebau GmbH u. Co.	116
SEE/RESCUE Corporation	330
Signal Engineering, Inc.	432
Specmat Technologies, Inc.	114
SSK Industries, Inc.	430
Stacato, LLC	124

Stratus Systems, Inc	333
Survitec	332 & 334
Survival Innovations, LLC	130
Switlik Survival Products	329 & 331
Systems Technology, Inc.	126 & 128
Teledyne Energetics	206 & 208
US Air Force Research Laboratory	108
Wild Things	400
Wing Inflatables, Inc.	141 & 238
Wolf Technical Services	103
Zodiac Aerospace	307 & 309

SATURDAY, OCTOBER 12TH

SATURDAY – NOON – 5:30 PM
EXHIBITOR MOVE-IN
EXHIBIT HALL - SUMMIT PAVILION

SUNDAY, OCTOBER 13TH

SUNDAY - 7:00 AM – 4:00 PM
EXHIBITOR MOVE-IN
EXHIBIT HALL – SUMMIT PAVILION

SUNDAY – 2019 SAFE GOLF TOURNAMENT
START TIME - 8:30 AM – SHOTGUN START
REGISTRATION/SIGN-IN - 8:00 AM-8:30 AM (AT GOLF COURSE)

SUNDAY - NOON – 6:00 PM
REGISTRATION OPEN
LOCATION: GRAND SALON

SUNDAY – 5k RUNNER 2019
START TIME - 3:00 PM

SUNDAY - 7:00 PM – 9:00 PM
GET – ACQUAINTED RECEPTION
LOCATION: EXHIBIT HALL- SUMMIT PAVILION
EXHIBITS WILL BE OPEN

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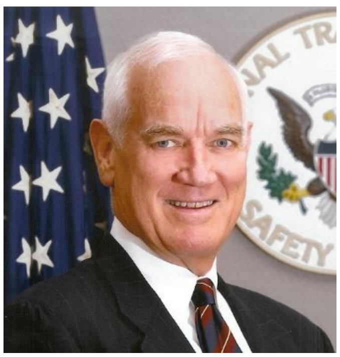
MONDAY, OCTOBER 14TH

MONDAY - 7:00 AM – 4:00 PM
REGISTRATION OPEN
LOCATION: GRAND SALON REGISTRATION

MONDAY – 8:00 AM – 8:30 AM
SYMPOSIUM WELCOME AND OPENING
LOCATION: RENO BALLROOM

MONDAY – 8:30 AM – 9:30 AM
SPECIAL PRESENTATION SPEAKER - MR. DICK HEALING
LOCATION: RENO BALLROOM

Immediately following the Special Presentation Speaker, the 2019 SAFE Association Awards will be presented. We ask that you remain in the Reno Ballroom and help us congratulate our 2019 SAFE Award Recipients.



SPECIAL PRESENTATION SPEAKER

HONORABLE RICHARD F. HEALING, P.E.
President and Chief Executive Officer
Air Safety Engineering, LLC

National Commission on Military Aviation Safety, Vice Chairman
(November 2018 – present)
National Transportation Safety Board, Board Member
(March 2003 - July 2005)
Director, Safety & Survivability, Department of the Navy

Richard F. Healing, a professional engineer and internationally recognized transportation safety expert, founded Air Safety Engineering, LLC in 2015 to provide expert air safety analysis and effective solutions to all aviation communities, from general aviation to military aviation and commercial operators.

In November 2018, President Donald Trump appointed him as Commissioner, National Commission on Military Aviation Safety, where he serves as Vice Chairman of the Commission. In July 2002, Mr. Healing was nominated by President George W. Bush to become a Board Member of the National Transportation Safety Board (NTSB) where he held the Safety Engineering position and provided key technical inputs on numerous transportation accident investigations with major national interest.

From 1985 to 2002, as Director, Safety and Survivability, for the Department of the Navy, most of his work involved aviation safety for both Navy and Marine Corps. He co-developed the Secretary of the Navy's Non-Development Item and Commercial-Off-The-Shelf (NDI/COTS) program, cutting "red tape" to rapidly bringing state of the art safety and survivability technology into the Navy and Marine Corps. His team introduced HEED bottles – mini-SCBAs that saved the lives of more than 200 Navy and Marine Corps helicopter crewmembers in at-sea crashes before his retirement from Navy Civilian Service in 2002. Mr. Healing is also an expert in human factors which are primary causal factors in aviation crashes.

Mr. Healing retired as a Captain from the U.S. Coast Guard Reserve. In his 32-year combined active and reserve service, he held 4 commands including a coastal patrol boat on combat missions in Vietnam in 1966-67.

He retired in 1993 following his command tour of the Secretary of Defense Crisis Coordination Center Joint Reserve Unit in the Pentagon during OPERATIONS DESERT SHIELD and DESERT STORM.

He earned numerous awards, including the Navy's highest civilian award - the Distinguished Civilian Service Medal and an Aviation Week "Laurel" for bringing improvements in wiring health and condition monitoring technology in aviation. His military awards include the Defense Superior Service Medal, a Navy Meritorious Service Medal, USCG Commandant's Letter of Commendation, and the Combat Action Ribbon.

A licensed Professional Engineer since 1974, Mr. Healing attended the U.S. Coast Guard Academy from 1959-1962 and graduated from Worcester Polytechnic Institute in 1964. He graduated from the Naval War College in 1990 and was a Senior Executive Fellow (SEF) at Harvard University in 1991.

Mr. Healing and his wife, Darlene, reside in Lewes, Delaware. He is a member of AOPA (Aircraft Owners and Pilots Association), Flight Safety Foundation (FSF), International Helicopter Safety Team (IHST), Helicopter Association International (HAI), Vertical Flight Society (formerly AHS), Naval Helicopter Association (NHA) and HeliOffshore (an international aviation safety association based in London). He is a charter member of the National Safety Council's (NSC's) Road To Zero (RTZ) highway safety coalition, and Vice President and a Director of the Laura Taber Barbour Air Safety Foundation.

MONDAY – 9:30 AM –10:00 AM
PRESENTATION OF 2019 SAFE ASSOCIATION AWARDS
LOCATION: RENO BALLROOM

MONDAY – 10:00 AM – 10:30 AM
AM REFRESHMENT BREAK
LOCATION: GRAND SALON

MONDAY – 10:30 AM – 11:15 AM
SAFE ASSOCIATION GENERAL MEMBERSHIP MEETING
LOCATION: TAHOE ROOM

MONDAY – 11:15 AM – 11:45 AM
AUTHOR'S COORDINATION BRIEFING
LOCATION: CARSON 1 & 2

MONDAY – 11:30 AM – 7:00 PM
EXHIBITS OPEN
LOCATION: EXHIBIT HALL - SUMMIT PAVILION

MONDAY – 11:30 AM – 1:00 PM
AWARDEE LUNCHEON
LOCATION: EXHIBIT HALL - SUMMIT PAVILION

MONDAY: 1:00 P.M. – 2:30 P.M.
HEARING PROTECTION
LOCATION: CARSON 1 & 2
MODERATOR: Dr. Alston Rush, NAVAIR

BRIEFING: Evaluation of Custom Earplug Variation and Digital Ear Canal Scanning Technologies - Tyler Winningham, Kristen Semrud, M.S.; Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD

INTRODUCTION: The U.S. Navy currently uses the silicone impression method, an invasive procedure that carries a risk of ear injury such as a blow by or ear irritation, to obtain the ear canal geometry required for custom molded earplugs. This study is evaluating two digital ear canal scanning technologies relative to the current physical impression method in order to qualify one of the digital devices as a replacement for the existing legacy method.

METHODS: Thirty volunteers had physical impressions and two types of digital scans taken. One set of digital scans using the United Sciences eFit scanner and the other using the Lantos Aura 3D scanner. Each volunteer completed personal attenuation rating (PAR) assessments for five pairs of earplugs from each ear canal geometry source using the FitCheck Solo system. The PAR measurements were used to analyze variability of outsourced manufactured earplugs from a single ear canal geometry source and compare the performance of the earplugs between sources. Real Ear Attenuation at Threshold (REAT) testing was conducted on the top performing earplugs from each sub-set as determined by the PAR scores.

Three dimensional scans of the physical impressions were compared to the direct digital scans using an overlay technique to highlight differences in ear canal geometry between the methods.

RESULTS AND DISCUSSION: Testing and data collection will commence in August of 2019. The data collected over the past eight months of the study will include 450 PAR assessments, 90 REAT tests, and 180 digital overlays.

BRIEFING: **Hearing protection for aircraft maintainers and the effect on speech intelligibility –** Billy Swayne[1], Hilary Gallagher[2]; [1]Ball Aerospace and Technologies Corporation, Dayton, OH, [2]Air Force Research Laboratory 2, Wright-Patterson Air Force Base, OH

INTRODUCTION: Aircraft maintainers work in hazardous noise nearly every day of their military careers. The noise environment on the flight line varies in level and spectral properties, both of which affect the amount of hearing protection required to reduce the risk of hearing loss and other hearing related disabilities. Typically, single hearing protection (SHP) is required on the flight line until aircraft are powered on, after which double hearing protection (DHP) is required. DHP may provide an adequate amount of protection from aircraft noise, but the proper use of earplugs, specifically foam earplugs, may degrade speech intelligibility (SI) performance. Due to this degradation, many maintainers fit foam earplugs incorrectly or fail to wear them at all in order to improve SI performance, ultimately lowering the amount of protection provided. The objective of this study was to assess the impact of single and double hearing protection on noise attenuation and SI performance.

METHODS: Passive noise attenuation measurements were conducted in accordance with ANSI S12.6 and speech intelligibility performance measurements were conducted in accordance with ANSI S3.2. Three general categories of earplugs were examined: foam, filtered, and communication earplugs. The earplugs were tested alone (SHP) and in combination with a passive circumaural headset (DHP).

RESULTS AND DISCUSSION: All DHP combinations provided appropriate levels of protection for aircraft maintainers operating on the flight line, regardless of the earplug worn in combination with the headset. However, SI performance was dependent on the type of earplug worn in combination with the headset when communicating through an aircraft intercom system in noise environments of 105 dBA and greater. Filtered and communication earplugs provided acceptable SI performance, while performance with foam earplugs in combination with the headset was unacceptable. Face-to-face SI performance measurements were acceptable for SHP (foam and filtered earplugs) in 85 dBA noise environments.

BRIEFING: **Insta Active Noise Reduction Evaluation in Finnish Air Force F/A-18 Fleet –** Mr. Pekka Lehtonen; Insta ILS Oy, Tampere, Finland

INTRODUCTION: Exposure to high noise levels is a common problem in military aviation. Pilots and aircrews suffer from noise-induced problems such as permanent hearing damage. Noise also causes different psychologic and physiologic effects such as pain, discomfort, speech intelligibility problems, increased number of mistakes and degraded focus and decision-making capability. (FAA)
Finnish Air Force pilots have traditionally used helmets with soft earcups and custom molded CEP's. However, the protection level and overall performance has not been satisfactory. Noise issues persist especially at low frequencies where passive noise attenuation is not effective.

METHODS: Finnish Air Force has evaluated Insta ANR Active Noise Reduction earcups in their F/A-18 JHMCS flight helmets since the beginning of the year 2019. The evaluation included reference measurements performed by Finnish Institute of Occupational Health and several flights in F/A-18 aircraft as part of daily flight operations. Insta ANR earcups have been used in operational flights in two squadrons for several months. This briefing summarizes the results of the evaluation including results from the reference measurements and feedback gathered from the pilots.

RESULTS AND DISCUSSION: Results from reference measurements show that Insta ANR effectively reduces noise levels in pilot ears. During the time of writing this abstract, the evaluation period is still ongoing. Final results will be available by the end of the year 2019. Feedback from F/A-18 pilots has been very positive. Pilots report easier understanding of radio communications, easier to hear warnings and overall much more comfortable noise levels during flight.
Insta ANR can be used as an effective way of reducing pilot and aircrew noise exposure both in fixed wing and rotary wing aircraft. Insta ANR earcups can be tailored to fit most available flight helmets and the technology can be transferred to headsets and hearing protector applications.

MONDAY: 1:00 P.M. – 2:30 P.M.
BIOMECHANICS (INJURY PREVENTION)
LOCATION: CARSON 3 & 4
MODERATOR: Jeff Somers, KBR

BRIEFING: **Rate-Activated Tethers: Wearable Smart Materials to Reduce Mechanical Injuries to Body and Brain –** Dr. Eric D. Wetzel; CCDC U.S. Army Research Lab, Aberdeen Proving Ground, MD

INTRODUCTION: Injuries during work and play, for both civilians and military personnel, result in lost time, decreased productivity, increased health care costs, and reduced quality of life. A common theme in many of these injuries, from sprained ankles to brain injury, is an association between rapid dynamic mechanical input and injury likelihood. Existing wearable protective devices, including ankle and knee braces, helmets, and body pads, are typically constructed from materials whose low-speed and high-speed behaviors are very similar. In contrast, a dynamically responsive material that transforms into a more protective state during high rate mechanical impulses could improve the comfort and performance of wearable protection.

METHODS: The U.S. Army Research Laboratory has invented a dynamic strapping material called a "rate-activated tether" (RAT). RATs exhibit elastic compliance at low speeds, similar to elastic straps, but resist extension with up to 100 times more force when elongated at high speeds. The rate sensitivity of RATs is derived from an enclosed shear thickening fluid (STF), a colloidal material with speed-sensitive resistance to flow. This talk will describe the basic design and behavior RATs, the influence of STF and component properties, and challenges with integration. A number of application examples will be presented, including goggle straps, ankle braces, helmet suspensions, and helmet chinstraps. Various biomechanical metrics include limb kinematics, head acceleration, and protective material displacement are quantified using accelerometers, specialized impact testing, high speed video, and video analysis.

RESULTS AND DISCUSSION: Over a wide range of system evaluations, the RAT technology demonstrates a unique combination of injury metric reduction combined with low-speed comfort. It is hoped that this presentation will stimulate new ideas and collaborations for using RAT technology for other safety and injury-prevention applications.

BRIEFING: **Advanced Technologies for Long-Term Aircrew Stamina (ATLAS)** – Deepak Sathyanarayan, Lisa Lucia, Zachary Keihl, Robert McCormack; Aptima, Inc., Woburn, Massachusetts

INTRODUCTION: The physical stress of military flight can lead to serious, long-term musculoskeletal injuries. Managing and mitigating health risks of aircrews is problematic when insufficient data exists to properly diagnose, treat, and prevent injuries. The Advanced Technologies for Long-Term Aircrew Stamina (ATLAS) system is being developed to proactively identify, assess, and manage musculoskeletal risks to aircrew. A focus on cervical and lumbar spine data guides ATLAS to provide immediate insights to high-occurrence aircrew injuries.

METHODS: ATLAS includes three key features: (1) a novel spine sensor to collect musculoskeletal state data along the spine, (2) a functional state estimation (FSE) engine that enables modeling and classification of musculoskeletal function, and (3) an advanced decision support tool leveraging partially observable Markov decision processes (POMDP) for generating adaptive treatment recommendations (i.e. physical therapies/exercises, behavioral modifications). Data obtained from in situ sensors (via cervical spine electromyography, pelvic pressure sensing, and spine accelerometry) provide real-time longitudinal tracking of spine kinematics and body loading during a mission. ATLAS system components have been tested in the laboratory setting, in flight gear, while replicating operational cervical spine motions. Supplemented by acute-event and pain self-report data, ATLAS data is analyzed by the FSE engine to differentiate and identify dynamic spinal heath states through and across missions. Robust classification models enable timely predictive analyses necessary for effective recommendations before the onset of acute pain and chronic injury.

RESULTS AND DISCUSSION: Cervical spine muscle activations are tracked in parallel with spine accelerations to support lumbar spine injury risk models, cumulative occupational load analytics, and spine health classification algorithms. Model outputs provide feedback to medical practitioners and aircrew members in the form of recommended treatment options focused on physical therapies/exercises and behavioral modifications. ATLAS will improve operator physiology and equipment system design within ergonomically risky occupations (e.g., excessive vibration, on-body loads, and sitting).

BRIEFING: **Counterbalance Usage Toward Mitigating Neck Pain –** Philip S. E. Farrell, Ph.D; Defence Research and Development Canada, Toronto, Ontario, Canada

INTRODUCTION: Counter Weight (CW) is used to counterbalance Night Vision Googles (NVGs) to mitigate neck discomfort. However, Griffon helicopter aircrew neck pain prevalence rates continue to be high at 80% (Adam, 2004) and 75% (Chafé& Farrell, 2016). Although this counterbalance concept seems logical, its operational use has not been optimized.

METHODS: Three studies produced scientific advice on counterbalance. Tack, Bray-Miners, Nakaza, Osborne, and Mangan (2014) investigated various Griffon aircrew CW-helmet-NVG configurations using task and physical demands modelling and simulation. Farrell, Shender, and Fusina (2018) developed a neck supported mass model expressed symbolically in terms of head, helmet, NVGs, and CW mass properties, neck joint angles, a friction coefficient term representing helmet fit, and resultant neck loads and muscle activation. This model allowed us to track counterbalance effectiveness as a function of head position. Farrell, Maceda, et al. (2018) collected muscle activity and external loading for three helmet systems with different mass properties. The study's participants wore their in-service (often poorly fitted) helmet system with their own CW ranging from 0.0 to 0.896 kg (recommended maximum weight is 0.370 kg).

RESULTS AND DISCUSSION: From these studies we observe that 1) CW adds to neck loading, 2) CW adds to neck torques in a head down position, and 3) CW coupled with poor helmet fit adds to neck loading and muscle activation. Given that CW provides counterbalance only in a relatively neutral head position, we advise that the minimum CW needed for each role and mission is used, the recommended CW limit is not exceeded, fast dynamic head movements and non-neutral positions are avoided whenever possible, and a proper helmet fit be obtained that minimizes slippage and maximizes comfort.

MONDAY: 1:00 P.M. – 2:30 P.M.
TRAINING (HYPOXIA)
LOCATION: CRYSTAL 1 & 2
MODERATORS: Beth Atkinson, NAVAIR / LCDR Tim Welsh, ASTC, Pensacola

PANEL: Hypoxia Training: Advancing & Understanding the Mask-On Hypoxia Training Environment

INTRODUCTION: The panel will include presentations that provide an overview of advances underway for mask-on hypoxia training, as well as research underway to continue to advance the understanding of mask-on hypoxia training. In particular, the focus of the panel will be:

(1) Advances to mask-on hypoxia training devices and instructional capabilities
(2) A comparative analysis of training experiences between experts and novices
(3) The predictability of demographic factors based on recovery time
(4) A review of qualitative speech measures for automated detection of hypoxic states

PANEL CHAIRS:

Ms. Beth Atkinson –Basic & Applied Training & Technologies for Learning & Evaluation Lab (BATTLE Lab) Lead, Naval Air Warfare Center Training Systems Division, Orlando, FL

LCDR Tim Welsh – Director, Aviation Survival Training Center, Pensacola, FL

PRESENTERS:

Technology Solutions for Advanced Instruction of Mask-on Hypoxia – Beth F. Wheeler Atkinson[1], LCDR Lee Sciarini[2], LT Christopher Gilg[3], LCDR Gregory Boggs[4], Emily C. Anania[5]; [1]Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL; [2]Naval Survival Training Institute (NSTI), Pensacola, FL; [3]Aviation Survival Training Center (ASTC), Pensacola, FL; [4]Joint Strike Fighter Wing, Lemoore, CA; [5]Don Selvy Enterprises, Bel Air, MD

INTRODUCTION: Historically, the U.S. Navy has supported initial and refresher hypoxia training using the low-pressure chambers based on aviation survival training requirements (Department of the Navy, 2004). While these devices offer the ability to experience physiological responses to both hypoxia and pressure changes, their training value is limited due to the lack of relevant tasking available. In an effort to modernize training and overcome previous training limitations, the U.S. Navy is moving to normobaric hypoxia training devices for both mask-off and mask-on training.

METHODS: This presentation will focus on the advances in training and instructional technologies associated with mask-on hypoxia training, which includes the On-Demand Hypoxia Trainer (ODHT) and a reconfigurable cockpit. The ODHT is a mobile-sized hypoxia training device capable of delivering continuous pressure-on-demand airflow to an aviator's oxygen mask with varying oxygen levels. The development of this technology provides an alternative training system that minimizes existing training challenges due to air hunger (e.g., Artino, Folga, & Vacchiano, 2009) while increasing fidelity of training experience through pressure-on-demand capability. The reconfigurable cockpit provides a means to ensure aviators have relevant flight tasking, are using realistic controls, and have the ability to execute emergency procedures specific to their airframe.

RESULTS AND DISCUSSION: The goal of this training solution is to increase immersion, while avoiding any potential negative training. Additionally, the team will present initial feasibility investigations underway to determine the ability to train situations other than hypoxia leveraging this device, such as oxygen system malfunction situations. Finally, this presentation will address the continued research and development efforts that are underway to refine the embedded instructional capabilities to ensure that the fleet is provided technology that facilitates the training feedback through enhanced debriefing solutions. In addition to providing an overview of these technologies, this presentation will provide an overview of informal human factors evaluations of the prototype instructor console and engineering testing with a military population.

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REFERENCES:
Artino, A. R., Folga, R. V., & Vacchiano, C. (2009). Normobaric hypoxia training: the effects of breathing-gas flow rate on symptoms. *Aviation, Space, and Environmental Medicine*, *80*(6), 547-552.
Department of the Navy. (2004, March 1). *NATOPS General Flight and Operating Instructions* (OPNAV Instruction 3710.7U). Washington, DC: Office of the Chief of Naval Operations.
Scheeler, W. T., Atkinson, B. F. W., & Tindall, M. J. (2014). Training naval aviators to recognize hypoxia symptoms: Advancing technologies to address a continued safety threat. *Proceedings of the SAFE Symposium,* Orlando, FL.

Comparing the Hypoxia Training Experiences of Novice and Expert Pilots – Jacob Entinger[1], Emily Rickel[1*], Benjamin Finch[1*], Mitchell Tindall[1], Beth F. Wheeler Atkinson[1], CDR Jon D. Champine[2]; [1]Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL; [2]Aviation Survival Training Center (ASTC), Miramar, CA

INTRODUCTION: Hypoxia, or oxygen deprivation at the tissue level, is a well-known threat to aviators that can cause significant impairments in cognitive, physical, and/or psychomotor capabilities (Files, Webb, & Pilmanis, 2005). Current training efforts induce hypoxia symptoms in a controlled environment to familiarize trainees with the hypoxic experience (Smith, 2008). These training efforts have been shown to promote aviator recognition of hypoxia in operational settings (Cable, 2003; Files, Webb, & Pilmanis, 2005; Smith, 2008). However, past research demonstrates that the training experience between novice and experienced aviators is not always consistent (Tindall, Atkinson, & Entinger, 2019). Experienced aviators reported more instances of air hunger than novice aviators. Beyond this, little research has been done to determine what, if any, other differences in experience exist between novice and experienced pilots.

METHODS: To address this research gap, trainees' demographic (i.e., age, gender, flight hours, lifestyle/wellness factors, stress survey), symptomatic (i.e., frequency and severity of self-reported and observed symptoms), and physiological (i.e., heart rate, breath rate, and temperature) data was collected from three Aviation Survival Training Centers (ASTCs). Participants were divided into two groups, Novice (n = 66) and Expert (n = 26), based on their number of completed flight hours and previous hypoxia training events.

RESULTS AND DISCUSSION: Results discussed in this presentation will highlight differences in the frequency and severity of observed and self-reported symptoms between the Novice and Expert groups. Additionally, this presentation will explore the most commonly missed symptoms by both observers and trainees. Overall, the results will provide a more holistic understanding of the differences that exist between these two populations. Understanding these differences may provide opportunities to enhance training fidelity and contribute to constructing future learning and monitoring systems that aim to prevent and combat the detrimental effects of hypoxia.

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REFERENCES:
Cable, G. G. (2003). In-flight hypoxia incidents in military aircraft: Causes and implications for training. *Aviation, Space, and Environmental Medicine, 74*(2), 169-172.
Files, D. S., Webb, J. T., & Pilmanis, A. A. (2005). Depressurization in military aircraft: Rates, rapidity, and health effects for 1055 incidents. *Aviation, Space, and Environmental Medicine, 76*(6), 523-529.
Smith, A. M. (2008). Hypoxia symptoms in military aircrew: Long-term recall vs. acute experience in training. *Aviation, Space, and Environmental Medicine, 79*(1), 54-57.

Tindall, M., Atkinson, B. F. W., & Entinger, J. (2019, May). Understanding the causes of air hunger during mask-on hypoxia training. Presented at the 90th Annual Scientific Meeting of the Aerospace Medical Association (AsMA), Las Vegas, NV.

Predictability of Demographic Factors on Recovery Time - Mitchell Tindall, Benjamin Finch*, Jacob Entinger, Emily Rickel*, Beth F. Wheeler Atkinson; Naval Warfare Center Training Systems Division (NAWCTSD), Orlando, FL

INTRODUCTION: Hypoxia, a lack of oxygen in the body, is a subtle and potentially deadly threat for aviators. More specifically, acute hypoxia, or hypoxia brought upon by a sudden and drastic change in altitude, can lead to various deleterious effects on an individual's mental and physiological state (Van Puyvelde, Neyt, McGlone, & Pattyn, 2018). When training, aviators receive classroom education on the signs and symptoms of hypoxia, common factors that can lead to higher susceptibility to hypoxia, and the proper emergency procedures in case of a hypoxic experience. However, little information is given or known about factors that affect an individual's ability to recover from a hypoxic experience.

