The Development of Pilot Flight Equipment in Japan

Mr. Kazuhito Emura, Fujikura Parachute

Abstract

Fujikura Parachute has been designing and manufacturing PFE (pilot flight equipment) for the JASDF(Japan Air Self-Defense Forces) for 50 years. The PFE has been designed and developed to accommodate Japanese unique requirements and features.

The first feature is geographical characteristics. Since JASDF's mission is to operate to defend islands primarily over surrounding waters, emergency egress from the aircraft has very focused requirements for egressing over ocean.

The second is climatic characteristics. JASDF aircrafts are expected to operate in very different climate such as humid and subtropical climate of Okinawa and the frigid climate of Hokkaido, requiring safety and performance in both extremes of the state of environment.

The third is physiological characteristics. Japanese people have unique physical dimensions, and PFE are designed accordingly to improve the suitability of PFE for JASDF pilots. In addition, in hot and humid environments, Japanese people have very thin subcutaneous fat, which allows them to easily regulate their body temperature through perspiration.

The fourth is the development methodology. JASDF PFE is developed by Fujikura Parachute and evaluated in cooperation with the JASDF and any related government agencies. It is the private sector that takes input from such government agencies, such as operational assumptions, and breaks them down into specific performance requirements for PFE. Fujikura Parachute has the contract with JASDF to provide system sustainment support for their PFE where Fujikura Parachute collects and compiles PFE related technical information for JASDF.DISCUSSION: Through engineering innovation and evolving operational demands, military aircraft are flying for longer periods. Providing effective support to urination is needed to maintain hydration and support optimal human performance. This research suggests that human behaviour and responses around urinating in the airborne environment contain the ingredients for a potential risk to crew safety, performance and wellbeing, demonstrating that optimal support to urination is not being achieved and there is a signficant and disproportionate sex-based difference.

Biography

Mr. Kazuhito Emura graduated from the Tokyo Institute of Technology in 2013 and joined Fujikura Parachute in 2014. He has worked with JMOD ATLA for Life Support System Development from 2014-2018 and with JAXA for HTV Recovery Capsule Development from 2014-2019.

He has continuously worked from 2018 onwards to develop new Fast Jet Life Vest, Life Jacket and Torso Harnesses for JASDF (Japan Air-Self Defense Force).

He has served JASDF as system support and maintenance technical coordinator from 2022 onwards for their survival gears.

The Development of the Enhanced Emergency Oxygen System and Future Improvements

Michael Vetter, Jeff Walsh, East/West Industries

Abstract

East/West Industries designed and qualified the original Seat bucket Survival Kit for the Navy Aircrew Common Ejection Seat (NACES) and has been in continuous production since the late 1980's. NACES is used worldwide for the F-18 and T-45 aircraft. The NACES survival kit is a critical piece of safety equipment for the aircrewmember