METHODS: The purpose of this research is to identify sources of variability in an aviator's recovery time from a hypoxic experience. Data was collected from Naval aviators (*N=109)* with varying levels of experience from three Aviation Survival Training Centers (ASTCs). Previous factor analysis results (Keebler & Simonson, 2019) were used to create four demographic variables of interest: Physical Health, Mental Health, Drug Usage (i.e., caffeine intake, alcohol consumption), and Experience. A linear regression was performed to determine the predictability of various demographic factors on recovery time. Initial results yielded an insignificant model (R^2=.09, $F(4,82)$=1.98, p>.05), however, Experience (β=.01, p<.05) remained a significant predictor and Physical Health (β=-.17, p=.11) approached significance. A second regression was run using only Physical Health and Experience. The resulting model was significant (R^2=.12, $F(2,85)$=5.55, p=.005).

RESULTS AND DISCUSSION: Results from this study can be used to inform aviators on ways to reduce the amount of time needed to recover from hypoxia. Overall, this study will result in a more holistic understanding of the entire hypoxic experience.

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REFERENCES:
Cable, G. G. (2003). In-flight hypoxia incidents in military aircraft: Causes and implications for training. *Aviation, Space, and Environmental Medicine, 74*(2), 169-172.
Files, D. S., Webb, J. T., & Pilmanis, A. A. (2005). Depressurization in military aircraft: Rates, rapidity, and health effects for 1055 incidents. *Aviation, Space, and Environmental Medicine, 76*(6), 523-529.
Smith, A. M. (2008). Hypoxia symptoms in military aircrew: Long-term recall vs. acute experience in training. *Aviation, Space, and Environmental Medicine, 79*(1), 54-57.
Tindall, M., Atkinson, B. F. W., & Entinger, J. (2019, May). Understanding the causes of air hunger during mask-on hypoxia training. Presented at the 90th Annual Scientific Meeting of the Aerospace Medical Association (AsMA), Las Vegas, NV.

A Review of Qualitative Speech Measures for Detecting Hypoxia - Emily Rickel[1*], Benjamin Finch[1*], Corey Zucker[1*], Mitchell Tindall[1], & Beth F. Wheeler Atkinson[1], LT Christopher Gilg[2]; [1]Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL; [2]Aviation Survival Training Center (ASTC), Pensacola, FL

INTRODUCTION: Hypoxia, or oxygen deprivation at high altitudes, is a hazard frequently encountered in aviation that can lead to catastrophic outcomes. Detecting hypoxia through individual physiological indicators (e.g., SpO_2, heart rate, breath rate) alone is insufficient as numerous observations in training show aviators exhibit and report the onset of symptoms at varying levels of these physiological indicators. Additionally, the devices used to measure physiological indicators are prone to inaccuracy. Furthermore, aviators may not be the most reliable source for recognizing whether they are hypoxic due to the adverse cognitive states that can result from hypoxia.

METHODS: Slurred speech is one of many hypoxia symptoms experienced by military aircrew during hypobaric chamber training sessions. Prior research also indicates that hypoxic aviators and mountain climbers exhibit several changes in their speech characteristics. These findings suggest that speech may provide a noninvasive, unobtrusive supplement to current hypoxia detection methods. To investigate whether speech is a viable detection method for hypoxia, a multi-disciplinary literature review of qualitative speech metrics was conducted.

RESULTS AND DISCUSSION: This review found efforts from the medical domain (e.g., speech analysis of Parkinson's patients, questionnaires used in speech therapy evaluations) that have developed tools and defined metrics used to analyze speech. This presentation will discuss some of these metrics (e.g., intelligibility, post-prompt silent pauses, disfluency frequency), as well as how they can be used to determine the presence of hypoxia. Overall, analysis of speech characteristics demonstrate potential as a biomarker for hypoxia. Efforts to understand how variations in speech characteristics can detect hypoxia may lead to a method of early and objective identification of hypoxia, increasing aviators' ability to detect and mitigate physiological events.

*Author's Note: The views expressed herein are those of the authors and do not necessarily reflect the official position of the DoD or its components. Distribution Statement A - Approved for public release; distribution is unlimited, as submitted under NAVAIR Public Release Authorization 19-ORL056. *Ms. Emily Rickel, Mr. Benjamin Finch, and Mr. Corey Zucker were participants of the Naval Research Enterprise Internship Program (NREIP) assigned to NAWCTSD at the time of this publication.*

REFERENCES:
Acharya, S., Rajasekar, A., Shender, B., Hrebien, L., & Kam, M. (2016). Real time hypoxia prediction using decision fusion. *IEEE Journal of Biomedical and Health Informatics, 21*(3), 696-707.
Files, D. S., Webb, J. T., & Pilmanis, A. A. (2005). Depressurization in military aircraft: Rates, rapidity, and health effects for 1055 incidents. *Aviation, Space, and Environmental Medicine, 76*(6), 523-529.
Johnston, B. J., Iremonger, G. S., Hunt, S., & Beattie, E. (2012). Hypoxia training: Symptom replication in experienced military aircrew. *Aviation, Space, and Environmental Medicine, 83*(10), 962-967.
Kiss, G., Sztahó, D., Vicsi, K., & Golemis, A. (2014, November). Connection between body condition and speech parameters-especially in the case of hypoxia. In *2014 5th IEEE Conference on Cognitive Infocommunications (CogInfoCom)* (pp. 333-336).
Lieberman, P., Morey, A., Hochstadt, J., Larson, M., & Mather, S. (2005). Mount Everest: A space analogue for speech monitoring of cognitive deficits and stress. *Aviation, Space, and Environmental Medicine, 76*(6), B198-B207.
Obrenović, J. (2002). Fundamental frequency of the voice in relation to hypoxia as a stress factor. *FACTA UNIVERSITATIS-Philosophy, Sociology, Psychology and History*, (9), 683-689.
Smith, A. M. (2008). Hypoxia symptoms in military aircrew: Long-term recall vs. acute experience in training. *Aviation, Space, and Environmental Medicine, 79*(1), 54-57.
Sondhi, S., Khan, M., Vijay, R., Salhan, A. K., & Sharma, S. K. (2015). Effect of normobaric and hypobaric hypoxia on formant characteristics of human voice. *International Journal of Computer Applications, 122*(15), 32-37.
Van Puyvelde, M., Vanderlinden, W., Van den Bossche, M., Bucovaz, T., De Winne, T., Neyt, X., & Pattyn, N. (2017). When the hypoxia "silent killer" starts to talk: The early detection of pre-symptomatic hypoxia through voice stress analysis. *Journal of Science and Medicine in Sport, 20*, S44.

MONDAY: 1:00 P.M. – 2:30 P.M.
SYSTEMS & SAFETY
LOCATION: CRYSTAL 3 & 4
MODERATOR: Danielius Zilevicius, NAVAIR

BRIEFING: **SAE International Best Practice Standard for Human Systems Integration (HSI) –** Stephen Merriman; SCMerriman Consulting, LLC, Allen, TX

INTRODUCTION: This presentation will provide an introduction to Human Systems Integration (HSI) and the new SAE International HSI best practice standard (SAE6906), released in February 2019. DoD and other customers currently require HSI program plans in accordance with Department of Defense Data Item Description (DID) DI-HFAC-81743A. It is assumed that, for future system acquisition programs, customers (especially DoD) will require establishment and execution of a Human Systems Integration program in compliance with SAE Systems Management Standard SAE6906.

This presentation will provide an overview and description of HSI and its seven Domains and describe the HSI program planning process. In addition, it will describe development and tailoring of HSI program plans, coordination of HSI activities with other program disciplines, execution of HSI programs, documentation and progress reporting.

Briefing: Retrospective Review of Causes in Military Ground Vehicle Accidents, 2010-2015 - Jennifer D. Dudek, MPH[1,2], MAJ Grace M. Lidl, DVM, MD MPH[1], V. Carol Chancey, PhD[1], Mary C. Clouser, PhD MPH[3, 4]; [1]U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL; [2]Katmai Government Services, Orlando, FL; [3]Leidos, San Diego, CA; [4]Naval Health Research Center, San Diego, CA

INTRODUCTION: A team from the Tank Automotive Research, Development, and Engineering Center (TARDEC) requested the Joint Trauma Analysis and Prevention of Injuries in Combat (JTAPIC) partnership conduct a retrospective analysis of casualties from ground vehicle accidents. The primary focus of the study was to examine accident narratives and casualty injuries to improve occupant survivability. The analysis included nonbattle related injuries and deaths sustained by U.S. Army Service Members in the following vehicle platforms: High Mobility Multipurpose Wheeled Vehicle (HMMWV), Mine Resistant Ambush Protected (MRAP), Stryker, and Family of Medium Tactical Vehicle (FMTV).

METHODS: The Survival Analysis Team of the United States Army Aeromedical Research Laboratory (USAARL) conducted a multistage retrospective analysis of ground vehicle collision, rollover, or collision with rollover accidents from 2010 through 2015. Cases were identified from multiple data sources and reviewed by a panel of military, civilian, and contractor subject matter experts. Statistical significance was set as $p < 0.05$.

RESULTS and DISCUSSION: There were a total of 365 accidents with 558 casualties (512 nonfatal and 46 fatal). Rollovers were the leading cause of accidents, casualties (both nonfatal and fatal), and injuries. Rollovers were most frequently caused by a sequence of driver actions and difficult environmental conditions. Overall, driver actions were the leading causes of all accident types.

This study identified several common trends among the vehicle platforms important to the development of strategies to prevent or mitigate traumatic injuries in ground vehicle accidents. Driver errors seemed to be rooted in drivers' failure to match driving maneuvers to the vehicle characteristics and environmental conditions. These findings have implications for doctrine, training, and vehicle design. Further study regarding driver attitude and training methods is needed. As expected, unrestrained occupants sustained more injuries and injuries of greater severity compared to restrained occupants.

BRIEFING: Blending Chronic Injury Mitigation with Acute Injury Mitigation in Crashworthy Seating Systems – Lindley Bark; Naval Air Warfare Center Aircraft Division, Patuxent River, MD

INTRODUCTION: Since the 1970s, crashworthy seating systems have been developed and fielded for military rotorcraft. While the human was considered in shaping, contouring, and sizing a seating system, the then current state-of-the knowledge brought to bear was often focused on geometric accommodation. Further, there are several examples were human accommodation was at least partially compromised during aircraft design to achieve system-level aircraft requirements. This ‘comfort degradation’ and the resulting accommodation deficit was not considered to be a major issue requiring correction. Historically, there is a persistent differentiation between cockpit occupants and cabin occupants resulting in more money and focus on cockpit crewmembers.

METHODS: More recently, ergonomic issues have been shown to potentially cause substantial long-term harm in environments that were either accepted or previously believed to be benign. This is true for the cockpit and cabin occupants. One such location is the MH-60S Gunner position for which a program was initiated and executed to develop and field a new seating system that would improve acute injury mitigation (crash safety) and also provide mitigation of chronic injury for these occupants as well.

DISCUSSION: The proposed presentation will describe the blending of the seemingly contradictory requirements and design practices to achieve both acute and chronic injury mitigation. The thought processes, engineering trades, and balancing of the trades will be described. Additionally, the methodologies of soliciting fleet aircrew input for subjective requirements will be brought to light.

MONDAY – 2:30 PM – 3:00 PM
PM REFRESHMENT BREAK
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

MONDAY: 3:00 P.M. – 4:30 P.M.
OXYGEN (MONITORING)
LOCATION: CARSON 1 & 2
MODERATOR: Erica Gowen, NAVAIR

BRIEFING: Aircrew Mounted Gas Analysis System (AMGAS): Developing a Sensor for Monitoring Nitrous Oxide & Volatile Organic Compounds in the Aircrew Breathing Gas - Katie Cabungcal, Leela Bhat; NAVAIR, Human Systems Department, Patuxent River, MD

INTRODUCTION: A concern that aircraft On Board Oxygen Generating Systems (OBOGS) may contain nitrous oxide (N_2O) prompted an interest in measuring N_2O in the aircrew breathing gas during aircraft operations. A market survey failed to identify a compact, battery-operated N_2O sensor with sensitivity in the range of interest (0-10 PPM). The Navy worked closely with engineers to develop and package the N_2O sensor with other sensors of interest into the Aircrew Mounted Gas Analysis System (AMGAS). Along with the N_2O sensor, the AMGAS includes a Photo Ionizing Detector (PID) for measuring volatile organic compounds (0-2 PPM), an oxygen sensor for measuring breathing gas O_2 concentration (0-100%), and a barometric pressure sensor (0-15 PSIA) so the data can be correlated with cockpit altitude. The AMGAS is a passive data collection system that includes all of the hardware necessary to adapt the system to T-45, F/A-18, and T-6 aircrew flight equipment. The AMGAS is man-mounted on the aircrew survival vest and independent of the aircraft. Oxygen breathing gas from the OBOGS is routed to the sensor suite using a flow-restricting orifice for T-45 and F/A-18 aircrew and a sample pump for T-6 aircrew. Data collection begins automatically which eliminates any action by the pilot. Data is stored in internal memory for post-flight download, or it can be viewed in real time using a laptop computer. System performance testing was conducted at ground level and in an altitude chamber with simulated human breathing to validate AMGAS performance. The overall results of testing showed exemplary performance from the VOC PID sensor, O_2 sensor, and barometric pressure sensor while the N_2O sensor showed satisfactory performance. Flight-testing in Navy aircraft is scheduled to begin in summer, 2019.

BRIEFING: PUNISHER: On-Aircraft Performance Testing – Nicke Boyd; NAVAIR, Human Systems Department, Patuxent River NAS, MD

INTRODUCTION: PUNISHER testing was developed to test the Carbon Monoxide catalyst and sieve material found in the T-45 and F/A-18 concentrator. The testing helps to determine the performance lifespan of the catalyst.

METHODS: The PUNISHER box is a mobile test set that can move from jet to jet to conduct testing on fleet aircraft. The concentrator is run at various flowrates and supply pressures and the oxygen concentration is recorded and compared to standards. The CO catalyst is tested by introducing a set concentration of Carbon Monoxide into the system. There are CO detectors in the box that sample air to determine performance of the catalyst. The lifespan of the catalyst is determined by repeat testing of set aircraft and squadrons. For the T-45, the same aircraft and concentrators, at various sites, are tested every 3 months to see if there is any degradation in the system. For the F/A-18, the same squadrons are tested every 3 months.

RESULTS AND DISCUSSION: The goal of the PUNISHER project is to add in additional maintenance requirements as necessary as degradation in the system is detected. To date, the highest hours on one of the tested aircraft is 1800 hours, with no issues. Through the end of FY20, the PUNISHER team will continue to track the same aircraft and squadrons and collect data using the PUNISHER test set to assess the lifespan of the CO catalyst.

BRIEFING: **Performance Evaluation of Handheld Gas Monitors Used in Aircraft Bleed Air Quality Ground Tests Targeting Nitrogen Oxides (NO_x) –** Ms. Raisa Marshall, Dr. Krisiam Ortiz-Martinez, Dr. Leah Eller; Naval Air Systems Command, Patuxent River NAS, MD

INTRODUCTION: Inorganic gases such as Nitrous Oxide (N_2O), Nitric Oxide (NO), and Nitrogen Dioxide (NO_2) are not captured by sorbent tubes that target volatile organic compounds (VOCs). A separate effort was made to evaluate air quality in the ECS systems of T-45 and F/A-18 aircraft in ground tests using handheld, portable meters. The Viasensor G200 Nitrous Oxide meter and the Rae Systems Multi-RAE, equipped with Nitric Oxide and Nitrogen Dioxide sensors, were used in combination to analyze ECS air for nitrogen oxides. These devices are typically used for indoor air quality assessments and in emergency responder situations. A subsequent laboratory evaluation of these devices was performed to establish the degree of uncertainty in results from the aircraft ground testing environment.

METHODS: The Viasensor G200 and RAE Multi-RAE devices were tested in a controlled laboratory environment using a range of concentrations of the target gases. Multiple units were tested to determine limits of reproducibility. Calibration drift as well as cross-sensitivity issues were considered. Limits of reliable quantification were compared against MIL-STD-3050 requirements and OSHA exposure limits.

RESULTS AND DISCUSSION: Results of these evaluations are reported and the suitability of these devices in the ground testing setup is discussed. This work establishes additional guidance for future air quality monitoring efforts in which nitrogen oxides are analytical targets.

MONDAY: 3:00 P.M. – 4:30 P.M.
BIOMECHANICS (ATD/MODELING)
LOCATION: CARSON 3 & 4
MODERATOR: Dr. Casey Pirnstill, WPAFB

BRIEFING: **Development and Calibration of the LSTC Hybrid III Large Male Finite Element Model Head-Neck Complex to Improve Predictive Capability Under Aerospace Loading Environments –** Jacob Putnam[1], Preston Greenhalgh[2], Jeffrey Somers[2], Charles Lawrence[3]; [1]NASA Langley Research Center, Hampton, VA; [2]KBR, Houston, TX; [3]Analytical Mechanics Associates Inc., Hampton, VA, USA

INTRODUCTION: In an effort to quantify the predictive capability of the Livermore Software Technology Corporation (LSTC)-provided Hybrid III (small female, mid-size male, and large male) anthropomorphic test device (ATD) finite element models (FEMs) within aerospace loading environments, the National Aeronautics and Space Administration

(NASA) performed a series of sled tests with the isolated head-neck complex of each ATD. These tests and subsequent modeling efforts revealed significant deficiencies in the large male head neck FEM. Differences in both the shape and material properties between the FEM and the physical ATD were identified. In order to improve the predictive response of the FEM, a model development effort was undertaken to update the head-neck complex to better represent the geometric and material properties of the physical ATD.

METHODS: To better match the physical geometry, a new neck component model was meshed and implemented into the Hybrid III large male head-neck complex. The updated geometry and weight were verified against measurements of the physical ATD to insure accuracy. The primary source of material discrepancy between the physical ATD and FEM was found to be in the material definition of the rubber neck pucks. Using LS-Opt® the material properties of this part were calibrated to match physical response of the head-neck complex in the isolated head-neck testing performed.

RESULTS AND DISCUSSION: The updated geometry and calibrated material properties were shown to significantly improve the FEM predictive accuracy under lateral, rear, and frontal impacts with combined horizontal and vertical loading. The results of this study demonstrate an effective means for improving ATD FEM response through isolated component level testing and material parameter optimization. The improved and quantified accuracy of the Hybrid III large male FEM head-neck complex stemming from with work lends to confidence in its future use for occupant protection evaluation of large male occupants.

BRIEFING: **Finite Element Modeling of the Isolated Head and Neck of Small Female and of Midsized Male Hybrid-III ATDs in Spaceflight Conditions –** Preston Greenhalgh[1], Jacob Putnam[2], Charles Lawrence[3], Jeffery Somers[1]; [1]KBR, Houston, TX; [2]NASA, Hampton, VA; [3]Analytical Mechanics Associates, Inc, Hampton, VA

INTRODUCTION: During spaceflight, crewmembers are subjected to complex, multi-axial loading. Anthropomorphic test device (ATD) finite element (FE) models are frequently tested in these conditions to assess injury risk. Past physical tests of ATDs in spaceflight conditions exhibited limited initial condition control, significant test variability, and data collection issues, which limited the effectiveness of these tests for correlation with FE models. To improve the confidence of FE models in these conditions, component level tests with a wider range of input loading conditions need to be explored.

METHODS: To improve the confidence in the spaceflight FE models, a test series was performed to explore the response of the isolated head-neck complex of a small female and mid-sized male Hybrid-III ATD when subjected to various spaceflight landing accelerations and loading directions. To correlate these tests, the input and boundary conditions were modeled using the Livermore Software Technology Corp. (LSTC) Hybrid-III ATD FE models in LS-DYNA. The head and neck were isolated, and the neck bracket was constrained and a prescribed impact pulse acquired from the experimental accelerometers was applied. ISO was used to objectively compare the experimental and model responses [1].

RESULTS AND DISCUSSION: In comparing the physical ATDs and the FE ATD models, a positive correlation between input acceleration and ISO score for the small female ATD was found for the frontal and lateral input cases; however, low correlation was found for the rearward input tests and for all cases with the midsized ATD. For both models, the frontal loading conditions had the highest average correlation, and both ATDs ranked similarly on data channel and injury metric performance. Understanding how FE ATD models correlate to physical ATDs gives better awareness of the confidence in the FE models to predict injury in spaceflight conditions.
[1] Barbat S., Fu Y., Zhan Z., Yang R. J. and Gehre C. "Objective Rating Metric for Dynamic Systems." in *Enhanced Safety of Vehicles Seoul*, Republic of Korea, 2013.

BRIEFING: A Global-Local Approach for Modeling Neck Injury during Ejection - Harsha T. Garimella[1], ZJ Chen[1], Phil Whitley[1], Andrzej Przekwas[1], Vikram Subramani[2], Reuben Kraft[2], John Buhrman[3], Casey Pirnstill[3]; [1]CFD Research, Huntsville, AL; [2]The Pennsylvania State University, University Park, PA; [3]Air Force 711th HPW/RHBNB, Wright-Patterson AFB, OH

INTRODUCTION: Pilot ejection is a hazardous event, made a higher risk event in recent years by the inclusion of head mounted devices. A comprehensive modeling approach that can determine spinal, particularly cervical, injury is required. Finite element (FE) analysis provides a platform to assess the potential for pilot injury during ejection from inertial and aerodynamic threats. A novel 'Global-Local' FE modeling approach will be presented to predict neck tensile loading similar to that of ejection windblast forces.

METHODS: The Global model is an anthropometrically representative whole-body FE model developed in CFDRC's CoBi Multiphysics software. This model was calibrated/validated using the neck-tension tests of twelve post-mortem human subjects (PMHS). A parametric approach and an averaging procedure were adopted to characterize a generic joint definition, for Head/Neck and Neck/Thorax joints, with comparison to the experimental test data. The corresponding joint displacements were used to drive the local LS-DYNA FEM spine model. The failure locations and failure times were compared to the experimental data.

RESULTS AND DISCUSSION: Global model joint stiffnesses for the head/neck and the neck/thorax joints were estimated to be 3.94e4 (SD=3.18e4) and 1.61e5 (SD=7.28e4), respectively, resulting in good predictions of head/neck and neck/thorax displacements during 5000 N tensile loading. For the local model element deletion method, initial failure occurred at 60 ms at C1-C2. Without element deletion, large posterior ligament deformations occurred at 140 ms throughout the cervical spine, suggesting tensile ligament failure potential. Experimental data for specimen revealed atlanto-occipital dislocation and inferior C6 endplate failure with onset at 182 msec. Traditional manikin neck injury criteria for load, load duration, and N_{ij}, for the head-neck and neck-thorax global FE model initially exceeded at 184 ms coincident with model predictions. The Global-Local FEM method shows promise for injury prediction through spinal element material failure. This method is currently being applied to evaluate neck injury in ejection seat exposures.

MONDAY: 3:00 P.M. – 4:30 P.M.
TRAINING (SURVIVAL)
LOCATION: CRYSTAL 1 & 2
MODERATORS: Beth Atkinson, NAVAIR / LCDR Lee Sciarini, NSTC, Pensacola

PANEL: Aviation Survival Training: Advances for the Future

INTRODUCTION: The panel will include presentations that provide an overview of challenges and advances underway for aviation survival training. In particular, the focus of the panel will be:

(1) A review of student perceptions of current aviation survival training
(2) Technology under investigation to advance the experience of mishap awareness training
(3) Advancing parachute descent procedure training capability and instructor feedback tools

PANEL CHAIRS:

Ms. Beth Atkinson –Basic & Applied Training & Technologies for Learning & Evaluation Lab (BATTLE Lab) Lead, Naval Air Warfare Center Training Systems Division, Orlando, FL

LCDR Lee Sciarini – Director of Training Technology, Naval Survival Training Institute, Pensacola, FL

PRESENTERS:

Perceptions of Aviation Survival Training: A Review of Student Feedback – LTJG Zachary Johnson, LT Christopher Gilg, LCDR Tim Welsh; Aviation Survival Training Center (ASTC), Pensacola, FL.

INTRODUCTION: Aviation Survival Training Centers (ASTCs) are responsible for providing both initial survivability training as well as refresher training, with the goal of maintaining Warfighter readiness and proficiency. Annually, ASTC Pensacola trains approximately 4,800 students with varying backgrounds that range from new recruits to advanced aviators going through refresher training. These students learn and practice survival skills such as seat ejection, parachute descent and landing procedures, aeromedical impacts (e.g., hypoxia, hyperventilation, decompression illness, G-LOC, spatial disorientation), and open water survival.

METHODS: Though these classes provide the means by which to establish and maintain skill proficiency for aircrews, changing needs of the Warfighter and constantly evolving technologies necessitate the need to understand the areas of opportunity for further development and design (or redesign) of training. One impetus for new developments in training comes from ASTC Student feedback, completed by each individual post-training (both initial and refresher). This feedback might range from areas where students felt a lack of engagement, to gaps in training content, as well as inputs on how to enhance training in the future.

RESULTS AND DISCUSSION: This presentation will include a summary of the training critiques from ASTC Pensacola to provide an overview of areas for improvement in the future based on a qualitative analysis of student feedback.
Author's Note: The views of the author expressed herein are do not necessarily represent those of the U.S. Navy or Department of Defense (DoD). Presentation of this material does not constitute or imply its endorsement, recommendation, or favoring by the DoD. NAWCTSD Public Release 19-ORL059 Distribution Statement A – Approved for public release; distribution is unlimited.

Bringing New Mishaps to Life in the Classrooms – LCDR Lee Sciarini[1], LT Christopher Murr[1], Beth F. Wheeler Atkinson[2], Sarah M. Warnham[2]; [1]Naval Survival Training Institute (NSTI), Pensacola, FL; [2]Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL

INTRODUCTION: Spatial disorientation (SD) and situational awareness (SA) are significant contributing factors to the majority of aviation mishap events. The aviation survival training community has requirements to provide sensory physiology/situation awareness training; however, the current training is predominantly classroom based instruction that leverages videos which are not easily updated as new platforms or situations occur. Providing a more immersive range of training opportunities will allow for more trainee experience and engagement and likely improve the fidelity and appropriateness of the training. Operator performance will also increase through the ability to better recognize and/or implement emergency procedures when experiencing SD/SA situations, creating safer and more effective warfighter operations.
METHODS: One current solution being investigated is a customizable software program that supports recreation of aviation mishap events to improve safety training through classroom-based videos and interactive, immersive visualization techniques. The ability to recreate aviation mishaps as needed provides instructors the capability to customize training as needed, focusing on key topics at hand, and providing an immersive look at mishaps that have happened in the past, or example events for which aircrew members may otherwise not experience.

RESULTS AND DISCUSSION: This presentation will focus on the training concepts that have been identified through this research and development, including how to advance the training to be inclusive of a broader range of aircrew positions and platforms. The goal of these efforts are to advance training solutions to increase the immersion of existing classroom training. Additionally, some preliminary concepts of how to provide a more robust mishap and disorientation training solution in the future will be explored.

Author's Note: The views of the author expressed herein are do not necessarily represent those of the U.S. Navy or Department of Defense (DoD). Presentation of this material does not constitute or imply its endorsement, recommendation, or favoring by the DoD. NAWCTSD Public Release 19-ORL059 Distribution Statement A – Approved for public release; distribution is unlimited.

Parachute Training: Technology for Instructional Feedback - Beth F. Wheeler Atkinson[1], Dr. Brian Stensrud[2], LT Christopher Gilg[3], CDR Jon D. Champine[4]; [1]Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL; [2]Soar Technology, Inc., Orlando, FL; [3]Aviation Survival Training Center (ASTC), Pensacola, FL; [4]Aviation Survival Training Center (ASTC), Mirmar, CA

INTRODUCTION: Current Parachute Descent Procedure (PDP) training is based on antiquated virtual reality technology that has inadequate effectiveness and realism. These Virtual Reality Parachute Decent Trainer (VRPDT) systems are currently used for initial and refresher training for all aircrew designated to fly in parachute equipped fixed wing aircraft. Parachute Descent Procedure (PDP) training is intended to provide trainees with the ability to train on PDPs, malfunctions and decision-making. However, there are three main capability gaps: 1) training quality and effectiveness, 2) supportability, and 3) training realism. A VR solution does not allow the student to effectively interface with standard flight and parachute equipment. To address these capability gaps, a new system is in iterative development in order to provide a new solution for training PDPs.

METHODS: The new solution currently under research and development includes several monitors for aircrew members to view while hanging in a parachute seat. These monitors include front visuals, as well as an overhead visual which displays different parachute configurations and mishaps. This system is intended to provide a reconfigurable connection for a variety of aircrew equipment and seat kits, which differ by platform.

RESULTS AND DISCUSSION: This presentation will provide an overview of the current training challenges and new system under development. Additionally, the presentation will provide an overview of the feedback being received by the fleet actively using the prototype, as well as future directions for continued research and development. Finally, future steps for proposed research intended to provide training effectiveness data will be addressed.
Author's Note: The views of the author expressed herein are do not necessarily represent those of the U.S. Navy or Department of Defense (DoD). Presentation of this material does not constitute or imply its endorsement, recommendation, or favoring by the DoD. NAWCTSD Public Release 19-ORL059 Distribution Statement A – Approved for public release; distribution is unlimited.

MONDAY: 3:00 P.M. – 4:30 P.M.
BIOMECHANICS (INJURY/MISHAPS)
LOCATION: CRYSTAL 3 & 4
MODERATOR: Dr. Camille Bilger, Martin-Baker Ltd.

BRIEFING: **Modelling of Escape System Performance and Injury Metrics –** Mr. Robin Saaristo, Mr. Mark Elson; Martin-Baker Aircraft Company Ltd., Higher Denham, United Kingdom

INTRODUCTION: Martin-Baker has been developing a six degrees-of-freedom (6DOF) ejection dynamics model – Seat6D – for over 25 years, capable of predicting seat and occupant trajectories, accelerations and rates, and the sequencing of events throughout the ejection envelope, from seat initiation to crew touchdown. The unique strength of Seat6D lies in its ability to handle the full ejection sequence, for any escape system type or variant, as it is being developed in line with a large range of ejection seat designs and corresponding hardware thereof. Seat6D is extensively validated against test data (from both sub-systems and ejection testing), with an accurate performance representation achieved to a very high resolution and for a very low computational cost.

Martin-Baker continuously improves Seat6D models through research and development, from conceptual designs to qualified products. This paper will outline the methodology used in the evolution of Seat6D models, while improving the accuracy and the validation process it goes through. The validated model is used to understand variations in performance from changes to seat configuration, with the intent of constant product design safety improvement. Validated models also serve Martin-Baker in predicting seat performance and assessing crew safety in off-nominal conditions unattainable via testing. Seat6D is able to perform both Sensitivity and Monte-Carlo analyses.

In conjunction with seat performance predictions, Seat6D is used for its physiological predictive capability, as it enables the user to assess injury metrics. These include metrics from MIL-HDBK-516C, e.g. DRI and MDRC, but also limits devised by Martin-Baker that have over the years been found to be indicative of safe seat performance. The constant in-house research in biomechanics modelling and physiological response of Hybrid-III manikins in testing is used alongside Seat6D to better predict injury levels in ejections – in an attempt to bridge the physiological gap between Hybrid-III manikins and injury metrics, and human response.

BRIEFING: Standardising Ejection Records - Wg Cdr M.E.Lewis RAF[1], Steve Roberts[2]; [1]OC Aviation Medicine Operational Wing, RAF Centre of Aviation Medicine, RAF Henlow, Bedfordshire, UK; [2]Martin-Baker Aircraft Co. Ltd, Higher Denham, UK

INTRODUCTION: Ejection records have been maintained by Air Forces and by Martin-Baker since the introduction of Martin-Baker Ejection Seats 72 years ago. These records vary significantly by Air Force, both in content and in classification criteria. A significant part of the ejection record is the injury recording and injury classification made for each ejection attempt.

Historically, the classification process has been problematic due to the varying levels of post-ejection medicals and the inconsistent and uncoordinated nature of the classification and recording criteria.

Without some standardization of the ejection records, it is difficult to carry out the following:

- Identify trends in aircraft operation and aircrew population;
- Provide the best possible rehabilitation to the ejectee;
- Monitor the functional performance of the various Ejection Seat types, in order to justify continual improvement in the various Ejection Seat types in-service

The entry into service of Helmet Mounted Displays (HMD) and the wider aircrew anthropometry has introduced new ejection hazards due to the increase in head-borne mass, size and center-of-gravity. New metrics have appeared during ejection test development programs in order to quantify risk and certify new escape systems; however, there has been no similar change in the classification of live ejection records.

A unique opportunity now exists with the introduction to service of the F-35 to standardize the ejection recording across the 14 Nations. Martin-Baker and the RAF Centre of Aviation Medicine (RAFCAM) proposes to use the Abbreviated Injury Scale (AIS) to describe and classify the severity of any injuries. The AIS scale is an anatomical-based coding system created by the Association for the Advancement of Automotive Medicine and adopted by the automotive industry due to its large database.

Martin-Baker and RAFCAM will be looking to revise the guidance within NATO STANAGS, other aeromedical Standards, and the JSSG-2010-11 Crew Systems Emergency Egress Handbook.

BRIEFING: USAF Mishap Investigation of Aircrew Flight Equipment & Egress Systems – Caleb Wagner P.E.; AFLCMC Human Systems Program Office, Wright-Patterson AFB, OH

INTRODUCTION: When an emergency occurs aboard U.S. Air Force (USAF) aircraft and Aircrew Flight Equipment (AFE) or Egress Systems are involved, the Life Sciences Equipment Laboratory (LSEL) provides technical, subject matter expert support to Safety Investigation Boards (SIBs).

Depending on the situation, our investigators may travel to the crash site, evidence may be shipped to the lab for forensic analysis, or both. Our investigators use forensic engineering techniques to determine if the AFE or Egress Systems functioned successfully. If the systems did not function as intended, recommendations are made to prevent system failures in the future. This briefing will contain a brief history of the LSEL, our workflow and investigation philosophy, and recent system issues.

MONDAY – 5:00 PM – 7:00 PM
NETWORKING RECEPTION (MONDAY NIGHT FOOTBALL)
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

TUESDAY, OCTOBER 15TH

TUESDAY - 7:00 AM – 4:00 PM
REGISTRATION OPEN
LOCATION: GRAND SALON REGISTRATION

TUESDAY: 8:00 AM – 9:30 AM
OXYGEN (OBOGS)
LOCATION: CARSON 1 & 2
MODERATOR: Rachael Ryan, NAVAIR

BRIEFING: **Performance Evaluation of MOCON VOC-TRAQ II Photoionization Detector Used for In-Flight Hydrocarbon Detection –** Raisa Marshall, Dr. Krisiam Ortiz-Martinez, Dr. Leah Eller; Naval Air Systems Command, Patuxent River NAS, MD

INTRODUCTION: A MOCON VOC-TRAQ II photoionization detector, dubbed the Hydrocarbon Detector (HCD), was used in conjunction with sorbent tubes during in-flight monitoring of pilot breathing air for both T-45 and F/A-18. The HCD provided real-time continuous monitoring for volatile organic compounds (VOCs). The device was used to qualitatively determine if chemicals captured in sorbent tubes were travelling through the system as bursts of higher concentrations or as continuous low-level concentrations. A subsequent laboratory evaluation of this device was carried out to determine absolute error bars on reported results.

METHODS: Limits of detection (LOD) and limits of quantitation (LOQ) were determined for a range of relevant organic compounds both at ground pressures and at altitude. Chemicals were introduced via vapor generator to simulate field samples. Chemicals were introduced as short pulses as well as continuous streams. Oxygen effects were examined.

RESULTS AND DISCUSSION: The HCD performed remarkably well in the evaluation. Sensitivity decreased with altitude linearly and the correction factor was determined. At 10,000’, even short pulses of compounds at low concentration were detectable. The use of the device as a qualitative monitor for pulses of chemicals has been validated. The pressure correction factor provided increases the utility of the device as a quantitative measure of VOCs. The consistent readings of zero VOCs on a ppm scale from flight-monitoring efforts have been validated by this performance evaluation. These results affirm the quality of the pilot breathing air.

BRIEFING: Concentrator Pressure Sensor for the Assessment of Oxygen Systems – Ms. Tonia Sofoluke; Naval Air Systems Command, Patuxent River NAS, MD

INTRODUCTION: Understanding the causes of Physiological Episodes (PEs) and methods to reduce them has been a top safety priority across the Navy. The On Board Oxygen Generating System (OBOGS) pressure supply was a factor examined as a possible contributor to PEs. The OBOGS system concentrates oxygen and relies on pressurization of molecular sieve in order to remove nitrogen from the air. Low input pressure can result in the inability to maintain a sufficient concentration or quantity of oxygen. A test plan was developed to understand the input and output pressure to potentially provide indications of a poorly performing concentrator or other aircraft components that could result in an OBOGS failure indication or a physiological episode.

METHODS: In order to measure these pressures on the T-6 aircraft, a self-contained system mounted on the concentrator was developed. The system consists of a self-powered data logger connected to pressure sensors installed on the concentrator inlet and outlet test ports. A total of 452 usable data sets were collected on 99 different aircraft. Analysis of the pressure data provided an established baseline of normal performance and revealed that some concentrators are able to maintain output pressure when input pressure drops, while others are not.

RESULTS AND DISCUSSION: Analysis revealed that pressure was most likely not the cause of fail lights, however, there were other insights found about the concentrator. The data revealed the fail lights are most likely from low O_2

concentration. This data supports continuation of the current standard practice of advancing the throttle when having an OBOGS light while at engine idle. It further recommended that current and future concentrators be monitored for greater understanding of their performance and life cycle.

BRIEFING: STAT Techniques for LSS/OBOGS Testing – Andrew Klein; Human Systems Program Office Aircrew Performance Branch, Wright-Patterson AFB, Dayton, OH

INTRODUCTION: Scientific Test and Analysis Techniques (STAT) are the scientific and statistical methods and processes used to enable the development of efficient, rigorous test strategies that will yield defensible results. STAT encompasses such techniques as design of experiments, observational studies, reliability growth, software coverage, and survey design used within a larger decision support framework. Recent experiences testing life support systems (LSS) provides multiple contexts for the application of STAT to LSS testing and how to make STAT applicable to all program managers, engineers, and analysts. The presentation will introduce the OSD STAT Center of Excellence and through examples demonstrate how this organization and the STAT process can enable more rigorous, efficient, and effective LSS testing.

TUESDAY: 8:00 AM – 9:30 AM
BIOMECHANICS (I-PREDICT: EXPERIMENTAL METHODS)
LOCATION: CARSON 3 & 4
MODERATOR: Dr. Barry Shender, NAVAIR

PANEL: Development of the I-PREDICT Behind Armor Blunt Trauma Injury Prediction Model – Part 1: Experimental Foundation

INTRODUCTION: While the limitations of behind-armor-blunt-trauma (BABT) injury predictions based on clay forms are well known, no advancement in the understanding of blunt injuries to the thorax has been achieved. Tests with clay can record the plastic depth of penetration from BABT events, however, variables such as the elastic response of the clay, the velocity of the impact, and the physiological response of a human are not known. To address this challenge, a human finite element model that contains the rate-dependent materials properties of the thorax and abdomen tissues characterized for military or BABT rates, as well as a damage model that predicts the transient response of the tissue during the damage, is required. This two part panel presents the experimental and modeling work conducted under the Office of Naval Research's Incapacitation Prediction for Readiness in Expeditionary Domains - an Integrated Computational Tool (I-PREDICT) program, that is designed to address the gap.

Part 1 presents the development of testing techniques and collection of the material properties for the model. The first talk from Marquette University and the Medical College of Wisconsin describes their procedures and results to obtain the high strain rate constitutive properties of thoracic tissues (adipose, cardiac, cartilage, lung, muscle) using fresh porcine specimens. The second talk from the Duke University Department of Biomedical Engineering describes an indentor laboratory procedure that recreates thoracic injuries in porcine specimens that accurately represent in-field BABT injuries to the ribs, liver, and lung. The third talk describes full-scale testing on a whole body postmortem human surrogate (PMHS) of BABT using an impactor approach rather than traditional ballistic testing.

PANEL CHAIR:

Barry S. Shender, Ph.D., SSTM, Naval Air Warfare Center Aircraft Division, Patuxent River, MD

PRESENTERS:

BRIEFING: **High Rate and Viscoelastic Property Characterization of Thoracic Tissues in Support of an Advanced Computational Model to Predict Injury During Behind Armor Blunt Trauma –** Brian D. Stemper, PhD[1,2], Alok S. Shah, MS[1], Devin Wozniak[1,2], Jared Koser[1], Narayan Yoganandan, PhD[1], Frank A. Pintar, PhD[1,2], Barry Shender[3], Timothy Bentley[4]; [1]Department of Neurosurgery, Medical College of Wisconsin and Zablocki Veterans Affairs Medical Center, Milwaukee, WI; [2]Marquette University, Milwaukee, WI; [3]Naval Air Warfare Center Aircraft Division, Patuxent River, MD; [4]United States Office of Naval Research, Arlington, VA

INTRODUCTION: Thoracic injury associated with Behind Armor Blunt Trauma (BABT) results from high rate backface deformation (BFD) of body-borne protective armor. BFD impacts the thorax at high rates and can injure local tissues and organs, including the lungs, liver and heart. Finite element models (FEMs) can be used to predict injury and develop advanced body armor to minimize effects of BFD and better protect the warfighter. However, the accuracy of FEMs is dependent on the quality of material properties and many FEMs have not incorporated high rate and viscoelastic material properties.

METHODS: Fresh porcine thoracic tissues (adipose, cardiac, cartilage, lung, muscle) were obtained within minutes of death from an abattoir, placed in a portable incubator with temperature at 37 deg C, and transported to our laboratory for preparation and testing. High strain rate (1500 and 2000 /s) compressive material properties were obtained using a Split-Hopkinson Pressure Bar (SHBP) setup with 12-ft solid aluminum incident and transmission bars. Viscoelastic tests incorporated a stress-relaxation protocol (SRP) with a 5-mm indenter producing a high rate compression to a maximum of 10-35% strain and hold for 60 seconds. Tissues were compared based on tissue type, strain rate (SHPB), and relaxation properties (SRP) using ANOVA techniques.

RESULTS AND DISCUSSION: The compressive elastic response of thoracic tissues (SHPB) demonstrated differences ($p<0.05$) between tissues and strain rates. The compressive and shear relaxation response (SRP) demonstrated differences ($p<0.05$) based on hold time and tissue type. The current dataset, derived from fresh thoracic tissues within hours of death, presents valuable high rate and viscoelastic material properties that can be used to develop biofidelic finite element models for applications including BABT. Significant differences based on strain rate and tissue type indicate a necessity to incorporate those different properties in computational models to better estimate the internal responses.

BRIEFING: Injury test model for behind armor blunt trauma (BABT) – Joost Op 't Eynde[1], Christopher P. Eckersley[1], Cameron R. Bass[1]; [1]Injury Biomechanics Laboratory, Duke University, Durham, NC

INTRODUCTION: Ballistic body armor reduces torso injury severity for civilian and military victims of high-velocity projectile wounds. High-rate deformation of the armor backface from projectile impact can cause trauma to the ribcage and internal organs, termed behind armor blunt trauma (BABT). Criteria for assessing BABT risk relies on studies determining backface deformation in clay or ballistic gelatin; neither have direct correlation to human or animal models and are insufficient for developing accurate thoracic BABT injury criteria. This study employs an indenter to produce BABT in a porcine model and relate backface deformation impact to physiological outcomes. The use of an indenter improves test repeatability and provides a simplified, controllable test environment.

METHODS: Flash x-ray measurements of soft armor backface deformation guided the development of a polycarbonate indenter. The indenter with onboard accelerometer (mass: 0.214 kg, diameter: 100 mm) was launched using a pneumatic propulsion device. Four impacts (bilateral in the upper and lower thorax) of varying speeds (22-54 m/s) were performed on each of two live pigs. Impacts were recorded using high-speed video, and injuries assessed with post-test necropsy and micro CT scan.

RESULTS AND DISCUSSION: Impact energy varied from 104 J to 624 J. Peak deceleration upon impact varied from 3,740 to 26,700 g. Non-displaced rib fractures occurred in the 104 J impact test on the upper thorax in one pig, but not for the same energy impact in the other pig. For higher energy impacts, multiple non-displaced rib fractures occurred at all impact sites. Ribs did not penetrate the chest cavity. Liver and lung contusions occurred in impacts above 233 J, and lung contusion also occurred in the 104 J impact with broken ribs. These injuries are a realistic representation of in-field BABT injuries. The presented test model provides energy-based injury thresholds in an animal model to develop a BABT injury criterion.

BRIEFING: **Methods for Full-Scale Testing of Behind Armor Blunt Trauma –** Madelyn Eaton[1], Kyvory Henderson[1], Robert Salzar[1]; [1]Center for Applied Biomechanics, University of Virginia, Charlottesville, VA

INTRODUCTION: Injuries resulting from the non-penetrating energy dispersion of a projectile missile into body armor is known as behind armor blunt trauma (BABT). BABT occurs when the body armor stops the projectile without penetration but deforms into the body of the wearer, resulting in thoracic injuries. The goal of this study was to design and implement a systematic testing methodology for use in full-scale testing of BABT.

METHODS: A testing rig was created to simulate a BABT event. To reduce the risks associated with traditional ballistic testing, an impactor was made to mimic the exact shape and dimensions of armor's deformation from an impact of a high-caliber round or shrapnel. This 3D-printed carbon fiber impactor is cylindrical with a hemispherical front, measuring 10.16cm in diameter and hollow to accommodate a wireless accelerometer sensor/data acquisition system used to calculate exact force transferred into the test subject. The test rig is comprised of a 6m long steel launch tube with an inner diameter of 10.16cm and a pressurized locking mechanism at one end to load the impactor. The launch tube is connected to a system of three volumetric tanks capable of 175psi and a launching speed of 100m/s.

RESULTS AND DISCUSSION: Three tests were performed on a whole body postmortem human surrogate (PMHS). The first two velocities were 28m/s and 29m/s with accelerations 1338g and 1118g respectively, intended to be non-injurious. The third impact reached 59m/s and 6843g causing a massive failure of the PMHS ribcage, halting further testing. The autopsy for the PMHS revealed 16 different rib fractures, including a fracture pattern indicative of flail. The data obtained from testing will be integrated into a finite element model so that future pass/fail testing of body armor can be performed via computer simulation, negating the need for costly equipment and protocols.

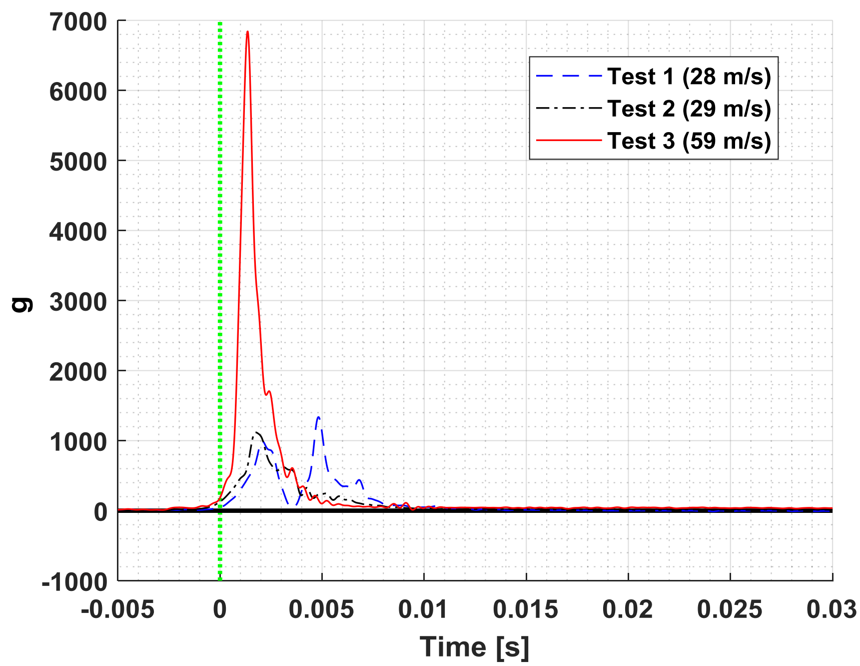

Figure 1 shows the time history of the wireless accelerometer sensor/data acquisition system inside the impactor for all three-whole body PMHS runs. The x-axis is the time in seconds, with a vertical line at zero indicating the start of the hit. The y-axis is in g's.

TUESDAY: 8:00 AM – 9:30 AM
CAD/PAD
LOCATION: CRYSTAL 1 & 2
MODERATOR: Rae Azorandia, NSWC-IHEODTD

BRIEFING: CAD/PAD Engineering Investigations – Nicholas Schombs; Naval Surface Warfare Center – IHEODTD, Indian Head, MD

INTRODUCTION: CAD/PAD are used on Navy, Marine Corps, Air Force, Army, Coast Guard, NASA, and 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.

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. Process for engineering investigations will be discussed as well as engineering methods. Status and key findings will be identified to support root cause analysis of the investigations.

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BRIEFING: Cartridge Actuated Device/Propellant Actuated Device Ordnance Assessment - Jeffrey D. Watts, Jay Dalton; Naval Surface Warfare Center Indian Head Explosive Ordnance Disposal Technology Division CAD/PAD Ordnance Assessment/Logistics Branch, Indian Head, MD

INTRODUCTION: The Cartridge Actuated Device (CAD) and Propellant Actuated Device (PAD) Ordnance Assessment (OA) programs assess the quality, reliability and serviceability of all CAD/PADs to determine if any deficiencies occurred due to aging and/or environmental conditions. These evaluations benefit the end users by identifying/analyzing aging trends to assign appropriate service lives, identify deficiencies due to environmental conditions and/or maintenance procedures, and ensure CAD/PADs are working as intended within requirements of system or end-item application. This presentation will provide insight into the process of OA, explain engineering methods utilized and new improvements incorporated, and give examples of recent findings/analysis.

BRIEFING: **Cartridge Actuated Device/Propellant Actuated Device (CAD/PAD) U.S. Air Force Mishap Investigation Support Team (MIST) –** Jacob Parkin; Naval Surface Warfare Center - IHEODTD, Indian Head, MD

INTRODUCTION: When a mishap occurs, the U.S. Air Force establishes a Safety Investigation Board (SIB) to conduct a safety-focused investigation. The SIB's purpose is to prevent similar mishaps from reoccurring. These mishap investigations are conducted on-site and consist of hands-on processing of all evidence related to the mishap.

RESULTS AND DISCUSSION: The U.S. Air Force CAD/PAD MIST supports the SIB by providing subject matter expert technical assistance. MIST travels to the site of the mishap, which involves an emergency crew escape system utilizing explosive energetics. The support role of the investigation varies depending on the type of mishap. For example, if the mishap involves a crewmember successfully ejecting from an aircraft, the focus of MIST is to ensure all CAD/PAD devices functioned as intended. Additionally, MIST evaluates the emergency crew escape system as a whole to determine the level of performance. If the mishap involves unsuccessful recovery of crew, the investigation will focus on determining if an ejection was attempted, as well as identify any defects or malfunctions which may have occurred.
This brief will focus on mishaps supported by MIST during the 2018 calendar year.

TUESDAY: 8:00 AM – 9:30 AM
ALSS (CBRN)
LOCATION: CRYSTAL 3 & 4
MODERATOR: Mike Jaffee, NAVAIR

BRIEFING: **Next Generation Aircrew Protective Ensemble (NGAPE) –** Lt Hunter Mangueira[1], Maj Joseph Speakman[1], Mr. William Greer[1], Mr. Jerry Jensen[1], Mr. Kevin O'Neal[2]; [1]Air Force Life Cycle Management Center (AFLCMC), Human Systems Program Office, Wright-Patterson Air Force Base, Ohio; [2]Air Combat Command (ACC/A3T), Combat Developer Team, Joint Base Langley-Eustis, Virginia

INTRODUCTION: Legacy aircrew Chemical, Biological, Radiological, and Nuclear (CBRN) protective equipment for fixed-wing, ejection-seat aircraft is designed to meet outdated, operationally irrelevant contamination challenge levels and severely reduces or eliminates combat capability. Legacy Equipment significantly increases physiological task load through thermal burden, system bulk, and hydration limitations; reduces field of view, field of regard, tactility, dexterity, g-performance and mobility.

In order to provide increased combat capability Next Generation Aircrew Protective Ensemble (NGAPE) is testing the feasibility of a concept based on an operationally-relevant challenge level and a reduced CBRN ensemble. Operating at a lower challenge level, one-tenth of legacy levels, an aircraft cockpit will be able to purge contaminate from the aircraft through continuous air cycles of the Environmental Control System (ECS). Aircrew CBRN protective equipment in this environment will have a reduced physiological task load and may be able to be removed after cockpit purge.

METHODS: Conducted by AFRL, aircraft ECS systems are tested by challenging the cockpit to a vapor only, operationally-relevant concentration with a chemical weapon agent simulant followed by aircraft taxi to a clean area. Real-time qualitative data is collected along with periodic sampling to determine the quantitative concentration of the simulant in the aircraft over time.

RESULTS AND DISCUSSION: NGAPE ECS testing has shown a positive capability for aircraft to quickly purge contaminant, which could vastly reduce the amount of protection required and enable combat capability. F-22 cockpit will purge in approximately 14 minutes at idle power, preliminary data from the F-16 and F-15 tests show similar purge trends. Future NGAPE efforts will focus on a medical pivot, understanding the physiological and toxicological effects of aircrew exposure to the contamination level present during ECS purge. Findings from NGAPE will support the development of CBRN defense materiel solutions and tactics, techniques, and procedures relevant to SAFE community stakeholders in Military Services, Aircrew Flight Equipment, Flight Physiology, and Industry.

BRIEFING: Toxicshield: CBRN Protection for Aircrew and Aircraft – Philipp Ostertag; Autoflug Gmbh, Rellingen, Germany

INTRODUCTION: AUTOFLUG has decades of experience and expertise in the areas of rescue and safety, ergonomics, textiles, mechanical systems, precision engineering, electronics, and software, as well as measuring and control technology. As a globally recognized supplier and service partner of the international aviation industry and for defence technology, we develop, produce and service a wide range of textile, mechanical and electronic components and systems, amongst others.

This presentation focuses on developments and innovations for CBRN protection. Our military, fully-qualified CBRN-suit for jet-pilots offers state-of-the-art protection for aviators. A new development focuses on rotary and fixed wing non-ejection aircraft. This new integrated CBRN-protection system is optimized for use on all crew stations on various aircraft. The main design issues that were addressed were weight, modularity and energy autarchy. The system is based on in-service personal protection garments and adds no more than a thin layer for CBRN protection; hence, it doesn’t feel like a CBRN mission, because it enables the aviators to perform their duties without feeling encumbered.

As a derivative product, AUTOFLUG has invented a solution for transportation of contaminated personnel and material without contamination of the aircraft interior.

BRIEFING: **Protective Gloves for Military Aircrew –** Ms. Jennifer L. Farrell[1], Lt Col Paul Hendrickson[1], Ms. Rose LaRocque[1], and Maj Brendan Kallander[1]; Mr. Kevin O’Neal[2]; Mr. Donald Garey[3]; [1]Air Force Life Cycle Management Center (AFLCMC), Human Systems Program Office, Wright-Patterson Air Force Base, OH; [2]Air Combat Command, Langley, VA; [3]Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense, Aberdeen Proving Ground, MD.

INTRODUCTION: Over the last three years the United States Air Force (USAF) has introduced electronic flight bags (EFB) into most, if not all, aircraft. EFBs provide USAF aviators with an electronic means to access critical flight data and publications for flight operations using a touch-screen interface. During regular flight operations, USAF aircrew wear flame retardant gloves that support the ability to use EFB equipment. For flight operations in a chemical, biological, radiological, and nuclear (CBRN) environment, the current protective glove materiel solution consists of three layers (cotton glove inserts, 7 mil butyl protective gloves, and standard screen Nomex flight gloves). This solution introduces functionality challenges regarding touch-screen capability and results in a reduced ability to employ EFB devices and feel the cockpit’s controllers. This presentation addresses operational and materiel considerations associated with the Uniform Integrated Protection Ensemble Family of Systems (UIPE FoS) Program with a specific focus on providing the Air Force with an improved, standard Aircrew CBRN protective glove solution. The USAF, through the UIPE FoS Program, has identified a glove solution for conduct of missions in CBRN environments that addresses functionality challenges including proper fitting, tactility, dexterity, thermal burden and touch-screen capability. Assuming successful validation and verification of this item through the Safe-to-Fly (StF) process, the benefits of implementation include increased aircrew comfort, efficiency, interoperability, and safety while streamlining inventory management at the operational level and reduced UIPE FoS life cycle support costs for gloves. Our goal is to seek feedback from operational aircrew, Industry, Aircrew Flight Equipment, Flight Physiology, and fellow Military Services regarding (1) our overall approach to validating this materiel solution, (2) information regarding other similar materiel solutions, and (3) challenges to consider as the USAF looks to meet prevalent and future requirements.

TUESDAY – 9:30 AM – 7:00 PM
EXHIBITS OPEN
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

TUESDAY – 9:30 AM – 10:00 AM
AM REFRESHMENT BREAK
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

TUESDAY: 10:00 AM – 11:30 AM
OXYGEN (HYPOXIA TECHNOLOGIES)
LOCATION: CARSON 1 & 2
MODERATOR: Robert Garner, Odyssey II Solutions

BRIEFING: **SPYDR: In-Flight Human Performance Quantification for Risk Prediction and Real-Time Warning of Impending Physiological Emergencies –** Brian S. Bradke, Ph.D.[1,2], Brad R. Everman[1]; [1]Spotlight Labs, Beavercreek, OH; [2]Norwich University, Northfield, VT

INTRODUCTION: Given the number and significance of Unexplained Physiological Events (UPE) in manned military aircraft, a device (SPYDR) along with an analytical methodology was created to produce high-fidelity physiological data that could be compared with aircraft parameters to develop an accurate picture of human performance in the cockpit. The device was designed to capture, process and record data with the intent of performing these functions: 1) Identify immediate human performance degradation and warn aircrew as or before they perceived any degradation. 2) Capture on-ground and in-flight data to provide post-flight debrief analysis of human performance during high-intensity military flight. 3) Analyze collected data using machine learning algorithms to predict human performance to mitigate risk in ongoing airborne operations. 4) Correlate human performance with aircraft performance and environmental factors to create a holistic model of human performance as it pertains to a dynamic environment.

METHODS: Inserted unobtrusively into the helmet, SPYDR is independent of the aircraft and captures the following data: full plethysmograph, acceleration (6DOF), temperature, and cabin pressure. On-board processing is completed to provide immediate detection and warning of potentially dangerous conditions, such as hypoxia. An aural warning system indicates potential degradation before the aircrew is likely to sense the degradation.

RESULTS AND DISCUSSION: The Department of Defense (DoD) has long recognized human performance as the leading cause of mishaps. For the last decade, operational risk management tools have sought to account for physiological factors by asking pilots to assess their readiness to fly before each mission. As the DoD attempts to maximize training effectiveness and human performance while mitigating risk, an objective tool to quantify human performance is becoming an urgent need. A relative performance index as developed and presented here could ultimately improve training effectiveness while accurately quantifying risk due to decrements in human performance.

BRIEFING: **Laboratory Evaluation of VigilOx for Monitoring Pilot's Breathing Gas in Tactical Aviation –** G. Alston Rush, Ph.D.[1], S. A. Warner[2], Adam E. Gohl[1]; [1]Naval Air Warfare Center Aircraft Division, Patuxent River, MD; [2]Naval Medical Research Unit, Dayton, OH

INTRODUCTION: Pilot respiratory rates, tidal volumes, and air composition in tactical aircraft are not well understood or documented. Recent Physiological Episode investigations have highlighted the need for the U.S. Navy to examine all aspects of human performance in tactical aviation and to evaluate available commercial products for physiological monitoring. VigilOx is a tactical aircrew-mounted system capable of collecting data from pilot inspiration and expiration, and cockpit environmental conditions in-flight. VigilOx consists of an Inhalation Sensor Block (ISB) for measuring post-regulator inspiratory gas and an Exhalation Sensor Block (ESB) for measuring post-mask expiratory gas and mask pressure. The objective of this study was to evaluate, verify, and validate VigilOx for inhalation and exhalation respiratory monitoring for Naval Aviators in T-45 and F/A-18 aircraft. Results from this study will aid in data collection efforts for Root Cause and Corrective Action and Physiological Episode investigation of the respective aircraft.

METHODS: A joint validation effort has been established to evaluate the VigilOx system and other available commercial products for functional monitoring of TACAIR pilots. This effort includes flight, human subject, and laboratory test and evaluation participation from a diverse interagency team including NAVAIR, the Naval Medical Research Unit – Dayton (NAMRU-D), the U.S. Air Force School of Aerospace Medicine (USAFSAM), the National Air and Space Administration (NASA), and the Royal Australian Air Force (RAAF). The laboratory portion of this test effort consists of unmanned steady state and dynamic testing. Steady state testing utilized flow-controlled and pressure-controlled experiments in NAMRU-D's Sensors Lab Environmental Chamber in a range of conditions that included variations in temperature, altitude, humidity, and gas concentration. Dynamic testing utilized sinusoidal breathing profiles for single and dual breathing simulator configurations in NAVAIR's Altitude Chamber with standardized and simulated flight profiles.
RESULTS AND DISCUSSION: Laboratory results of six VigilOx ISB and ESB systems were evaluated and compared to baseline measurements in steady state and dynamic flow conditions. Implications of the breathing resistance and data quality of these systems were deduced from the systemic conditions of these dynamic tests that utilized aircraft concentrators, plumbing, regulators, and oxygen masks. Inferences into the verification and validation of VigilOx Inhalation and Exhalation Sensor Blocks are presented.

BRIEFING: Human Systems Program Office Physiological Monitoring Roadmap – Andrew Klein; Human Systems Program Office Aircrew Performance Branch, Wright-Patterson AFB, Dayton, OH

INTRODUCTION: The Air Force Life Cycle Management Center, Human Systems Program Office (AFLCMC/WNU) is responsible for developing, qualifying, and fielding aircrew flight equipment (AFE), to include physiological monitoring devices worn by pilots. In response to the numerous pilot reports of physiologic symptoms in flight, the Human Systems Program Office is pursuing multiple avenues to develop pilot-worn monitoring devices. The program office strategy and timeline for the next 3 years will be outlined and discussed in detail.

TUESDAY: 10:00 AM – 11:30 AM
BIOMECHANICS (I-PREDICT: MODEL DEVELOPMENT)
LOCATION: CARSON 3 & 4
MODERATOR: Dr. Barry Shender, NAVAIR

PANEL: Development of the I-PREDICT Behind Armor Blunt Trauma Injury Prediction Model – Part 2: Finite Element Model

While the limitations of behind-armor-blunt-trauma (BABT) injury predictions based on clay forms are well known, no advancement in the understanding of blunt injuries to the thorax has been achieved. Tests with clay can record the plastic depth of penetration from BABT events, however, variables such as the elastic response of the clay, the velocity of the impact, and the physiological response of a human are not known. To address this challenge, a human finite element model that contains the rate-dependent materials properties of the thorax and abdomen tissues characterized for military or BABT rates, as well as a damage model that predicts the transient response of the tissue during the damage, is required. This two-part panel presents the experimental and modeling work conducted under the Office of Naval Research's Incapacitation Prediction for Readiness in Expeditionary Domains - an Integrated Computational Tool (I-PREDICT) program, that is designed to address the gap.

Part 2 presents the enhancement of the Advanced Total Body Model (ATBM) torso model by incorporating the high strain rate data described in Part 1. The first talk is presented by Elemance, LLC that modified the ATBM from its current state to one that could be applied to BABT conditions by enhancing the model's 3-dimensional models of the ribs, thoracic spine, costal cartilage, and sternum. The second talk by MITRE Corporation describe its effort to identify, evaluate, and minimize errors arising from the process of numerically modeling physical phenomena present in BABT for the ATBM thorax model. The final talk describes how the Southwest Research Institute exercised the enhanced ATBM human torso model within a probabilistic framework as a proof of concept for quantifying risk of injury that accounts for the inherent biological variability across human populations and uncertainty in loading parameters during BABT events.

PANEL CHAIR:

Barry S. Shender, Ph.D., SSTM, Naval Air Warfare Center Aircraft Division, Patuxent River, MD

PRESENTERS:

BRIEFING: **Enhancements to a Torso Finite Element Model for the Prediction of Injury and Functional Incapacitation Due to Behind Armor Blunt Trauma –** Matthew L. Davis[1], Derek A. Jones[1], Travis D. Eliason[2], Dan P. Nicolella[2]; [1]Elemance, LLC, Clemmons, NC; [2]Southwest Research Institute, San Antonio, TX

INTRODUCTION: While the benefits of ballistic protective body armor systems for military personnel have been well documented, deformation of the armor back-face can cause local, high-rate loading of the underlying tissues resulting in trauma to the thoracic cage and internal organs. The objective of this project is to further develop an existing torso model to advance the state of the art for prediction of injury and incapacitation due to behind armor blunt trauma (BABT).

METHODS: The Advanced Total Body Model (ATBM), a finite element torso model representing the 95th percentile male, served as the baseline model used in this study. To enhance the model's predictive capabilities for BABT, 3-dimensional models of the ribs, thoracic spine, costal cartilage, and sternum were developed using TrueGrid software. Additional ATBM modifications, such as enhanced contact definitions, element quality improvements, and updated material properties were also implemented to increase the model's stability and biofidelity. A series of 5 low speed blunt impacts and 3 ballistic impacts to the torso were performed to evaluate the model's response. Model performance was quantitatively assessed using the ISO-TS 18571 standard for objectively evaluating response time histories.

RESULTS AND DISCUSSION: Project updates to the model anatomy, constitutive properties, element formulations, and control card implementations resulted in improved stability and biofidelity of the ATBM. The average ISO score for the low-speed impacts improved from 0.05 (poor rating) in the baseline ATBM to 0.64 (fair rating) in the enhanced model. The objective of this effort was to lay the groundwork for the ATBM to be integrated into a probabilistic framework for the prediction of injury and functional incapacitation of military personnel exposed to external threats. Future work will include integration of further enhanced constitutive models of biological tissues and inclusion of additional anatomical structures to increase the confidence in simulations results.

BRIEFING: **Numerical Modeling Considerations for Behind Armor Blunt Trauma to the Thorax –** Nichole Davis[1], Anthony Santago II[1], Timothy Bentley[2], Lisa Lalis[1]; [1]MITRE Corporation, Bedford, MA; [2]Office of Naval Research, Arlington, VA

INTRODUCTION: Office of Naval Research Code 34 Warfighter Performance Department is funding development of a validated finite element model (FEM) to predict injury and incapacitation resulting from Behind Armor Blunt Trauma (BABT). Due to significant biomedical challenges in modeling injury associated with BABT, robust model validation requires an understanding of how numerical implementation contributes to the overall or apparent error. The objective for this effort was to identify, evaluate, and minimize errors arising from the process of numerically modeling physical phenomena present in BABT for the validated thorax FEM.

METHODS: A set of simulations were performed to evaluate the response of the thorax model to BABT impacts. Several factors contributing to numerical modeling error, including mesh quality and solver controls, were evaluated in LS-Dyna using established numerical evaluation metrics including geometric criteria, solution energy signatures, and gradient recovery-based error estimation.

RESULTS AND DISCUSSION: The use of computationally efficient, reduced integration element formulations was found to significantly impact the realism of solution energetics. This is attributed to hourglass deformation modes arising in under-integrated elements; generally associated with the use of a simplified rubber material model in soft internal organs. Stiffness-based hourglass control was found to be effective and produced a kinematic response closest to that of a model without under-integrated elements. Error estimation was used to identify how mesh discretization error develops over the course of the simulation, which will be used to drive mesh refinements for specific impact investigations. Through this evaluation of the thorax model, recommendations were developed for mitigating numerical modeling error. These findings provide key steps towards evaluation of the overall numerical error in FEM solutions and development of validated models that can be leveraged to preserve human life through improved protective equipment, medical response protocols, and operational planning.

The view, opinions, and/or findings contained in this report are those of The MITRE Corporation and should not be construed as an official Government position, policy, or decision, unless designated by other documentation.

This technical data deliverable was developed using contract funds under Basic Contract No. W56KGU-18-D-0004.

BRIEFING: **Probabilistic Analysis of Injury Risk Using High-Fidelity Human Body Finite Element Models –**
Travis Eliason[1], Matthew Davis[2], Derek Jones[2], Dan Nicolella[1]; [1]Southwest Research Institute, San Antonio, TX; [2]Elemance LLC, Clemmons, NC

INTRODUCTION: Computational modeling is a powerful and widely implemented tool for the analysis of biomechanical systems. However, nearly all applications of computational human body modeling are deterministic; a deterministic model represents a single individual and cannot accurately predict injury risk across population groups. Exercising a computational model within a probabilistic framework addresses this deficit by accounting for the inherent biological variability across human populations.

METHODS: In this study we utilized a provided human torso model (Advanced Total Body Model, ATBM) within a probabilistic framework as a proof of concept for quantifying risk of injury due to behind armor blunt trauma. Probabilistic analyses were performed for three versions of the model representing a 5th percentile female, 50th percentile male, and 95th percentile male. Tissue material properties of each major anatomical structure (e.g. ribs, liver, etc.) as well as the boundary conditions were included in the probabilistic analysis. Custom code was written to process the computed model response distributions to calculate the probability of tissue injury on an element by element basis and produce a probability of injury contour plot. Rib fracture analysis was completed for all three subject sizes and compared quantitatively as well as qualitatively with the probability of failure contours.

RESULTS AND DISCUSSION: The 5th percentile female model had a 34% probability of at least one rib fracture, a 17% chance of between 2 and 5 fractures, and an 8% chance of 6 or greater fractures. Conversely, the 95th percentile male had a 10% chance of at least 1 fracture, a 5% chance of between 2 and 5 fractures, and a 0% chance of 6 or more fractures. While time consuming and technically challenging, we believe that this probabilistic approach to injury prediction gives significant advantages to the traditional deterministic approach. While the work done in this study is a proof of concept, when applied in combination with rigorous model development, verification, and validation methodologies, the probabilistic approach to injury prediction will help better explain the "so what" of modeling results and help users make actionable decisions from those results.

TUESDAY: 10:00 AM – 11:30 AM
CAD/PAD
LOCATION: CRYSTAL 1 & 2
MODERATOR: Matt Weiderspon, NAVAIR

BRIEFING: **CAD/PAD Energetic Materials Obsolescence Strategy –** Jon Kilikewich; Naval Surface Warfare Center - IHEODTD, Indian Head, MD

INTRODUCTION: Material obsolescence impacts virtually all energetic formulations that power numerous safety systems. In recent years, the CAD/PAD division of Naval Surface Warfare Center Indian Head EOD Technology Division has monitored a range of chemicals, using this data to guide risk evaluations, prioritize product improvement efforts, and inform future designs. In anticipation of additional funding in future years, we have targeted several ingredients for action.

RESULTS AND DISCUSSION: This presentation discusses the overall risk mitigation strategy for CAD/PAD with regard to material obsolescence. Typical concerns include single source suppliers, low volume/low profit materials, environmental regulations, and difficulty obtaining raw materials from domestic sources. In many legacy systems, we have been forced to work from stockpiled material in order to continue production of otherwise unsupportable items. We utilize several tools to collect data, including industry surveys, direct feedback from manufacturers and end users, and interaction with regulatory agencies. Information from these sources is collected in our database and rated according to the severity of the risk, timeframe that it may be incurred, and the impact it would have on sustainability of existing products. This guides our internal investment strategy for addressing obsolescence issues and the results shared with working groups within the DoD energetics community influence higher level efforts. As a result of this effort in prior years, we have identified several materials that are candidates for action in FY20. This presentation will provide an overview of the goals of these projects and discuss expected results.

BRIEFING: **Predictive Digital Twins for CADs and PADs –** David Goodwin, Steve Roemerman; Lone Star Analysis, Addison, TX

INTRODUCTION: PMA-201 contracted Lone Star Analysis to develop a digital twin of MT29, WB15, and MT30/31 CAD/PADs used in F/A-18 aircraft. The digital twin is intended to predict the remaining useful life of the CAD/PADs due to heat exposure to the stabilizers in the devices based on the historical and scheduled future location of the aircraft they are installed in. Utilizing this modeling PMA-201 can better optimize the replacement schedule of CAD/PADs while maintaining a safe operating environment.

METHODS: Lone Star Analysis worked with Indian Head Explosives Ordnance Disposal Technology Division (IHEODTD) over a period of six months to develop the digital twin utilizing a combination of historical weather data collected at various locations, previously conducted location temperature and cockpit thermal studies, regression analysis, and stabilizer thermal studies. Lone Star Analysis built and delivered the digital twin in its TruNavigator™ platform which allows the user to quickly run as many scenarios as desired to predict the remaining useful life of the specified device.

RESULTS AND DISCUSSION: Preliminary results show that the current policy of removing and replacing devices after 2 years of service life does not provide optimal utilization based on the location of the A/C. Depending on location, stabilizer depletes in as little as 12 months to over 5 years. PMA-201 can now utilize the digital twin to help identify an optimal and safe device replacement and inventory strategy as well as applying the current methodology to scale to other devices.

TUESDAY: 10:00 AM – 11:30 AM
BIOMECHANICS (ATD/NECK)
LOCATION: CRYSTAL 3 & 4
MODERATOR: John Buhrman, Wright-Patterson AFB

BRIEFING: Anthropomorphic Test Device Repeatability and Reproducibility to Vertical Impact Accelerations - Elizabeth L. Lafferty[1,2], Ray W. Daniel[1,2], Nathan L. Flath[1,3], B. Joseph McEntire[1]; [1]U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL; [2]Katmai Government Services, Anchorage, AK; [3]Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN

INTRODUCTION: An analysis of injury patterns in U.S. Army aviation mishaps revealed a strong relationship between vertical velocity change and spinal injuries; however, current Army aircrew seats are designed to the legacy specification, MIL-S-58095. This standard predates thoracolumbar injury metrics and therefore does not require direct measurement of the lumbar forces in anthropomorphic test devices (ATDs). Current ATDs are instrumented to evaluate thoracolumbar loads and accelerations. This effort demonstrates ATD response repeatability and reproducibility when exposed to the vertical impact performance limits specified in MIL-S-58095.

METHODS: An acceleration pulse matching the MIL-S-58095 seat performance requirement was generated on the USAARL vertical acceleration tower. Two ATD types, a standard Hybrid III (HIII) and the Federal Aviation Administration Hybrid III (FAAHIII), were used in this study; both types were 50^{th} percentile males. ATDs were instrumented with load cells and accelerometers to record responses at the head, neck, thoracolumbar spine, and pelvis. Each ATD, secured with a five-point restraint harness onto a rigid seat attached to a carriage, was exposed to six identical vertical loading profiles. Acceleration and force metrics were calculated from select body regions to assess ATD repeatability and reproducibility.

RESULTS AND DISCUSSION: Coefficients of variation for acceleration metrics at the thoracic spine and pelvis, as well as load means for the lumbar spine, upper neck, and lower neck, compare well to repeatability values reported in literature. The average coefficients of variation of the FAAHIII and HIII were 2.0 and 5.9%, respectively. The variation between the FAAHIII and HIII is more pronounced when comparing reproducibility between ATDs, where coefficients of variation were much larger. These differences suggest the lumbar spine design differences between the two ATD configurations have an impact on responses, which could influence injury risk outcomes when testing seats for vertical impact performance.

BRIEFING: **Impact Biodynamics of Three Anthropometric Test Device Necks -** Chris Perry[1], John Buhrman[1], Jeff Somers[2]; [1]711th Human Performance Wing, Air Force Research Laboratory, WPAFB OH; [2]KBR, Houston, TX

INTRODUCTION: Unique research was recently conducted on a horizontal sled comparing the biodynamic response of different sized anthropomorphic test device (ATD) head and neck configurations subjected to concurrent impact accelerations. The effort was part of an on-going collaboration between AFRL and NASA. Data collected during the impacts will be used by both organizations to support the development of occupant injury criteria, computational models used to evaluate crew injury risk, and to aid in the design of seat and restraint systems.

METHODS: Approximately 50 impact tests were completed on the AFRL Horizontal Impulse Accelerator (HIA) at WPAFB OH. The impacts were conducted concurrently using a head and neck combination from a 5th Hybrid III female aerospace ATD, a 50th Hybrid III male aerospace ATD, and a 95th Hybrid III male aerospace ATD. Each ATD response was assessed as a function of impact orientation, magnitude of the impact acceleration input pulse, and rise-time or time-to-peak of the impact acceleration input pulse. The impact orientations consisted of +X-axis, -X-axis, and Y-axis with the directions relative to the ATD head's anatomical axes. The ATD head and necks were mounted on a specially designed test fixture attached to the top of the sled, and which allowed the ATD's to be rotated into the designated impact orientations. ATD head accelerations and neck loads were analyzed to develop regression models for estimation of human response, and to document and compare/contrast the relationship between the responses at the upper and lower neck load cell.

RESULTS AND DISCUSSION: Analysis of ATD head accelerations and neck loads indicated a trend for the responses to increase as a function of the impact level, and a majority of the data indicated minor differences between the average peak responses of the ATD head and necks. The ATD responses were maximum with the ATD in the –X-axis impact orientation compared to the other impact orientation configurations. Analysis of ATD upper and lower neck loads and torques indicated that the lower neck generated greater response in shear load, Z-axis compression, and forward or lateral flexion (torque) in all the impact orientations and at all the impact levels when compared to the upper neck response. Relative to a given impact acceleration level, there was little difference between the percent change values across all three ATD head/necks and across analyzed parameters. Relative to a given ATD head/neck, there was a noticeable trend for the percent change values for each parameter to decrease in magnitude as the input acceleration level increased in magnitude.

BRIEFING: **Small Female, Mid-Size Male, and Large Male Hybrid-III Anthropomorphic Test Device Head and Neck Response Comparison –** Somers, J.T. [1], Putnam, J.[2], Greenhalgh, P.[1], Newby, N.[1], Perry, C.[3], Buhrman, J.[3], Burneka, C.[3]; [1]KBR, Houston, TX; [2]NASA Langley Research Center, Hampton, VA; [3]Air Force Research Laboratory, Dayton, OH

INTRODUCTION: For human-rating of new crewed spacecraft, each must meet specific requirements for protecting the crew from injuries due to dynamic loads. NASA specifies that each design must be assessed using the Hybrid III Anthropomorphic Test Device (ATD) adult sizes (small female, midsize male, and/or large male). Because each spacecraft design is unique and imparts unique loading conditions on the occupant, each is evaluated against a range of expected dynamics. While these dynamics typically diverge from the Hybrid III certification tests for automotive use, additional testing was conducted in a range of orientations and loading conditions to better characterize the 3 ATD sizes in these conditions.

METHODS: A total of 49 tests were conducted at the Air Force Research Laboratory's Horizontal Impact Accelerator. Each test consisted of all 3 ATD head and neck assemblies attached to a custom mount that allowed the angle of each assembly to be adjusted independently. Tests were conducted at 6-12 *g* peak accelerations with rise times that varied between 50 and 100 ms. Head and neck assemblies were oriented in several different directions relative to the sled direction of travel to exercise the flexion, extension, lateral, and combined-direction moments.

RESULTS AND DISCUSSION: Overall results showed significant differences between the small and midsize neck responses and the large ATD. The lateral frequency of the neck motion for all of the 50 ms rise-time were 4.1, 4.5 and 5.1 Hz for the small, midsize, and large ATDs respectively. For the 100 ms rise-time impulse, the lateral frequency responses were 3.3, 3.7, and 4.3 Hz. These results are consistent with the designs of the ATDs. Both the small and midsize ATDs use the same density rubber; however, the large ATD uses a denser rubber, resulting in a higher natural frequency, thus affecting the response.

TUESDAY – 11:30 AM – 1:00 PM
NETWORKING LUNCH
LOCATION – EXHIBIT HALL - SUMMIT PAVILION
EXHIBITS HALL REMAINS OPEN

TUESDAY: 1:00 PM – 2:30 PM
ALSS (SPACE)
LOCATION: CARSON 1 & 2
MODERATOR: Matt Zu & Brian Griffin, NASA Armstrong

PANEL: Low Boom Flight Demonstrator (LBFD) X-59 and F-15 Chase Aircraft Life Support System (LSS) Development

INTRODUCTION: The panel will include presentations of current Low Boom Flight Demonstrator (LBFD) X-59 and F-15 chase aircraft Life Support System (LSS) design, challenges, and integrated system qualification test planning, execution, and results. In particular, the focus of the panel will be:

(1) Operational Challenges Associated with the X-59 and F-15 Chase Aircraft Life Support System (LSS) Design
(2) Life Support System (LSS) Oxygen Analysis For the Low Boom Flight Demonstrator (LBFD) X-59 Aircraft
(3) Low Boom Flight Demonstrator (LBFD) X-59 Aircraft Life Support System (LSS) Integrated Test Planning, Execution, and Results

PANEL CHAIRS:

Mr. Matt Zu – Low Boom Flight Demonstrator (LBFD) Life Support System Lead; New Horizons Aeronautics - Millennium Engineering and Integration Co., NASA Armstrong Flight Research Center, Edwards, CA
Mr. Brian Griffin – Low Boom Flight Demonstrator (LBFD) Deputy Operations Lead; NASA Armstrong Flight Research Center, Edwards, CA

PRESENTERS:

Operational Challenges Associated with the X-59 and F-15 Chase Aircraft Life Support System (LSS) Design – Mathew J. Sechler; Vertex Aerospace; NASA Armstrong Flight Research Center, Edwards, CA

INTRODUCTION: NASA is currently designing and building the Low Boom Flight Demonstrator (LBFD) X-plane, designated X-59 Quiet SuperSonic Technology (QueSST), that will demonstrate that aircraft can fly at supersonic speeds over land without producing loud sonic booms on the ground. NASA is designing, testing, and integrating the life support system for both the X-59 and its chase aircraft. This presentation summarizes several of the design challenges that the project encountered using existing parts as well as integrating them into an older aircraft (F-15).

METHODS: Several topics will be discussed in this paper. These include fitting an F-22 BRAG Valve derived Panel Mounted Breathing Regulator (PMBR) into an F-15 and having to route the ECS air for G-suit pants to the opposite side of the aircraft. With mission profiles requiring higher flight levels, the standard emergency oxygen quantity was insufficient, and so several modifications, including additional capacity, were made for pilot safety both on the X-59 and F-15 ejection seats. Many of the LSS components were affected by the desire to fit them into limited space within the X-59 fuselage (such as LOX converter, heat exchanger, and PMBR), and this imposed additional challenges. Finally, several operational issues, involving organizational availability and mission limitations associated with the modified chase aircraft, are also discussed.

RESULTS AND DISCUSSION: This briefing summarizes a variety of operational issues impacted by the design of the X-59 and F-15 chase aircraft LSS. The brief will feature a large number of images to depict the various topics. Although the design of the X-59 does indeed pose challenges, the development team has been successful in addressing them, to ensure pilot safety for both normal and emergency situations, to include ejection and a rapid decompression at 60,000 ft.

Life Support System (LSS) Oxygen Analysis for the Low Boom Flight Demonstrator (LBFD) X-59 Aircraft – Mr. Kurtis Long; NASA Armstrong Flight Research Center, Edwards, CA

INTRODUCTION: NASA and Lockheed Martin are currently designing the Low Boom Flight Demonstrator (LBFD) X-59 aircraft; the X-59 will demonstrate that aircraft can fly at supersonic speeds over land without producing loud sonic booms on the ground. Since the X-59 will be flown at altitudes up to 60,000 feet, its NASA-designed life support system must provide sufficient oxygen for the pilot for routine operations, as well as emergency oxygen for use during emergency descent and/or post-ejection descent. This presentation summarizes several analyses which were performed to ensure the safety and adequacy of the X-59 oxygen system.

METHODS: A set of fluid mechanics math models was developed to estimate the performance of both the baseline Liquid Oxygen (LOX; the LBFD is NOT using OBOGS - Onboard Oxygen Generating System) and the compressed gas emergency oxygen system (EOS) for high altitude (60,000 ft.) ejection or "fly down" emergency scenarios. Analytic models developed for this project included component inflation volumes and leak rates, pilot/seat/parachute weight and drag, post-ejection descent rate and duration, EOS bottle flow variation with altitude and pressure, pilot respiration rate, pressure breathing, cockpit pressurization system performance, and oxygen system internal pressure drop and flow characteristics. These analytic models were validated and then used to evaluate both "typical" and "worst case" X-59 mission scenarios, for routine and limited component failure modes.

RESULTS AND DISCUSSION: This analysis indicates that the proposed LBFD oxygen system will safely support post-ejection descent or flight, from 60,000 ft. down to 10,000 ft., under extreme worst-case mission conditions, with and without limited component failures. This paper is of significance to the SAFE community because it presents the results of recent analytic efforts which were conducted to ensure the safety and adequacy of the X-59 oxygen system. These efforts span a variety of topics which have relevance to both military and civilian aircraft designs.

Low Boom Flight Demonstrator (LBFD) X-59 Aircraft Life Support System (LSS) Integrated Test Planning, Execution, and Results - Mr. Brian Griffin; NASA Armstrong Flight Research Center, Edwards, CA

INTRODUCTION: NASA is currently designing and building the Low Boom Flight Demonstrator (LBFD) X-plane, designated X-59 Quiet SuperSonic Technology (QueSST), that will demonstrate that aircraft can fly at supersonic speeds over land without producing loud sonic booms on the ground. NASA is designing, testing, and integrating the life support system for both the X-59 and its F-15 chase aircraft. This presentation includes the details of the system integrated test planning, the execution, and a preliminary look at the results.

METHODS: A fluid mechanics analysis was performed on the system to validate a representative test configuration assembled for the integrated testing of both the X-59 and F-15 designs. A comprehensive test plan was developed and includes both unmanned and manned testing. Testing covers breathing impedance and rapid decompression testing of both the primary and emergency oxygen delivery systems, with the inclusion of emergency system performance and duration testing ensuring sufficient operation for emergency descents and ejections from altitudes up to 60,000 ft. The testing was performed in collaboration with KBR at the Brooks City-Base facilities in San Antonio, TX.

RESULTS AND DISCUSSION: This presentation will discuss the requirements and assumptions of the fluid mechanics analysis resulting in the as tested system configuration. An overview of the life support integrated system test plan and test matrix will be presented. In addition, results (to the extent available at the time of presentation) will be presented.

Please note at time of submission, testing has not been conducted, hence detailed results are unknown, and the abstract reflects this.

TUESDAY: 1:00 PM – 2:30 PM
BIOMECHANICS (GUNNER SEAT CRASH PROTECTION)
LOCATION: CARSON 3 & 4
MODERATOR: Eric Anderson & Lindley Bark, NAVAIR

PANEL: MH-60S NextGen Gunner Seat Program – Crash Protection Performance and Expanded Functional Capability

INTRODUCTION: The MH-60S NextGen Gunner Seat Program is a rapid development effort to design and field a new gunner seat for the MH-60S model with specific goals to improve crashworthiness and aircrew comfort and endurance with a long-term aim of mitigating chronic injury in MH-60S aircrew. This panel will focus on various aspects of the NextGen Gunner Seat program dealing specifically with crash protection performance and increased functional capabilities.

PANEL CHAIRS:

Mr. Lindley Bark – Branch Head; Crashworthiness & Escape Systems, Human Systems Department, Naval Air Warfare Center Aircraft Division, Patuxent River, MD

Mr. Eric Anderson – Mechanical Engineer; Crashworthiness & Escape Systems Branch, Human Systems Department, Naval Air Warfare Center – Aircraft Division, Patuxent River, MD

PRESENTERS:

Introduction: The Background and Genesis of the NextGen Gunner Seat Program - Lindley Bark; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD

New Features and Expanded Capabilities - Martin Lawson; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will provide an overview of the features included in the NextGen Gunner Seat and the improved capability that they offer. Several new capabilities have been added to the H-60S gunner seat that allow the occupant to optimize seat position, crash protection, lumbar support, and many more aspects that are deficiencies in the legacy seat.

Redesigning Restraints to Address Legacy Deficiencies - Roger Podob; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will provide an overview of the features included in the NextGen Gunner Seat restraint system. Design efforts focused on addressing the major deficiencies found in the legacy restraint system. Several improvements allow for

increased occupant mobility, greater adjustability, decreased nuisance locking, and improved occupant restraint during crash events.

Crash Protection Performance of the MH-60S NextGen Gunner Seat – Eric Anderson; Naval Air Warfare Center – Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will provide an overview of the crash protection performance of the NextGen Gunner Seat and the results of dynamic qualification testing. Occupant injury data was collected and utilized to evaluate performance and qualify the crashworthiness of the system. Static load testing was also performed as a supplement to dynamic test in order to evaluate the structural integrity of the system.

Implementation and Correlation of Dynamic Modeling - Amir Jafri; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will discuss the effort to create a dynamic model to qualify the crashworthiness of the system as a supplement to dynamic test. Development of this model was performed in tandem with system design and further refined and correlated by dynamic test. This process greatly expedited both the development and testing of the NextGen Gunner Seat and allowed the program to operate with improved efficiency and reduced risk.

Closing Remarks: Preliminary Feedback, Next Steps, and the Way Forward - Mr. Lindley Bark; Crashworthiness & Escape Systems, Human Systems Department, Naval Air Warfare Center Aircraft Division, Patuxent River, MD

TUESDAY: 1:00 PM – 2:30 PM
ANTHROPOMETRY
LOCATION: CRYSTAL 1 & 2
MODERATOR: Keith King, NAVAIR

Predicting Whole Body Seated Center of Gravity (CG) Using Linear Regression Equations Generated from Anthropometric Measurements – Dr. Casey Pirnstill[1], Mr. Chris Albery[2], Mr. Charles Goodyear[2], Mr. James Elgersma[3], Mr. Martin Andries[4], Ms. Jennifer Whitestone[5]; [1]711th HPW/RHBN, WPAFB, OH; [2]Infoscitex Corp., WPAFB, OH; [3]AFLCMC/WLZG, WPAFB, OH; [4]AFLCMC/EZFC, WPAFB, OH; [5]AFLCMC/WNUV, WPAFB, OH

INTRODUCTION: In ejection seat design, current required CG_x/CG_z envelopes for the United States Air Force (USAF) are based on limited human data generated with legacy weight population and all-male dataset collected in 1967. To better understand a CG range required to accommodate current pilots anthropometries data reported by Albery et al.[1] (69 subjects), CG prediction verification (17 subjects) in combination with predicted CG data of JPATS (2,019 subjects) are utilized in this work to produce an updated CG envelope for males and females based on JPATS ranges. Prediction models for CG values of JPATS were generated using linear regressions of Albery CG data and anthropometric variables to produce 4 CG prediction equations.

METHODS: Utilizing CG/anthropometry data, Albery et al.[1], linear regression analysis of 34 measurements was performed to generate equations with minimal terms and predictability for male/female in both CG_x/CG_z. Models were selected based on estimation of lowest error of CG for subjects not used in the regression generation, based on models generated from linear regressions computed in SAS software. Resulting equations were used to predict CGs of JPATS[2] subjects using anthropometric terms. The predicted and measured CG data (>2,100) were combined to produce gender specific CG envelopes representative of JPATS ranges, defining CG envelopes more representative of the current USAF pilot population.

RESULTS AND DISCUSSION: Given the limited amount of CG data available for generating the prediction models (64) and large number of individual anthropometric measurements (34), the total measurement terms per model was limited to reduce the likelihood of overfitting the prediction models from anthropometric dimensions (i.e. the data with the highest R^2 is not always the best prediction model). For female CG_z, the model included 3 ratio-terms/6 variables for prediction and a CG_x model of 3 variables/ terms. The maximum error for female CG_z was 1.02” and CG_x 0.51”. For male prediction models, the best CG_z/CG_x models consisted of 4 variables/terms resulting in maximum error of prediction for males of 0.45” CG_z and 0.89” CG_x. Predicted JPATS CG’s (2,019) combined with measured CGs Albery[1] (69)/verification (17) produced gender specific CG envelopes based on the JPATS ranges for pilots and results illustrate measured CG’s and predicted CGs are closely overlapping in extrema for male and female values.

REFERENCES:

[1] Albery CB, Schultz RB, Bjorn VS. Measurement of whole-body human centers of gravity and moments of inertia. SAFE J. 1998 Jun; 28(2) 78-88. PMID: 11542768.

[2] Gordon, CC (1989). 1988 anthropometric survey of U. S. army personnel: Methods and summary statistics. *Technical Report Natick/TR-89/044*

BRIEFING: 3D Scanning and Digital Human Modeling Lab Efforts - Lori Brattin Basham, Andrew Koch; Naval Air Warfare Center - Aircraft Division, Physiology and Operational Performance Branch, NAS Patuxent River, MD

INTRODUCTION: The speakers will provide an introduction to the 3D Scanning and Digital Human Modeling (DHM) Lab that is part of NAVAIR's new Aeromedical Division. There will be an overview of work efforts in FY19 to include work performed for the H-60 NextGen Gunner Seat program and an E-2D Cockpit scan. Also being briefed is a project conducting a longitudinal comparison of anthropometry starting from when pilots begin training to when they enter U.S. Navy Test Pilot School. There will be an update on the lab's DHM research project to include work on a joint seat posture modeling process and the associated data collection, a portable body scanner prototyping effort, and other FY19 accomplishments. Future program support and research efforts will also be discussed.

BRIEFING: **Estimation of the Seated Center of Gravity using a Linear Regression Model on the Results of a Principal Component Analysis -** Jennifer J Whitestone[1], Jeffrey A Hudson[1,2], Cassie Muellenger[3], Chris Albery[3;]; [1]Airmen Accommodation Lab (AFMC AFLCMC/EZFC), Wright Patterson AFB, Dayton, OH; [2]STI-Tec, Dayton, OH; [3]Infoscitex, Dayton, OH.

INTRODUCTION: The relative location of a seated pilot's Center of Gravity (CG) with respect to that of the ejection seat is a key parameter in the system's successful function. A reliable estimation of the variation of pilot CG location for a user population has obvious value in predicting a design's success. Two past studies (Albery et al., 1997, Albery et al. 2019) have collected seated CG data as well as weight, and a variety of body size dimensions (circumferences, heights and breadths). These data can be used to generate a predictive model for seated CG based on variables that are also included in the JPATS (Joint Primary Air Training System) anthropometric database (851 females, 1301 males). The T-X acquisition program specified their anthropometric size requirements as the JPATS Boundary Cases 1 through 7, which were derived from, and represent, the extreme body size and proportions evident in the JPATS populations. Hence, an estimation and plot of the CG envelope for the entire JPATS population, based on the predictive model generated from available empirical data, is offered to inform the T-X program.

METHODS: A Principal Components Analysis (PCA) was used to characterize the size and shape space of the JPATS male and female populations separately. This procedure transformed the database distribution from original anthropometric space (defined by 30 variables) into Principal Component (PC) space using the variable correlation matrix. The resulting PC space has 30 principal component axes, each of which offers a new coordinate location value for the JPATS population members. The same PCA was performed on the studies which also contained the measured CGx and CGz values. These values were then used as input to define a multiple linear regression model that resulted in a predictive model for CGx and CGz. This Principal Components Analysis-Regression (PCA-R) predictive model was applied to the JPATS males and females resulting in estimations of their CGx and CGz values.

RESULTS AND DISCUSSION: The resulting CGx and CGz envelopes are plotted for the JPATS female and male populations. The residuals of the various predictive models are discussed. The predictive results of a test data set are contrasted with those of the training data set used to define the predictive model. In addition, the effect of iteratively reducing the number of PCs used as input, is discussed.

TUESDAY: 1:00 PM – 2:30 PM
DYNAMIC TESTING (HELMETS & EQUIPMENT)
LOCATION: CRYSTAL 3 & 4
MODERATOR: Joseph McEntire, USAARL

BRIEFING: A New Test Fixture Design for Measuring Helmet Mass Properties - Nathan L. Flath[1,2], Elizabeth L. Lafferty[1,3], B. Joseph McEntire[1]; [1]U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL; [2]Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN; [3] Katmai Government Services, Anchorage, AK

INTRODUCTION: Military service members wear helmets, which provide protective capabilities and frequently serves as a mounting platform for ancillary equipment. The cumulative effect of these components is increased mass, which increases cervical spine injury risk and decrease wearer performance. For rotary-wing aviators, USAARL recommends limiting total head-borne mass based on the center of mass (CM) location, measured relative to the head anatomical coordinate system (ACS). Current methods to measure CM and mass moment of inertia vary between services and within the Army. In collaboration with the Combat Capabilities Development Command-Solider Center, a new test fixture and methodology is being developed to standardize Army head-borne mass property measurements.

METHODS: The existing USAARL test fixture and methodology for collecting mass properties, implemented in 1993, were critiqued for limitations. Specifically, the limitations in measurement accuracy and testing efficiency with respect to changing headform orientations. The new test fixture was designed to address these limitations within the physical constraints of the Space Electronics KSR 330 mass properties instrument (MPI). A critical design requirement was to maintain the headform ACS alignment to the MPI's coordinate system for all six required headform orientations.

RESULTS AND DISCUSSION: The new design employs a gimbal concept to maintain the headform ACS alignment with the MPI coordinate system. The new fixture design allows for measurement of all six headform orientations for a single headgear placement. This feature improves testing efficiency and reduces error by eliminating the necessity to don/doff the test helmet between headform orientations. Three headform sizes, modeled from USAARL's existing three headform sizes (designed from tri-service aviator head anthropometry data) were digitally scanned, electronically modified to display anatomical reference planes, and 3D printed. Other headform types could be used on this design. This new fixture and test methodology will become the Army standard and could be easily adopted by other Services.

BRIEFING: Evaluation of Soft Spot Occurrences in the HGU-56/P Aircrew Ballistic Helmet - Benjamin C. Steinhauer; Air Force Research Laboratory, Wright-Patterson AFB, OH

INTRODUCTION: HGU-56/P Aircrew Ballistic Helmets (ABH) were returning from the field with soft spots despite passing all required specification criteria. The objective of the study was to develop a methodology for determining soft spots while also verifying no loss of protection capabilities when minor accessory modifications were made to the helmet.

METHODS: Five (5) older ABH and 10 redesigned ABH helmets were used to determine soft spot occurrences, as well as determine if installing Accessory Rail Connectors (ARC) would affect the impact properties of the redesigned ABH helmet. A methodology was developed using a digital tap hammer and a series of low velocity impacts to determine an occurrence of soft spots. Force and Acceleration data were collected through high velocity impacts on a CADEX helmet drop tower to determine impact characteristics with ARCs installed.

RESULTS: All tests showed a larger change in digital tap hammer readouts pre- and post- low velocity impacts on the original ABH helmet versus the redesign. The overall readout value on the redesigned ABH was, on average, lower than the original. All high velocity impacts using the ARCs passed the current ABH product specification requirements.

DISCUSSION: Alternative methods of testing soft spot occurrences could be considered in the future when redesigning a current helmet for defects in either material used or the manufacturing process. The methodology developed in this program could be a starting point for testing, but was specifically designed around the failure point of the original ABH helmet with respect to soft spots. Further understanding of the linear and rotational accelerations produced by the human head and its relationship to concussion could also be further expanded and how it correlates to current military helmet product specification requirements.

BRIEFING: Structural Integrity Evaluation of Medical Devices Exposed to a Dynamic Environment - Michael A. Collier, Benjamin C. Steinhauer; Air Force Research Laboratory, Wright-Patterson AFB, OH

INTRODUCTION: The Aeromedical Test Lab (ATL) was tasked to evaluate the structural integrity and dynamic response of several devices. This included a temperature controller, a medical training manikin, and a portable blood oxygenation device. The objective of the study was to demonstrate effective restraint of the devices when attached to a patient transport litter during a simulated crash event. This was performed to determine possible occupant risks, as well as risks to the devices themselves.

METHODS: The devices were strapped onto a medical transport litter and the litter was placed on a Horizontal Impulse Accelerator (HIA) to generate pure +X and +Y loading and a Vertical Deceleration Tower (VDT) to generate pure +Z loading. The tests were performed in this manner to abide by the Joint En Route Care Equipment Test Standard.

RESULTS & DISCUSSION: The temperature controller and medical training manikin remained structurally intact throughout the testing, while the portable oxygenation system broke when exposed to pure +X loading. Testing these devices on the HIA and VDT enables ATL to determine whether a device passed or failed according to the Joint En Route Care Equipment standard and may aid in developing new techniques to secure similar devices in the future.

TUESDAY – 2:30 – 3:00 AM
PM REFRESHMENT BREAK
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

TUESDAY: 3:00 PM – 4:30 PM
AEROSPACE PHYSIOLOGY
LOCATION: CARSON 1 & 2
MODERATOR: Brian Bradke, Spotlight Labs

BRIEFING: **Research on Pilots' Active Intelligent Protection Technology –** Shao-ping TIAN[1,2], Lei ZOU[1,2], Bing-jun SU[1,2], Hua PENG[1,2], Ru-dong TIAN[1,2]; [1]Aerospace Life-support Industries, LTD, Xiangyang, China; [2]Aviation Key Laboratory of Science and Technology on Life Support Technology, Xiangyang, China

INTRODUCTION: The modern high-performance combat aircraft is an airman-centric integrated weapons system. In this paradigm, the pilot's individual capacity can limit the scheduled operational effectiveness of the aircraft systems. The traditional design method of offering protective technology was to adopt a limit protection concept according to established work programs or a possible limit state, namely regardless of pilots' individual differences, and whether at any given moment protection is needed. Consequently, many current systems provide insufficient protection and/or over-protection of active pilots. The Pilots' Active Intelligent Protection Technology considers the need for "intelligence, initiative and high safety" in current and future advanced aircraft.

METHODS: Accounting for the unique flight environment confronted by the pilot, the intelligent protection life-support technology proposes a system scheme that combines intelligent protection and active protection. The pilot's active intelligent protection technology monitors physiological status of the pilots, combined with the pilot's external environment, via auto-detection and feedback of the information collected by aircraft and personal protective equipment to implement an all-round active defense. Using known data on pilots' physiological limits under complex conditions, and utilizing images, sound, and basic data processing, the collected information is analyzed to provide early warning and protection. The system actively adjusts the anti-g, oxygen supply, output pressure compensation, etc. to stimulate the pilots or flight attitude automatic adjustment that enhances flight safety.

RESULTS AND DISCUSSION: An intelligent early warning and active protection method is established for pilots experiencing aviation stressors. The technology is the next practical step in the development of individual protection techniques and can be widely used in future new fixed-wing, rotary-wing aircraft, soldier systems, and personal protective equipment in aerospace fields.

TUESDAY: 3:00 PM – 4:30 PM
BIOMECHANICS (GUNNER SEAT ENDURANCE)
LOCATION: CARSON 3 & 4
MODERATOR: Dr. Bethany Shivers & Lindley Bark, NAVAIR

PANEL: MH-60S NextGen Gunner Seat Program - Endurance, Comfort, and Chronic Injury Mitigation

INTRODUCTION: The MH-60S NextGen Gunner Seat Program is a rapid development effort to design and field a new gunner seat for the MH-60S model with specific goals to improve crashworthiness and aircrew comfort and endurance with a long-term aim of mitigating chronic injury in MH-60S aircrew. This panel will focus on various aspects of the NextGen Gunner Seat program dealing specifically with aircrew fit, comfort, and endurance, and ultimately chronic injury mitigation.

PANEL CHAIRS:

Mr. Lindley Bark – Branch Head; Crashworthiness & Escape Systems, Human Systems Department, Naval Air Warfare Center Aircraft Division, Patuxent River, MD

Dr. Bethany L. Shivers – Physical Scientist; Crashworthiness & Escape Systems Branch, Human Systems Department, Naval Air Warfare Center – Aircraft Division, Patuxent River, MD

PRESENTERS:

Introduction: The Background and Genesis of the NextGen Gunner Seat Program - Lindley Bark, Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
MH-60S NextGen Gunner Seat: Designing with Comfort and Endurance in Mind – Meredith Fielder; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will provide an overview of Navy efforts to address comfort and endurance issues during the MH-60S gunner seat redesign. Design efforts focused on developing a seating system that would accommodate a wider range of body dimensions, reduce muscle fatigue, and minimize vascular and nerve disruption. Specific details of the seat pan, back support, headrest, textile covers, and the aircraft integration all contribute to improve comfort and endurance without limiting mission capabilities.

Quantifying NextGen Gunner Seat Capability to Improve Endurance and Comfort and Reduce Chronic Injury: Subjective and Objective Metric Development –Dr. Bethany L. Shivers; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD
Speaker will provide an overview of Navy efforts to qualify the NextGen Gunner Seat in the absence of clearly defined standards for comfort, endurance, or chronic injury risk. Best practices were pulled from related industries including automotive seat design and wheelchair fit and function to identify viable metrics for seat qualification.

Assessing Seat Comfort Change Using Seat Interface Pressures – Matt Pontarelli; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD

Speaker will provide an overview of Navy efforts to quantify seat comfort improvement for the MH-60S gunner seat replacement using seat bottom interface pressure mapping. Seat bottom contact area pressures were collected during ground endurance testing using an ultra-thin, flexible sensor array. Pressure field values, and other quantities derived from the pressure field, were used to determine improvement to the distribution of pressure in key areas of the seating system important to comfort.

Anthropometric Accommodation for the MH-60S NextGen Gunner Seat – Lori Brattin Basham; Naval Air Warfare Center - Aircraft Division, Physiology and Operational Performance Branch, NAS Patuxent River, MD
Speaker will provide an overview of Navy efforts to improve anthropometric accommodation for the MH-60S Gunner Seat. The NextGen Gunner Seat program funded an anthropometric survey of the aircrew population for the Gunner Seat. These data were utilized to create use cases that better define the population and which helped refine the seat requirements. An accommodation evaluation was also performed on the production seat for requirements verification purposes.

Closing Remarks: Preliminary Feedback, Next Steps, and the Way Forward - Dr. Bethany L. Shivers; Naval Air Warfare Center - Aircraft Division, Crashworthy & Escape Systems Branch, NAS Patuxent River, MD

TUESDAY: 3:00 PM – 4:30 PM
ANTHROPOMETRY
LOCATION: CRYSTAL 1 & 2
MODERATOR: Jennifer Whitestone, USAF AFMC AFLCMC/EZFC

BRIEFING: Encumbered Anthropometry: Past, Present and Future – Dr. Todd N Garlie, Dr. Hyeg Joo Choi, Mr. Joseph L Parham; US Army Combat Capabilities Development Command Soldier Center, Natick, MA

INTRODUCTION: Encumbered, or equipped, anthropometry attempts to capture the total space claim of service members beyond the body size and shape information that traditional anthropometric data provide. Data from the 2012 U.S. Army Anthropometric Survey (ANSUR II) is widely utilized to specify nude human models for understanding body shape and size. Linear, circumferential, and volumetric allowances for clothing and individual equipment (CIE) are then either estimated or obtained from a growing database of equipped Soldier dimensions.
This study summarizes four selected encumbered anthropometry efforts conducted by the US Army Combat Capabilities Development Command (CCDC) Soldier Center since 2012. The significance for each study lies in the overall evaluation of: 1. The quantitative assessment of bulk on four different duty positions (Driver, Rifleman, Saw Gunner, Combat Medic), 2. The quantitative relationship between bulk and mobility in two different protection levels (IOTV and Plate Carrier) while wearing two different duty positions (Rifleman and Grenadier), 3. The quantitative relationship between bulk, mobility, performance and coverage of individuals in three different sizes of body armor (IOTV GEN III), and 4. The quantitative assessment of bulk related to wearing cold weather environmental clothing at four selected temperature levels.
The results from these studies help characterize the size, shape, and movement ability of the Warfighter with current CIE and helps to inform the design for future product development as well as workspace analyses. Recently, there are plans to feed those databases into digital human models to help develop realistic virtual Soldiers. All encumbered anthropometric data are available to PMs, designers, developers and human systems integration practitioners.

BRIEFING: Visualizing Head Size and Shape Variation in the US Army – Dr. Hyeg Joo Choi, Mr. Joseph L Parham, Dr. Todd N Garlie; US Army Combat Capabilities Development Command Soldier Center, Natick, MA

INTRODUCTION: Understanding variation in head size and shape is critical to aid in the design and development of protective head gear for the US Military. Delivering this information requires both univariate descriptive statistics (e.g. mean, median, mode, and variance) and multivariate approaches including Principal Component Analysis, cluster and discriminant analyses, as well as the use of 3D scan images. Head measurement data and 3D scan images were collected during the 2010-2012 US Army Anthropometric Survey (ANSUR II).

This study follows a traditional methodology to theoretically accommodate a representative sample of the US Army population within the current sizing system of the Advanced Combat Helmet (ACH), and summarizes the observed variability of head shape and size relative to the predicted helmet size. Summary statistics including frequency tables are developed for both male and female Soldier populations, and their data are plotted against each other to illustrate the resulting sex differences. Biological subgroup differences are also explored via the comparison of head descriptive statistics.

This study will further demonstrate head variability through visualizations utilizing 3D scan imagery. Within each predicted helmet size, scans are selected to highlight the minimum and maximum accommodated head breadths, lengths, and circumferences for each sex. Scans will further be used to visualize traditional descriptive statistics, as well as to illustrate the differences between the male and female Soldier populations in addition to the biological subgroups highlighted in the ANSUR II database.

BRIEFING: **Characterizing Size and Shape Variation in Female Scalps Using Standard Morphometric Techniques:** JA Hudson[1,5], BD Corner[2], B-KD Park[3], MP Reed[3], P Li[4], J Choi[4], JJ Whitestone[5]; [1]STI-Tec, Dayton, OH; [2]Marine Corps Systems Command, Quantico, VA; [3]University of Michigan Transportation Research Institute (UMTRI), Ann Arbor, MI; [4]U.S. Army Combat Capabilities Development Command Soldier Center (CCDC/SC),[5]AFLCMC/WNU

INTRODUCTION: Many anthropometry surveys over the last 3 decades have included 3D body scanning in their data collection. Individual body scan surfaces, or surfaces of body segments, can be matched, or fit, with a morphable reference template resulting in meshes with homologous vertices in 3D correspondence across all individual meshes. Morphometric analysis on the resulting sample of fit meshes can be used to characterize and quantify the size and shape variation of a body segment. To demonstrate this approach, the fit meshes of the scalps of 100 women were morphometrically analyzed for a general aircrew helmet application.

METHODS: As part of the multi-service "Head Under Hair" project, the USAF collected head scans and scalp geometry of 100 females. Template meshes were matched to the merged head scan and scalp shapes of the subjects and saved as *.obj files (UMTRI). Using MeshLab, the scalp region of interest was colorized on one female head, which identified the scalp region by its set of vertex numbers, which served as input to a Python segmentation program to extract the scalp regions of the remaining 100 females. The resulting scalp vertex (xyz) coordinates of all 100 females were concatenated and formatted as input to Morpheus (Florida State University) where a General Procrustes Analysis was run. Using R (and R-Studio), the aligned and scale-restored Morpheus output was input to a Principal Component Analysis (PCA) yielding a transformed distribution of the data that can be described as "scalp shape space." In this standardized scalp shape space, representative extreme scalp shapes were located at intersections of the first 12 principal components and an "inclusion shell" which contained 90% of the sample, which were then transformed back into original xyz space. The resulting scalp shapes, or model points, were then visualized and used to characterize the size and shape variation present in this female scalp data.

RESULTS AND DISCUSSION: The 902 vertices of the defined scalp region offered 2,706 total variables (3 xyz values x 902 vertices) for the PCA. The first 12 resulting PCs explained a combined 92% of the total variance in female scalp size and shape. The contrasting model point pairs (from the ends of the PC axes) can be used to visualize, describe, and name each PC in question and represents the change in size and shape as you move through PC space parallel to that PC. Examination of the model point pairs also helps determine the PC's relevance to the helmet design application. The differing results when using covariance or correlation matrices as input to the PCA are discussed as well as the usefulness of this morphometric approach to helmet design.

TUESDAY: 3:00 PM – 4:30 PM
BIOMECHANICS (EJECTION)
LOCATION: CRYSTAL 3 & 4
MODERATOR: Sam Trepp, NAVAIR

BRIEFING: ACES 5 Safety Features and Program Update – Mr. Don Borchelt; Collins Aerospace, Colorado Springs, CO

INTRODUCTION: Collins Aerospace is redefining safe escape with the Next Generation Ejection Seat (NGES), the ACES 5. Collins professionals listened closely to their customers and delivered the safest, most innovative ejection seat on the market. The ACES 5 is the only ejection seat available today qualified to the MIL-HDBK-516C industry standard with proven, sled-tested, injury reduction features during the entire ejection sequence. This presentation will review the safety features of the ACES 5 seat and provide an update of the many programs using the ACES "Family of Systems."

BRIEFING:_Mythbuster: "The Gen 5 Integrated Harness" - Steve Roberts, Martin-Baker Aircraft Company Ltd., Higher Denham, United Kingdom

INTRODUCTION: Ejection Seats are fitted with only 2 restraint harness types: either a Seat mounted "Integrated Harness" or with the interfaces for the man-mounted "Torso harness". Historically, both harness types have offered advantages and disadvantages in equal measure, with the usage of each type following National preferences. The Martin-Baker (MBA) database indicates that 9,400 MBA Seats are equipped with Integration harnesses, while 7,200 MBA Seats are fitted with interfaces for the Torso harness.

The Integrated harness was considered by its detractors to provide a reduced degree of body restraint compared to the Torso harness - because of its inherent benefits for variable adjustment and harness geometry. Harness comparisons have been studied by many governments and many aircraft primes.

In stark contrast to the Torso harness design, 55 years of continuous development has led to the Gen 5 Integrated harness configuration, which has replaced the Torso harness for all F-35 aircraft that will be operated by the 14 JSF countries. Many Operators are now making the choice to retrofit the Gen 5 Integrated harness onto legacy Ejection Seats.

The Myth is that the historical harness comparison is still accurate and relevant today.

This presentation will include analysis of recent test data that confirms that the Gen 5 Integration harness design provides equal body restraint to the Torso harness, while offering numerous advantages:

- Accommodating the CAESAR multi-variate body sizes, Cases 1 through 8;
- Introducing the patented Head Support Panel (HSP);
- Introducing the patented MWARS water activated automatic parachute release.

The latest revision of MIL-HDBK-516 "Airworthiness Certification Criteria" introduces different injury metrics for Ejection Seats not fitted with interfaces for the Torso harness. MBA will make recommendations to revise the guidance on aircrew restraint harnesses for both MIL-HDBK-516 and the JSSG-2010-11, "Crew Systems, Emergency Egress Handbook".

BRIEFING: **Ejection-Associated Injuries: A Retrospective Study for the Evaluation of Modern Escape Systems Safety –** Dr. Camille Bilger[1], Dr. Kathryn Hughes[1], Wg. Cdr. Matthew E Lewis[2]; [1]Martin-Baker Aircraft Company Ltd., Higher Denham, UK, [2]Accident Investigation RAF Centre of Aviation Medicine, RAF Henlow, UK

INTRODUCTION: Aircrew escape systems have evolved since their inception with an ever-increasing design focus on enhanced performance, effectiveness and safety. Constant programs of improvements are required, for not only escape systems currently in operational use, but also for future escape systems, to ensure aircrew eject safely and injuries are minimized. Although ejection-related injuries have been documented with respect to legacy escape systems, there has never been an analysis of system performance associated with current modern seats. This retrospective cohort study analyses the survivability of military accidents and the injuries associated with modern escape systems, in comparison to legacy systems. Martin-Baker has been producing aircrew escape systems for military aircraft since the 1940s. Since then, more than 7,600 lives have been saved by Martin-Baker products. In parallel, RAF Centre of Aviation Medicine (RAFCAM), has been involved with the investigation of military aircraft accidents since the 1940s.

METHODS: Martin-Baker's worldwide historical ejection records were interrogated to extract and examine relevant aircrew injury and fatality information, together with RAFCAM Accident Investigation data to provide comparative system performance information between legacy and modern escape systems.

RESULTS AND DISCUSSION: The level of post-ejection medical surveillance undertaken by different military safety investigators is extremely variable. This variability inevitably leads to significant apparent differences in injury rates that are actually a function of the level of surveillance rather than any true difference in incidence of injury. An internationally standardized medical surveillance and ejection reporting procedure would allow the collation and analysis of mishap data to be fully informative and representative of the ejection outcome for all future ejected aircrews.

TUESDAY – 5:00 PM – 7:00 PM
NETWORKING RECEPTION
LOCATION: EXHIBIT HALL – SUMMIT PAVILION
EXHIBITS REMAIN OPEN

WEDNESDAY, OCTOBER 16TH

WEDNESDAY - 8:00 AM – 3:30 PM
REGISTRATION OPEN
LOCATION: GRAND SALON REGISTRATION

WEDNESDAY: 8:00 AM – 9:30 AM
OXYGEN (POST-EMERGENCY)
LOCATION: CARSON 1 & 2
MODERATOR: Christine Brown, NAVAIR

BRIEFING: Characterization of Emissions from Smoldering Advanced Aircraft Composites - Austin Wardall, MS[1,2], Jerimiah Jackson[1,2], Ariel Parker, MS[1,2], Jacob Kirsh, MS[1,2], John Hatch[1,2], Ryan McNeilly, MS[1,2], Christin Duran, PhD[2]; [1]UES, Inc., 4401 Dayton-Xenia Road, Dayton, OH; [2]Airman Readiness Optimization Branch, 711th Human Performance Wing, Wright Patterson Air Force Base, OH

INTRODUCTION: Composite materials are the primary component of the modern aircraft. In the event of a mishap, combustion of composite materials can lead to exposure of hazardous components to first responders, follow-on support, and bystanders. During preliminary burn studies, it was identified that the majority of composite decomposition takes place during the smolder phase of combustion. Characterization emissions generated during the smolder phase is limited. Since aircraft composites can smolder for several days after an incident, it is necessary to characterize both the composition and dispersion of those emissions to understand the potential health impact of a mishap on exposed individuals. The primary objective of this study was to estimate the health risks of smoldering aircraft composites to recovery workers and local populations.

METHODS: Five replicate smolder experiments were completed for two composite resin-types representative of those used on advanced aircraft. Experiments were completed using a cone calorimeter at temperatures of 500 °C, 650 °C and 725 °C. These temperatures represent the phases where resin decomposes moderately, resin decomposes rapidly / carbon fibers begin to oxidize and resin decomposes rapidly / carbon fibers oxidize more readily. The data output from smolder experiments was used to build an air dispersion model and predict the impact of emissions on recovery workers and local populations.

RESULTS AND DISCUSSION: Carbon monoxide and ultrafine particles were primary components of smolder phase emissions for both composite types. Emission rates for gaseous and particulate emissions were scaled to the whole aircraft, and an air dispersion model was implemented to predict local smolder emissions exposure levels and clearance rates. Estimated smolder emissions exposure levels in the local area were compared to published exposure limits. The resulting knowledge set was used to develop recommendations for safe time and distances from smoldering aircraft for recovery workers and identify health risks for local populations.

Cleared, 88PA, Case#88ABW-2019-2682, 31May2019

BRIEFING: O2PAK Emergency Portable Oxygen System - John Graham; Safran Aerosystems Oxygen, Irvine, CA - Lancaster, NY

INTRODUCTION: The O2PAK emergency portable oxygen system is an FDA 510k approved, special operations grade chemical oxygen generator for use under the direction of trained medical military personnel in support for disaster relief, crisis response, wartime operations, deterrence/contingency operations, humanitarian relief situations, or peacetime engagements.

O2PAK is a single-use portable chemical oxygen generator (COG) that dispenses 99% medically pure oxygen. The O2PAK's duration is a guaranteed 22 minutes and offers a flow rate of 8 liters per minute (LPM) from activation to 4 LPM at completion. The oxygen flow begins within 4 seconds of actuation. The mimimum output of oxygen is 90 liters. By comparison, compressed gas in various forms can explode, ignite or become a projectile in the event a warfighter/medic comes under fire.

O2PAK has passed burn, ballistics, blast, vibration, drop and soak testing without exploding or suffering operational compromise. Studies performed by military medicine entities in 2013, which tested the O2PAK's performance against competing systems, concluded that O2PAK produced the most oxygen in terms of mean/flow duration. The O2PAK eliminates the risk of large oxygen cylinders, concentrators and power management equipment coming under fire. O2PAK offers safe, compact oxygen carriage, creating a safe oxygen application for field care, pre-evacuation and evacuation/pre-hospital phases of Tactical Combat Casualty Care (TCCC).

Safran Aerosystems Oxygen strives to align with TCCC modernization strategies, especially as special operations medicine transitions to a focus on ARC - Advanced Resuscitative Care, with oxygen being a key component. O2PAK is already used by operators such as USASOC Med Team 4, Medical Logistics NCOIC, USARMY MEDCOM USASOC SOAR, USAF 27 SOMDG, and DHHS PSC/FOH.

WEDNESDAY: 8:00 AM – 9:30 AM
BIOMECHANICS (ROTARY WING)
LOCATION: CARSON 3 & 4
MODERATOR: Joseph McEntire, USAARL

BRIEFING: **Dynamic testing of legacy helicopter troop seats using contemporary boarding masses and impact scenarios -** Paul Parker, QinetiQ, Farnborough, United Kingdom

INTRODUCTION: Energy Absorbing (EA) and non-EA seating in military aircraft are designed and qualified to defined limits, based on a range of both static and dynamic methods. To the user, these limits are typically expressed in terms of maximum occupant mass. In the UK, it is known that aircrew and passenger boarding masses can exceed these limits. This increase in mass is due to general increases in the mass of the population and the equipment they carry.

QinetiQ, on behalf of the UK Ministry Of Defence, has undertaken a programme of work to physically test legacy tube and fabric troop seats of the type used in some UK in-service helicopters. The testing aims to establish the crash performance of this type of seating, and hence any potential injury risk to occupants, including those whose mass exceed the design specification of the seating.

METHODS: Testing was undertaken using the decelerator sled facility at Cranfield Impact Centre, Bedfordshire, UK. The testing utilized instrumented Hybrid III dummies fitted with additional clothing and equipment to replicate the range of occupant masses of crewman and infantry users of UK military aircraft. Testing was conducted at a range of impact severities (peak acceleration and velocity change) that a review of the literature had shown were credible and survivable, in terms of occupiable cabin space post impact. Injury risk was assessed by consideration of seat structural integrity and standard Injury Assessment Risk Values.

RESULTS AND DISCUSSION: The presentation will highlight key results of the described testing. This will include how the tube and fabric seats designed against static load cases perform in a dynamic crash scenario and any associated occupant injury risk, and how these factors are influenced by different occupant boarding masses. The results of this assessment will be of interest to those working in the area of crash protection.

BRIEFING: **Evaluation of Spinal Injury Metrics in Rotary-Wing Crash Impacts Using Matched-Pair Testing -** Ray W. Daniel[1,2], Elizabeth L. Lafferty[1,2], Nathan L. Flath[1,3], Katie Logsdon[1,2], B. Joseph McEntire[1]; [1]United States

Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL; [2]Katmai Government Services, Anchorage, AK; [3]Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN

INTRODUCTION: Spinal injury is a known injury risk to rotary-wing aviators during crash impact events. To mitigate this risk, MIL-S-58095 was published with the intent to reduce crash impact forces through crashworthy seats. However, MIL-S-58095 only specifies seat pan acceleration thresholds and not response metrics of test surrogates. This method leaves a gap in correlation between injury risk and laboratory measurements. In order to bridge this gap, this study evaluates the response measurements of Anthropomorphic Test Devices (ATDs) recorded during vertical impact acceleration tests and matched to Post Mortem Human Subjects (PMHS) tests that resulted in spinal injury.

METHODS: Impact acceleration tests were conducted on the USAARL Vertical Acceleration Tower, which included 6 PMHS specimens and 14 matched-pair tests with two instrumented ATD types. ATD types included the standard automotive Hybrid III (STD) and the Federal Aviation Administration (FAA) configuration with a modified lumbar spine. All test surrogates received the same vertical acceleration pulse, which matched the MIL-S-58095 seat pan response performance requirement. Test surrogates were seated upright on a rigid seat, secured with a 5-point restraint harness. The measured ATD lumbar compressive loads were assessed against the available metrics, including the Dynamic Response Index (DRI).

RESULTS AND DISCUSSION: All six PMHS surrogates sustained severe spinal fractures. Fourteen ATD tests were completed, 10 with the STD and 4 with the FAA ATD. The applied dynamic test exposures were consistent with a velocity change of 41.9 (± 0.64) ft/sec, pulse duration of 89.6 (± 0.67) ms, peak acceleration of 22.1 (± 0.4) G, and an onset rate of 950.6 (± 30.6) G/sec. The average compressive lumbar load was 1394.8 (± 168.3) lbf and the average seat pan DRI was 22.1 (± 1.4). The average compressive lumbar load did not exceed lumbar load criterions from literature suggesting the available lumbar injury criteria may be inadequate.

BRIEFING: Retrospective Review of Spinal Injuries in US Army Rotary-Wing Mishaps: January, 1990 – December, 2014 - Frederick Brozoski[1], Joseph Licina[1,2], Mark Adams[1,3], and B. Joseph McEntire[1]; [1]United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL; [2]Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN; [3]Royal Army Medical Corps, Attach Helicopter Force HQ, RAF Station Wattisham, UK

INTRODUCTION: A retrospective review of spinal injuries in U.S. Army rotary-wing mishaps occurring between January 1, 1990 and December 31, 2014 was conducted to investigate the effectiveness of crashworthy seating in preventing spinal injuries. Results will guide future research into thoracolumbar injuries, which often result from exposure to high vertical acceleration.

METHODS: Data from Army Class A and B, rotary-wing, in-flight mishaps occurring within the study period were obtained from the U.S. Army Combat Readiness Center (USACRC) aviation mishap database. Survivable, partially survivable, and non-survivable mishaps were included in this analysis. Injury data were down-selected to include fractures, dislocations, and transections sustained by occupants who were coded as being seated during the mishap. This study was conducted under a Human Subjects research protocol approved by the U.S. Army Medical Research and Materiel Command Office of Research Protections, Fort Detrick, MD.

RESULTS AND DISCUSSION: A total of 664 U.S. Army Class A and B, rotary-wing, in-flight mishaps occurred during the 25-year study period. These mishaps involved 687 rotary-wing aircraft and 2,832 occupants. In 97 of 664 mishaps (14.6%), 157 seated occupants sustained 210 spinal injuries. Lower thoracic (T10-T12) and lumbar (L1-L5) vertebrae experienced the highest frequencies of injury (11.4% and 27.1%, respectively), with the L1 being most commonly injured. The frequency and location of spinal injuries found in this study were consistent with historic data on spinal injuries sustained in survivable and partially-survivable, Class A and B, rotary-wing, in-flight mishaps occurring between 1979 and 1985; both studies show L1 as being the most commonly injured vertebra. Study results indicate a need to revise seat performance standards listed in MIL-S-58095A. Additional research is needed to develop an improved performance standard for rotary-wing crashworthy seating based on human thoracolumbar injury thresholds.

WEDNESDAY: 8:00 AM – 9:30 AM
ALSS (FIT = PROTECTION)
LOCATION: CRYSTAL 1 & 2
MODERATOR: Jennifer Farrell, Wright-Patterson AFB

BRIEFING: How Comfortable is Your Oxygen Mask? Evaluating Oxygen Mask Behavior in Dynamic Conditions (An Update) - Steinman Y[1], Nederlof R[2] van den Oord MHAH[1]; [1]Centre for Man in Aviation, The Royal Netherlands Air Force, The Netherlands; [2]Faculty of Aerospace Engineering, Delft University of Technology, The Netherlands

INTRODUCTION: Gentex introduced three improvements to the MBU-20/P oxygen mask: softer face piece, maximal trim of the mask hard shell and straight pull bayonet design. Results of subjective and static testing showed that aircrew favored the new softer face piece and maximal hard-shell trim over the legacy face piece and hard shell, but no decisive preference could be made regarding the straight pull bayonet design. The Center for Man in Aviation (CMA) is evaluating new test methods that would allow comparison between the performance of different mask configurations in terms of fit, comfort and stability in a dynamic scenario.

PURPOSE: The purpose of the present study was twofold. Firstly, to compare the performance of the straight-pull and legacy bayonets. Secondly, evaluation of the test method.

METHODS: Six F-16 pilots of the RNLAF participated in a counterbalanced within-subjects study. The pilots tested four MBU-20/P mask configurations in the human centrifuge of the CMA. Mask movement was measured using an IR camera mounted on the pilot's helmet, tracking three IR LEDs attached to the MBU-20/P masks. At the end of each centrifuge run the pilots filled out a short questionnaire.

RESULTS: The results of the questionnaires show that mask configurations with the softer face piece and maximum trimmed hard shell scored better but not significantly on most outcome measures. Post hoc analyses of the total mask score revealed a significant difference between the legacy mask and the masks with the softer facepiece and maximum trimmed hard shell. Results of the IR LEDs are not available at the moment.

CONCLUSION: The pilots expressed their preference for the mask configuration with the softer face piece and maximum trimmed hard shell. No clear effect was seen for bayonet type.

BRIEFING: Female Aircrew Flight Equipment – Maj Saily Rodriguez; Human Systems Program Office – AFLCMC, Wright-Patterson AFB, OH

INTRODUCTION: At the 2018 SAFE Conference, the Human Systems Program Office presented a number of gaps that existed within Aircrew Flight Equipment (AFE) to solve the specific needs of Air Force female aircrew members. Amongst other causes, these capability gaps were described to result from poor communication, monetary restrictions, and requirements being reduced to only solve the needs of the user majority. Since last year's presentation, several changes have occurred within the Human Systems Program Office to resolve the requirements of our female aircrew. Those changes and the progress made thus far will be presented. But while these actions have been instrumental for restructuring the future of female aircrew, solutions with revolutionizing effects have still not been implemented. In order for these solutions to become a reality across the Air Force, a culture that accepts the need to develop options for our female community needs to be adopted by a much greater population. Implemented solutions will not result from a small group championing the cause. This effectively means two things: women cannot be the sole supporters for proper-fitting equipment on aircrew members who have rightfully earned their positions and outside industry needs to anticipate the requirements of the female community and develop products at a quicker pace to solve those needs.

WEDNESDAY: 8:00 AM – 9:30 AM
NECK PAIN
LOCATION: CRYSTAL 3 & 4
MODERATOR: Dr. Barry Shender, NAVAIR

PANEL: AIRCREW NECK PAIN PREVENTION AND MANAGEMENT - RECOMMENDATIONS FROM NATO HFM-252

INTRODUCTION: The prevalence of neck pain in pilots and aircrew of most aircraft types has been a long-standing challenge amongst North Atlantic Treaty Organization (NATO) and other national air forces. The incidents are greatest in high performance jet aircraft and helicopter aircrews. This is often associated with equipment (e.g., head supported devices), non-ergonomic seating, long duration missions, and environmental stresses (e.g., G-loading). Pain can impact performance, reduce situational awareness, affect behavior (i.e., limit aggressive maneuvering), and has led to aircrew grounding.

The NATO Human Factors and Medicine (HFM) Aircrew Neck Pain Research Task Group (RTG) 252 had a mandate to contextualize and understand aircrew neck pain, conduct the necessary research to evaluate a variety of mitigating solutions, and generate recommendations for reducing the risk of aircrew neck pain. Thus, the overall objective was to seek and ultimately recommend evidence-based administrative, procedural, ergonomic, engineering, preventative, and treatment solutions to aircrew neck pain. HFM-252 has developed a series of recommendations and guidance arrived at by consensus from the twelve participating nations addressing education, procedures, conditioning, and behavior strategies. The final report will be available in 2019.

The first presentation provides an overview of the epidemiology of neck pain and discusses some of the operational impacts of flight-related neck pain. The second summarizes the recommendations describing flight-related pain consistently and facilitates collaborative research in a manner that increases statistical power and facilitates population comparisons. It will also address recommendations for education and early intervention. The third presentation describes interventions and mitigations associated with human factors, body-borne equipment, aircrew behaviors, aircraft workspace, and organizational elements to address aircrew neck pain. The final presentation provides an example of how some of these recommendations have been implemented by the Royal Canadian Air Force to reduce spinal stress from vibration and a program that improves helmet fit.

PANEL CHAIR:

Dr. Barry S. Shender, SSTM – Lead Human Systems Technologist; Naval Air Warfare Center Aircraft Division, Patuxent River, MD

PRESENTERS:

BRIEFING: Neck Pain in Aviation—Who Gets It and Why? A Review of the Literature - J. Crowley; U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL

BACKGROUND: For decades, neck pain has been a familiar problem for jet fighter pilots, but more recently has become a common problem for helicopter pilots as well. This presentation will review the epidemiology of neck pain from different perspectives—rotary-wing vs. fixed-wing, pilots vs. rear crew, acute vs. chronic, etc. In jet pilots, neck pain tends to be more acute, and is frequently linked to a specific injurious event under high G; neck pain in helicopter pilots is usually gradual in onset and chronic, like a typical musculoskeletal overuse injury. The published studies are usually operational surveys that fail to control for important confounding factors (e.g., age, other sources of injury), but the link between fighter pilots' exposure to high levels of +Gz and neck pain appears strong, with prevalence rates ranging up to 85%. A particularly risky combination is unusual neck postures during unexpected +Gz exposure. A causal link with chronic neck pathology is harder to demonstrate. Between 20% and 75% of helicopter crewmembers admit to flight-related neck pain—both in pilots and rear crew. Neck problems in rotary-wing crew are usually linked to weight and offset center-of-gravity of the head/helmet complex. Neck pain is operationally important for two main reasons: inflight distraction and reduced range-of-motion. The effects of neck pain on flight operations and aircrew well-being are profound. While the mechanisms and risk factors may be unclear, the need for prevention and treatment strategies is certain.

BRIEFING: Aircrew Neck Pain Prevention and Management - Insights from NATO HFM RTG-252 – Metrics, Procedural, and Administrative Solutions - Barry S. Shender[1], Philip Farrell[2], Christopher Goff[3], John Crowley[4], Sarah Day[5], Valeria Di Muzio[6], William Dodson[7], Nathalie Duvigneaud[8], Sanna Feberg[9], Helmut Fleischer[10], Marina Lopes[11], Bethany Shivers[4], Ellen Slungaard[12], Adrian Smith[13], Erin Smith[14], Roope Sovelius[15], Thomas Wemes[16], Heather Wright Beatty[17]
1 Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA
2 Defence Research and Development Canada Toronto Research Centre, Toronto, Ontario, Canada
3 Dstl Platform Systems Division, Aerospace Systems Group, Fareham, Hampshire, UK
4 US Army Aeromedical Research Laboratory, Fort Rucker, AL, USA
5 QinetiQ, Farnborough, Hampshire, UK
6 Aero Space Medicine Department Flight Test Center, Pratica di Mare, Pomezia– RM, Italy
7 USAF School of Aerospace Medicine, Wright-Patterson AFB OH
8 Center for Physical Medicine & Rehabilitation, Military Hospital Queen Astrid, Brussels, Belgium
9 Finnish Defence Force, Medical Center, Kouvola, Finland
10 Taktisches Luftwaffengeschwader 74, Fliegerarzt, Neuburg/Donau, Germany
11 Air Force Aeromedical Center, Lisboa, Portugal
12 Royal Air Force Centre of Aviation Medicine, RAF Henlow, Bedfordshire, United Kingdom
13 Royal Australian Air Force Aviation Medicine, RAAF Base Edinburgh, Australia
14 Canadian Forces Environmental Medicine Establishment, Toronto, Ontario, Canada,
15 Finnish Defence Force, Pirkkala, FINLAND
16 Institute of Aviation Medicine, Norwegian Armed Forces Medical Services, Oslo, Norway
17 National Research Council Canada, Ottawa, Ontario, Canada

BACKGROUND: The stresses, tempo, and ergonomic factors associated with flying military fast jet and rotary wing aircraft have been strongly linked to neck pain and injury amongst North Atlantic Treaty Organization (NATO) air forces. The following are key recommendations and considerations to better understand the nature of aircrew neck pain and some solutions to reduce the magnitude and prevalence of aircrew neck pain.

UNDERSTANDING AIRCREW NECK PAIN: (1) While many surveys have been published over the last 30 years that have documented the prevalence of flight-related neck pain, each of these had unique questions, definitions, and metrics limiting the ability consolidate data across nations to increase statistical power and facilitate population comparisons. Therefore, the NATO HFM-252 Aircrew Neck Pain Questionnaire was developed with a set of core questions and rationale to address this shortfall. (2) Characterizing aircrew neck pain requires consistent definitions. Based on a proposal by Smith (2016), the RTG defines "significant neck pain" as the presence of discomfort that intrudes into one's awareness during usual activities, and has caused one to perform at a lower level, continue despite discomfort, or modify activity to reduce the discomfort. It *does not* refer to trivial mild aches that are easily dismissed and do not affect function. "Significant flight-related neck pain" refers to significant neck pain that occurs during or within 48 hours after flight. It *does not* refer to pain that is obviously due to other activities or causes.

PROCEDURAL AND ADMINISTRATIVE SOLUTIONS: (1) A comprehensive multifaceted aircrew conditioning program that includes enhanced physiotherapy support is recommended to all NATO air forces. Programs should collect data that can be used to determine effectiveness and cost/benefit of such conditioning programs. (2) Intervention for acute neck problems should occur on the same, or at the latest, the next calendar day. This may require a 24/7 on-call schedule for physiotherapy staff similar to flight surgeons. (3) Aircrew education should focus on a holistic, total lifestyle approach. Relying on musculoskeletal factors related to air operations alone will be insufficient and will not result in lasting benefits and lower injury risk. (4) Aeromedical disposition approaches for aircrew with neck pain should involve initial aircrew applicants, trained personnel, aeromedical summary, restrictions associated with treatment, gradual 'return to play' approach, follow-up, and suggested restrictions.

DISCUSSION: (1) There is no single solution or 'quick fix' that will solve the aircrew neck pain problem. The recommended solutions must work synergistically, over time, to minimize the risk of developing or aggravating neck pain. (2) Solutions should be implemented to prevent neck pain from the beginning of a military aircrew member's career, and continue through retirement. (3) Neck pain is a shared aircrew, physician, and command problem. Thus, neck pain solutions may require a shift in organizational behavior and culture.

REFERENCE: Smith, A. M. (2016). The prevalence and operational significance of neck pain and back pain in Air Combat Group: IAM-2016-003-CR, Institute of Aviation Medicine - Adelaide, Adelaide, Australia

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BRIEFING: **Aircrew Neck Pain Prevention and Management - Insights from NATO HFM RTG-252 – Equipment, Behaviours, and Workspace -** Sarah E Day[1] Philip S. E. Farrell PhD[2], Christopher P. Goff PhD[3], Heather E Wright-Beatty, PhD[4]; [1]QinetiQ Ltd, Farnborough, UK; [2]Defence Research and Development Canada, Toronto, Ontario, Canada; [3]Defence Science and Technology Laboratory, U.K. MOD, Fareham, UK; [4]National Research Council, Ottawa, Canada

INTRODUCTION: The prevalence of aircrew neck pain amongst NATO nations remains a recognized issue. The NATO HFM-252 Research Task Group (RTG) objective was to seek and recommend evidence-based administrative, procedural, ergonomic, engineering, preventative, and treatment solutions for the problem of aircrew neck pain.

METHODS: HFM-252 identified key interventions and mitigations associated with human factors, body-borne equipment, aircrew behaviours, aircraft workspace and organisation to address aircrew neck pain. These interventions were underpinned by evidenced generated from individual nations research, equipment development programs, medical screening and intervention, conditioning programs, training, policy and aircrew feedback.

DISCUSSION: The combination of non-neutral postures, inadequate cockpit / cabin ergonomics, poor equipment integration and vibration or G, while wearing a heavy, unbalanced helmet all influence the way a task is achieved and can increase the risk of neck pain. The evidence behind the recommendations associated with a systems approach to head supported mass, the role and importance of task analysis for an analysing aircrew behaviour and for identifying biomechanically advantageous postures and mitigating solutions for improving aircraft workspace ergonomics and reducing neck-level vibration are discussed.

BRIEFING: Royal Canadian Air Force Implementation of NATO HFM-252 Aircrew Neck Pain Recommendations - Heather E. Wright Beatty PhD[1], Erin E. Smith MD[2], Philip S.E. Farrell PhD[3]; [1]National Research Council, Ottawa, Canada; [2]Canadian Forces Environmental Medicine Establishment, Toronto, Canada; [3]Defence Research and Development Canada, Toronto, Canada

INTRODUCTION: Aircrew neck pain is a significant international issue for rotary wing and fast jet communities. The NATO HFM-252 research task group aimed to identify and recommend solutions to address neck pain in aircrew, where each nation is motivated to implement the recommendations that can be accommodated in their operations.
METHODS: From the solutions identified within the HFM-252, the Royal Canadian Air Force (RCAF) is working with stakeholders to implement several solutions from a multi-disciplinary approach. A number of recommendations have already been implemented, while others are in-progress of implementation.

DISCUSSION: Implementation of neck pain mitigating solutions within the Canadian Armed Forces has focused on the 2018 NATO Aircrew Neck Pain questionnaire, a conditioning program, occupation-specific education, and vibration mitigation. In 2016-2017, a survey on neck pain was given to the RCAF Fighter Force which incorporated the 2018 NATO Aircrew Neck Pain Questionnaire. The analysis is on-going and results will guide future research and mitigation solutions. Development of a comprehensive conditioning program for RCAF aircrew has been initiated, which is based on the RAF Aircrew Conditioning Program (ACP). The first phase of implementation includes delivery of the self-directed portion of the RAF ACP to all RCAF Squadrons by Fall 2019. Incorporating neck pain education into training at regular career intervals is being completed by multiple stakeholders, in addition to occupation-specific education related to task sharing and improved postures. Furthermore, to improve the fit of helmet and body-borne equipment, experienced Canadian Forces Environmental Medicine Establishment (CFEME) Aircraft Life Support Equipment (ALSE) technicians completed a 2017 RCAF tour of instruction. Similar training is expected to continue annually to support the ALSE technicians across the RCAF. Lastly, the National Research Council Canada (NRC) conducted several studies evaluating passive and active vibration mitigation technologies for RCAF rotary wing aircraft. A passive vibration absorbing seat cushion was tested, selected, and integrated into the new CH146 Griffon armoured pilot seats. Following the implementation of each of these interventions, longitudinal data will help determine effectiveness and operational impact for reducing aircrew neck pain.

WEDNESDAY – 9:30 AM – 1:30 PM
EXHIBITS OPEN
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

WEDNESDAY – 9:30 AM – 10:00 AM
AM REFRESHMENT BREAK
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

WEDNESDAY: 10:00 AM – 11:00 AM
OXYGEN (PHYSIOLOGIC EPISODE)
LOCATION: CARSON 1 & 2
MODERATOR: Erica Gowen, NAVAIR

BRIEFING: Mitigating risk of Physiological Event by using new Oxygen System Procedural Training Device - Bassovitch O.; Biomedtech Flight Training Systems Pty Ltd, Melbourne, Australia.

INTRODUCTION: Over the past 10 years, high performance aircraft have seen an alarming increase in the number of unexplained Physiological Events (PE). During 2016, over 120 physiological events occurred in US Naval aircraft utilizing Onboard Oxygen Generating Systems (OBOGS). The issue of unexplained PEs is concerning to fast jet pilots around the world and is currently being investigated by aviation medical specialists as a matter of urgency. Current PE training is largely being conducted via theoretical education and practical hypoxia awareness courses as well as a flight simulator integrated Hypoxia Recognition Recovery Training (HRRT), utilizing a GO2Altitude® hypoxicator. However, current flight simulator integrated hypoxia training systems only partially replicate oxygen regulator breathing sensations.

METHODS: Development of new training capability: Physiological Event Procedural Training Device (PE PTD). A PE PTD aims to provide high fidelity training to pilots on responses to different PE scenarios and use their emergency oxygen, and address various failure modes of the oxygen system. Such training will verify the pilot's ability to recognise a PE and to take the corrective action before becoming incapacitated.

RESULTS AND DISCUSSION: A comprehensive PE PTD enhances the quality of the training as it has the capability to simulate multiple types of oxygen equipment failure modes. It makes possible to measure whether pilots have identified failures in their life support system and whether appropriate checklists have been actioned. The new capability allows accurate teaching of oxygen regulator use on the ground. The development of a dedicated PE PTD training system for JSF/F-35 and other fast jet aircraft is a world first and will result in a system that provides more comprehensive PE training for the fast jet aircrew.

BRIEFING: **Validation of Sorbent Tube VOC Analytical Approach During Navy PE Investigation –** Dr. Leah Eller; Naval Air Systems Command, Patuxent River NAS, MD
INTRODUCTION: Ideally, chemical analyses should be tailored to particular target compounds to ensure optimal results. During the Physiological Episodes Investigation, there was a desire to assess breathing air quality for chemical contamination, broadly defined. Multi-bed sorbent tubes were selected for VOC collection and analysis, and chemical concentrations were reported as "toluene equivalents". This approach reduced the number of standards needed per run, increasing the speed of analysis and sample throughput by trading off absolute accuracy. A subsequent study was performed to capture the error bars of that tradeoff in order to increase final reporting accuracy.

METHODS: Controlled amounts of target chemicals in an ultra-high purity Nitrogen gas matrix were introduced into Markes Universal (Tenax TA, Carbograph TD, Carboxen 1003) and Perkin Elmer SVI sorbent tubes via vapor generation to simulate field sample collections. BTX calibration standards were introduced into Markes CRS (Tenax TA) sorbent tubes via two different methods for comparison: vapor generation and Markes Calibration Solution Loading Rig (CSLR). The tubes were analyzed by TD-GC-MS and target compounds were quantified using both sets of calibration standards and reporting in toluene equivalents. Calculated toluene equivalents were compared to the known values. Limits of detection (LOD) and Limits of Quantitation (LOQ) were determined for a series of relevant compounds. Oxygen effects were also investigated by introducing samples into sorbent tubes in an Oxygen gas matrix.

RESULTS AND DISCUSSION: Correction factors have been determined for several relevant hydrocarbon, chlorinated, and aromatic compounds of interest in air quality investigations. These correction factors reduce the impact of throughput speed on analytical accuracy in large-scale air quality investigations. This work establishes additional guidance for future air quality monitoring efforts in which specific chemical targets are unknown prior to sample collection and analysis.

WEDNESDAY: 10:00 AM – 11:00 AM
BIOMECHANICS (PARACHUTE)
LOCATION: CARSON 3 & 4
MODERATOR: Warren Ingram, NAVAIR

BRIEFING: **ACES II Parachute Container Pilot Chute Windblast Tests –** Caleb Wagner P.E., Matthew Conrad, Peter Stoddard; AFLCMC Human Systems Program Office, Wright-Patterson AFB, OH

INTRODUCTION: During inspections of B-1B Advanced Concept Ejection Seat II (ACES II) parachutes, marquisette canopy discoloration and material weave separation were discovered on two parachute container pilot parachutes. The chutes in question were installed in aircraft for 32 years, because the technical order did not impose a service life limit on pilot chutes. The Human Systems Program Office's Life Sciences Equipment Laboratory (LSEL) subsequently performed nondestructive textile material and 300-knot windblast tests utilizing these two aged pilot chutes as well as two new pilot chutes. These tests were performed to determine if the degraded pilot chutes, which provide additional drag to the parachute container after it is deployed from the seat, still function as designed.

METHODS: The LSEL performed nondestructive inspections and tests of the two aged and two new pilot parachutes. All four chutes were inspected for workmanship and defects. The LSEL also verified their textile materials, suspension line lengths, and the air permeability of their gore cloth.

Each pilot chute was subjected to a 300-knot windblast test. A parachute container was mounted on a pedestal, and the chute was deployed via a lanyard after the airflow velocity was achieved. High-speed video was used to analyze the deployment, inflation, and integrity of the pilot chute. Load cells were also attached to the pilot chute's bridle to record drag force versus time. After windblast testing, the chutes were inspected again for changes in existing defects and creation of new defects.

RESULTS AND DISCUSSION: The air permeability of the aged chutes was greater than the new chutes. Several minor defects were observed on the aged chutes prior windblast testing, however, none of these appeared to grow as a result of the windblast tests. Despite the presence of new post-windblast defects, the new chutes and aged chutes maintained their unitary integrity.

BRIEFING: **Assessing Neck Injury Risk Associated With Helmets and Helmet Mounted Equipment in Military Parachutists -** Paul Parker, Steven Luke, Sarah Day, Dr Henry Lupa; QinetiQ, United Kingdom

INTRODUCTION: Parachutists are at risk of experiencing neck pain and injuries while undertaking parachute jumps, in particular due to motion of the head during the highly dynamic Parachute Opening Shock (POS) phase. This is particularly the case for military parachutists who may complete a large number of jumps during a career using a range of different parachute types. Some military parachutists also use Helmet Mounted Equipment (HME) such as Night Vision Goggles, still and video cameras, which when worn during parachuting increases the potential neck injury risk.

METHODS: QinetiQ have developed a model of a parachutist, represented in MADYMO, which uses parachute inflation data obtained from qualification trials as an input. This model allows estimates of neck loading for different helmet and helmet mounted equipment configurations to be determined. In developing the model, it was necessary to replicate the helmet and HME, determine the worst-case parachute inflation cases and define relevant neck loading limits suitable for application to the parachuting case, where repeated loading will occur.

RESULTS AND DISCUSSION: The model has been used to assess nine different helmet types, eight different types of HME, and has covered assessments across eight parachute types. Examples of how the model and associated methodology have provided the UK Ministry of Defence with evidence on the neck injury risk associated with parachuting with different configurations of helmet and helmet mounted equipment are given. Limitations of the current approach and possible future improvements are also discussed, in particular the challenges in defining neck loading limits applicable for repeated lower magnitude loadings experienced by a military parachutist. This briefing will be of interest to those working in the area of occupant impact protection and neck injury biomechanics.

WEDNESDAY: 10:00 AM – 11:00 AM
SEARCH & RESCUE
LOCATION: CRYSTAL 1 & 2
MODERATOR: Mike Jaffee, NAVAIR

BRIEFING: Development of UNI-PAC III Search and Rescue Kit for P-8A – Eric Skoglund; Life Support International, Inc., Langhorne, PA

INTRODUCTION: Life Support International (LSI) designed, developed, tested, and produced the UNI-PAC III system for the Commonwealth of Australia (COA) – Royal Australian Air Force (RAAF) for the P-8A Poseidon aircraft in conjunction with the United States Navy (USN). This presentation will summarize the following:

- Overview of the system and operational requirements
- Stores clearance (safe carriage and release) and system ICD (mass properties and envelope dimensions)
- Design and development of system and subsystems
- Design and development of 20-person raft to meet TSO-C70a requirements
- Utilized industry partners and various facilities to test and develop the UNI-PAC III (i.e. use of various partners to produce the life raft and deployment parachutes; use of cranes to simulate entrance into water under canopy)
- Environmental Testing (shock, vibrations, salt/fog, centrifuge, sand, and dust)
- Pool trials at different locations to evaluate survivor boarding/righting under adverse conditions
- Trials and testing from various aircraft (challenges found during trials when using B-25 aircraft for the bomb bay and high air-speed tests)
- USN flight clearance for P-8 aircraft
- Lessons learned of the design and development process
- Versatility of the system (the system can be tailored to meet the customer's needs as the design envelope has been approved on the P-8A aircraft for use per its physical and dynamic properties; variations may include the type and/or quantity of life raft, the types of survival gear sets, the quantity of frontage line, etc.)

BRIEFING: Iridium's Entry into ALSE Emergency Communications - Paul Steward; Life Support International, Langhorne, PA

INTRODUCTION: Cospas-Sarsat has long been the lead and very capable satellite alerting system for search and rescue (SAR) response and SATCOM radios have been the staple of ALSE emergency communications. But a long-overlooked capability has been the Iridium satellite system and the SHOUT line of Iridium handheld devices. This presentation will introduce the Iridium system and explain the benefits of Iridium and the SHOUT line of handheld devices as an enhancement to ALSE emergency communications equipment.

DISCUSSION: The Iridium satellite system has significant capabilities beyond that of Cospas-Sarsat for military entities and government agencies, while being comparable to SATCOM radios for use as ALSE emergency communications equipment. These benefits include position accuracy, alert latency, operational security, tracking, and 2-way communications. Additional benefits also include size, weight and price (SWAP) of the Iridium SHOUT line of products for use by military and government personnel.

WEDNESDAY: 10:00 AM – 11:00 AM
ALSS
LOCATION: CRYSTAL 3 & 4
MODERATOR: Fillip Behrman, NAVAIR

BRIEFING: **Delivering First-Class Aeronautical Life Support Equipment to a Modernising Australian Defence Force: Challenges and Opportunities –** SQNLDR David Bywater; Department of Defence Capability Acquisition and Sustainment Group (CASG) Aeronautical Life Support Logistic Management Unit (ALSLMU), Adelaide, South Australia

INTRODUCTION: The Aeronautical Life Support Logistics Management Unit (ALSLMU) as a part of the Capability Acquisition and Sustainment Group (CASG) is responsible for the acquisition and support of common Aeronautical Life Support Equipment (ALSE) across the Australian Defence Force. ALSLMU has embarked on a strategic reform program to meet the contemporary challenges of delivering first-class ALSE capability to our 18 platforms. This briefing will overview this reform with actual case studies covering design standards, fleet harmonisation and international engagement vectors. ALSLMU endeavour to formulate new relationships with aircrew equipment OEM's, research agencies and partner militaries to support its objectives.

DESCRIPTION: The Australian Defence Force faces the concurrent challenges of introducing new, complex platforms, fiscal constraints and the need to reduce the time to introduce new equipment. ALSLMU aims to meet these changes through the following strategy:

a. **Standards reform.** Safety and mission capability require defensible, contemporary design requirements. ALSLMU is undertaking a baseline reform of ALSE design requirements for the Australian Defence Force. To date, success has been achieved with hoisting systems and hearing protection domains, with work in progress for next generation head protection.
b. **Fleet harmonisation.** Opportunities to consolidate ALSE offerings across multiple fleets yield significant technical, logistic and operational advantages. By 2020 ALSLMU will have completed the introduction to service the F-35 JSF pilot flying equipment ensemble across PC-21 ab-initio trainers and the BAE Lead-in Fighter Hawk.
c. **International engagement.** ALSLMU recognises the shared benefits of increasing knowledge and agility through partnerships for the identification, testing and purchasing of ALSE. ALSLMU is scoping options for next-generation equipment across multiple domains.

RESULTS AND DISCUSSION: ALSLMU is intent on building productive collaborations with international partners to deliver new solutions in a cost and time efficient manner. ALSLMU intend to raise awareness of their program, whilst identifying best practices to help deliver first-class ALSE solutions to the Australian Defence Force.

BRIEFING: Human Systems Program Office Try-Decide-Buy Initiative – Capt James Johnson; AFLCMC/WNU, Wright-Patterson AFB, Dayton, OH

INTRODUCTION: The purpose of Try-Decide-Buy (TDB) is to utilize established qualified vendors for the rapid procurement and delivery of Aircrew Flight Equipment (AFE) commercial items. TDB is a multiple award indefinite delivery indefinite quantity (MAC IDIQ) contract with a 950-million-dollar contract ceiling. TDB has a priority list that enables the Air Force Lifecycle Management Center, Air Force, and other DoD organizations to utilize this contract vehicle for procurement and fielding. TDB focuses on the rapid procurement and delivery of commercial-off-the-shelf (COTS) and modified COTS items by leveraging supplier relationships. Our team took a streamlined acquisition approach to follow USAF leadership's vision of rapid acquisition. This streamlined approach utilizes FAR part 16 for delivery orders. Not only does this process instill confidence in the equipment fielded to the warfighter, but it allows for very competitive pricing for each delivery order. The TDB method is to first Try by making a small purchase of one item or like items to introduce to the using community, then Decide by evaluating the items, and finally Buy with the submission of a delivery order to fulfill the users' needs. There are a number of various commercial items under the contract that include: uniforms, cold weather clothing systems, visual augmentation equipment, personal protective equipment, helmets, body armor, tactical carriers, individual equipment, lighting, survival equipment, aircrew support equipment, communication equipment, tactical equipment, load bearing equipment, lethality support items, boots, gloves, eye protection, egress equipment, aerial insertion equipment, search and rescue equipment, medical equipment, power management, hydration, electronics test equipment, and ancillary services and testing. The TDB contract is used specifically for supplies and will not be used for services. This contract is in place to rapidly procure and field equipment to our warfighters and is open for use to all DoD organizations.

WEDNESDAY: 11:15 AM – 11:45 PM
U.S. AIR FORCE SAFETY CENTER
LOCATION: RENO BALLROOM
MODERATOR: John Plaga, 711HPW/HPIF, 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 14 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.

WEDNESDAY – 11:45 AM – 1:15 PM
NETWORKING LUNCH
LOCATION – EXHIBIT HALL - SUMMIT PAVILION
EXHIBITS REMAIN OPEN

WEDNESDAY: 1:15 PM – 2:45 PM
USAF, USN AND USA ACQUISITION PM TRI-SERVICES BRIEF
LOCATION: RENO BALLROOM
MODERATOR: Edgar A. Poe III

This panel provides an update from Service Acquisition Office Leads on current and future aircrew protection equipment development and acquisition programs.

A question and answer session will follow after each Service presentation. Presenters include:

UNITED STATES AIR FORCE – PAUL C. WAUGH
Program Executive Office and Director, Agile Combat Support Directorate

Mr. Paul Waugh is the Program Executive Officer and Director for the Agile Combat Support Directorate at the Air Force Life Cycle Management Center, Wright-Patterson Air Force Base, Ohio. He leads more than 1,600 military and civilian personnel and is responsible for executing $5.1 billion in Air Force funds annually. The Directorate's six Program Offices, located primarily at Wright-Patterson AFB, Warner Robins AFB, Georgia and Heath, Ohio, provide materiel solutions, acquisition and sustainment life cycle management for simulators, support equipment and vehicles, electronic warfare and avionics, human systems, automatic test systems and metrology and calibration to meet Air Force operational needs. Prior to coming to Agile Combat Support, Mr. Waugh was Deputy Director of Air Delivered Capabilities Directorate, Air Force Nuclear Weapons Center, Kirtland AFB, New Mexico, where he enabled the acquisition and sustainment of air delivered nuclear weapon systems and extended deterrence systems in support of the nation's nuclear deterrence operations.

During his Air Force career, Mr. Waugh excelled in a variety of fields including engineering, program management, training, and logistics. He was the Chief of the Propulsion Sustainment Division, managed the Propulsion Program for the Joint Strike Fighter, served as the Deputy Director for the Joint Unmanned Combat Air System (J-UCAS) Program Office, and was also the Program Manager for the X-47. He commanded at the Detachment, Group, and Wing level, and retired from active duty as Vice Commander of the Oklahoma City Air Logistics Center.

Mr. Waugh entered federal civil service in March 2011 as a senior program manager and assumed his current position in April 2019.

EDUCATION

1983 Bachelor of Science, Metallurgical Engineering, Iowa State University
1987 Squadron Officer's School, Distinguished Graduate, Maxwell Air Force Base, Ala.
1988 Master of Business Administration, Management, University of Central Oklahoma
1994 Air Command and Staff College, Maxwell AFB, Ala.
1997 Advanced Program Management Course (PMT 302), Defense Acquisition University, Fort Belvoir, Va.
2002 Air War College, Maxwell AFB, Ala.
2002 Masters of Strategic Studies, Air War College, Maxwell AFB, Ala.
2006 Program Manager's Course (PMT 401), Defense Acquisition University, Fort Belvoir, Va.
2008 Executive Program Manager's Course (PMT 402), Defense Acquisition University, Fort Belvoir, Va.

CERTIFICATIONS
Level III, Program Manager, APDP
Level II, Test and Evaluation, APDP

CAREER CHRONOLOGY
1. October 1983 – June 1988, Technical Activities Management Engineer, Group Leader, Director of Maintenance, Oklahoma City Air Logistics Center, Tinker Air Force Base, Okla.
2. July 1988 – September 1990, Flight Commander, Squadron Officer School, Maxwell AFB, Ala.
3. September 1990 – June 1991, Deputy Chief, Training Division, Squadron Officer School, Maxwell AFB, Ala.
4. June 1991 – September 1992, F-110/F-16 Engine Test Manager, Subsystems System Program Office, Aeronautical System Center, Air Force Materiel Command, Wright-Patterson AFB, Ohio
5. September 1992 – August 1993, F-110/F-16 Engine Integration Manager, Subsystems System Program Office, Aeronautical System Center, AFMC, Wright-Patterson AFB, Ohio
6. August 1993 – June 1994, Executive Officer to the Vice Commander, Aeronautical System Center, AFMC, Wright-Patterson AFB, Ohio
7. August 1994 – June 1995, Student, Air Command and Staff College, Maxwell AFB, Ala.
8. June 1995 – December 1997, Precision Guided Munitions Program Element Monitor, Directorate of Global Power, Assistant Secretary of the Air Force (Acquisition), Arlington, Va.
9. January 1998 – October 1998, F-16 Program Element Monitor, Directorate of Global Power, Assistant Secretary of the Air Force (Acquisition), Arlington, Va.
10. November 1998 – July 2001, Joint Strike Fighter, Deputy Program Manager for Propulsion, JSF Joint Program Office, Aeronautical System Center, AFMC, Arlington, Va.
11. August 2001 – July 2002, Student, Air War College, Maxwell AFB, Ala.
12. July 2002 – January 2004, Commander, Detachment 3, Aeronautical Systems Center, AFMC, Patrick AFB, Fla.
13. January 2004 – July 2005, Deputy Director Joint Unmanned Air Combat System, X-47 Program Manager, Defense Advanced Research Projects Agency, Arlington, Va.
14. July 2005 – August 2006, Commander, 327th Contractor Logistics Sustainment Group, Oklahoma City Air Logistics Center, Tinker AFB, Okla.
15. August 2006 – July 2009, Commander, 327th Aircraft Sustainment Wing, OC-ALC, Tinker AFB, Okla.
16. July 2009 – November 2010, Vice Commander, OC-ALC, Tinker AFB, Okla.
17. March 2011 – July 2011, Senior Program Manager, Propulsion Sustainment Division, OC-ALC, Tinker AFB, Okla.
18. July 2011 – July 2015, Chief, Propulsion Sustainment Division, AFLCMC/LPS (formerly OC-ALC), Tinker AFB, Okla.
19. July 2015 – April 2019, Deputy Director, Air Capabilities Directorate, AFNWC/ND, Kirtland AFB, N.M.
20. April 2019 – present, Program Executive Officer and Director, Agile Combat Support Directorate, Air Force Life Cycle Management Center (AFMC), Wright-Patterson AFB, Ohio

MAJOR AWARDS AND DECORATIONS
Defense Superior Service Medal
Legion of Merit with two oak leaf clusters
Joint Meritorious Service Medal
Meritorious Service Medal with three oak leaf clusters
Collier Trophy – Joint Strike Fighter Team – 2001
Air Force Exemplary Civilian Service Award
Air Force Meritorious Civilian Service Award

UNITED STATES NAVY – GREG H. CREWSE
Deputy Aircrew Systems Program Manager

Greg is from Boise, Idaho and has over 39 years of US Navy Operational and Acquisition related leadership experience. He began his Navy career as an Air Traffic Controlman and after completing Officer Candidate Training in 1986, he earned his Naval Aviator wings at Naval Air Station (NAS) Corpus Christi, TX.

After completion of flight training he served as a Primary Flight instructor at NAS Whiting Field, Florida. Greg's first fleet tour was with Fleet Air Reconnaissance Squadron ONE (VQ-1) flying the EP-3E at NAS Agana, GU, followed by a tours with the Chief of Naval Operations Staff, onboard USS THEODORE ROOSEVELT (CVN-71), and the Naval Personnel Command. He reported to VQ-2 in 2003 to serve as the Executive Officer and Commanding Officer of the squadron, leading 480 Officers, Sailors, and Aircrew through simultaneous combat and classified reconnaissance missions across three continents. In 2005, he transferred to Maritime Patrol and Reconnaissance Aircraft program office (PMA-290) at NAS Patuxent River, MD. While attached to PMA-290, he served as Deputy Program Manager for the EP-3E, Aerial Common Sensor, and EPX Programs leading the Navy's effort to sustain and recapitalize the EP-3E. Following several staff tours at Patuxent River, he served as the Executive Assistant to Commander, Naval Air Systems Command.

Greg joined the Department of the Navy civilian workforce in 2011. His first assignment was the with Persistent Maritime Unmanned Aircraft Systems (UAS) Program Office (PMA-262) where he served as Program Integration Lead. His next assignment was as the MQ-4C Triton Deputy IPT Lead and included the leadership of a 600+ member government and contractor cross-functional team. His responsibilities included management of System Development and Demonstration, Multi-Intelligence (Multi-INT) Development, Production, In-Service/Fleet Support, Development and Operational Testing and Interoperability Program Teams for the Triton Program. Greg also served as the US Navy's chair for the Q-4 User's Group representing Triton on topics of common interest for operational and sustainment issues to national and international users of the Q-4 High-Altitude Long Endurance (HALE) system. After serving at PMA-262 for over seven years, he assumed the duties as Principal Deputy Program Manager for Aircrew Systems Program Office (PMA-202) in April 2018.

Greg is a member of the Navy's Acquisition Corps and is a graduate of Embry-Riddle Aeronautical University. Greg's awards include the Legion Of Merit Medal, Meritorious Service Medal (three awards), the Air Medal (Strike/Flight), Navy Commendation Medal (five awards), Navy Achievement Medal (two awards), numerous service, campaign, unit awards and a Navy Meritorious Civilian Service Award. He and his wife MaryAnne are the proud parents of three children, Brittany Elizabeth, Katherine Anne and Gregory Jackson.

UNITED STATES ARMY - CPT JEFFREY D. MAINWARING
Assistant Product Manager Air Warrior

Captain Jeff Mainwaring is from Dothan, Alabama. He attended the United States Military Academy, graduating with a bachelor's degree in mechanical engineering and a commission as an Aviation Officer.
His military education includes Aviation Officer Basic Course, SERE-C, Initial Entry Rotary Wing Course, OH-58D Qualification Course, Ranger School, Aviation Captain's Career Course, the AH-64D Aviator Qualification Course and the Army Acquisition Professional Course.

CPT Mainwaring has served in numerous command and staff positions including: Aeroscout Platoon Leader, B Troop, 3-17th Cavalry Regiment, 3rd Combat Aviation Brigade, Hunter Army Airfield, Georgia (2012-2013) deploying to Kandahar, Afghanistan in support of Operation Enduring Freedom XIII, Battalion S3, 603rd Aviation Support Battalion, 3rd Combat Aviation Brigade, Hunter Army Airfield, Georgia (2013-2014), Assistant Brigade S3, 1st Combat Aviation Brigade, Fort Riley, Kansas (2015-2016), Commander, HHT, 1-6th Cavalry Regiment, 1st Combat Aviation Brigade, Fort Riley, Kansas (2016-2017) rotating to the Republic of Korea, Commander, B Troop, 1-6th Cavalry Regiment, 1st Combat Aviation Brigade, Fort Riley, Kansas (2017-2018). CPT Mainwaring is currently serving as the Assistant Product Manager at PM Air Warrior, PEO Soldier, in Huntsville, AL.

His awards and decorations include: the Meritorious Service Medal (2nd Award), the Air Medal, Army Commendation Medal, Army Achievement Medal, National Defense Service Medal, Afghanistan Campaign Medal, Global War on Terrorism Service Medal, Korean Defense Service Medal, Army Service Ribbon, Overseas Service Ribbon (2nd Award), NATO Medal, Senior Army Aviator Badge, Parachutist Badge, and Ranger Tab.
CPT Mainwaring is married to the former Jennifer Lenn of Pfafftown, North Carolina. They have one son, Merritt (3 years), and one daughter, Jones (2 years).

WEDNESDAY – 2:45 PM – 3:00 PM
INDUSTRY/PRESIDENTS AWARDS PRESENTATION
LOCATION – RENO BALLROOM

WEDNESDAY – 3:00 PM – 8:00 PM
EXHIBITS HALL DISMANTLE
LOCATION: EXHIBIT HALL – SUMMIT PAVILION

THURSDAY, OCTOBER 17TH

THURSDAY – 8:00 AM – 6:00 PM
JOINT AIRCREW SYSTEMS INDUSTRY DAY
LOCATION – CRYSTAL MEETING ROOMS

FRIDAY, OCTOBER 18TH

FRIDAY – 8:00 AM – 6:00 PM
JOINT AIRCREW SYSTEMS INDUSTRY DAY
LOCATION – CRYSTAL MEETING ROOMS

2019 SAFE GOLF TOURNAMENT

Date: Sunday, October 13, 2019

Registration/Sign-in: 8:00-8:30 AM

Start Time: 9:00 AM - Shotgun Start

Location: Resort at Red Hawk, Hills Course
6600 N. Wingfield Parkway, Sparks, NV 89436

COURSE STATS: Three-time U.S. Open Champion Hale Irwin was instrumental in bringing soul and purpose to his signature design, The Hills Course. This 7,106-yard Reno NV golf course is known for its small greens, dramatic elevation changes and deep bunkers. The undulating fairways, surrounding mountains, big sky views, and natural wildlife create breathtaking panoramic views of the entire Spanish Springs Valley. Incorporating aspects of what was once a working ranch and adding crystal clear lakes for an additional challenge, Hale created a course that brings every club out of the bag and into play. A true experience you can't get at other golf resorts in Reno NV. Please visit their web site at http://www.redhawkgolfandresort.com

START-TIME & DRESS CODE: We will begin play at 9:00 AM with a shotgun start. The tournament format will be a 4-person team scramble. The Resort at Red Hawk is a soft spike golf shoe facility that requires collared shirts for men and Bermuda length shorts. Proper golf attire is required.

PAIRING REQUESTS: We will try to accommodate all pairing requests. Please specify handicaps and ensure that the people you are requesting to play with also have you on their request list. Once the pairings are assigned, Ebby Bryce will send the list out to all golfers who provide an email address when they registered. We would like to have a few more of our SAFE ladies play again this year, and golfers of all levels are welcome to come out and have fun.

GIVE-AWAYS, PRIZES, ETC: The golf committee is asking corporate members to consider providing give-a-ways in the form of golf balls, towels, tees, cash, etc. to be used as tournament prizes. Should you wish to make a cash contribution, contributions can be made at the golf tournament link on the SAFE website (www.safeassociation.com), or your contribution can be mailed to SAFE, Attention: Golf Tournament Chair, PO Box 130, Creswell, OR 97426. All contributions are appreciated and appropriate credit will be given in the SAFE Symposium Program as well as posted in the exhibit area. If you are interested in contributing to this year's golf tournament and have questions, please contact Stacy Stuber in the SAFE Office at (541) 895-3012; e-mail safe@peak.org or Ebby Bryce, (757) 927-2461, e-mail ebryce@ced.us.com.

RENTAL CLUBS: Rental clubs will be available to those who need them, but only if they are reserved in advance through either Stacy Stuber or Ebby Bryce. **The rental fee is not included in the price below so if you reserve rental clubs you will need to show up early to pay for your rental clubs. Cost to rent clubs this year will be $35.** Those who ask for rental clubs on the day of the tournament may find they are not available - please do not wait!! Also, make sure you specify right- or left-hand clubs.

ENTRY FEE: $85.00 INCLUDES: Included with your entry fee: Greens fee, cart, prizes, and a Taco bar (buffet) in the club house after the tournament.

SIGN-UP/REFUND DEADLINE: The sign-up and refund deadline is **Friday, September 27th, 2019** so please sign-up early. We cannot guarantee availability or refunds after this date due to the contractual agreement with the course. Due to past financial losses caused by player/team dropouts and late or non-payment, only players who have registered and paid in full will be placed on teams and participate in the tournament.

2019 SYMPOSIUM GOLF TOURNAMENT REGISTRATION FORM

Please sign me up to play in the tournament:

Name:____

Company/Affiliation: ____

Paring Request ____

Rental Clubs Needed (cost not included in registration entry fee):

(Specify men or women & left or right hand.) ____

Phone: ____

E-Mail: ____

Entry Fee Enclosed: $85.00

My Handicap is:_________________ (if not established, state average for 18 holes)

Make check payable to SAFE Association and mail to:
SAFE Association
Attn: Golf Tournament Chair
Post Office Box 130
Creswell, OR 97426-0130
Credit card payment also accepted (see below)

THE SAFE ASSOCIATION ACCEPTS VISA, MASTER CARD AND AMERICAN EXPRESS. SHOULD YOU WISH TO USE THIS FORM OF PAYMENT, PLEASE COMPLETE FORM:

Check one: Visa ______ MasterCard ______ American Express ______

PRINT NAME ON CARD ____

ADDRESS_____________________________ CITY_________________________ ZIP CODE ________________

ACCOUNT NUMBER____________________________________3 DIGITS ON BACK OF CARD _____________

AMOUNT $ _________________________ EXPIRATION DATE_______________________________________

PAYMENT FOR ____

SIGNATURE____

PHONE #____________________________________E-MAIL:____

SAFE 5k Runner 2019
Sunday, 13 October
Start Time: 15:00

COME HELP US CELEBRATE 10 YEARS OF FUN AND FRIENDSHIP!

Open to all SAFE Symposium Attendees, Friends and Family

Runners & Walkers are Welcome

LOCATION: Bartley Ranch Regional Park, Reno, Nevada

ONLINE REGISTRATION: Open until 9 October 2019. Onsite registration will also be available.
*****Pre-registration recommended for a race shirt in your size*****

TRANSPORTATION: A shuttle bus will be provided between the Grand Sierra Hotel and Bartley Ranch Regional Park (10 min ride). ***Available to all participants and spectators***

AWARDS RECEPTION: Awards for top finishers and much more! Race shirt and reception for all participants.

DAY OF EVENT SCHEDULE
10:00 – 14:00: Registration and packet pick-up
14.00: Shuttle bus from Grand Sierra to the Bartley Ranch Park (10 min ride)
15:00: Start of **SAFE 5k Runner**
15:45: Awards and reception
16:45: Bus departs the Bartley Ranch Park back to Grand Sierra Hotel
Event Details are posted on Facebook and SAFE Association website: www.safeassociation.com
To be a Volunteer or Sponsor, please contact: Marcia Baldwin at: **mkbaldwin@coresurvival.com**

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The SAFE Board would like to thank our Corporate Sustaining Members for their continued support of SAFE

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Please thank our 2019 Corporate Sustaining members and exhibitors – they are the backbone of our Association and are to be commended for their support of SAFE

NOTES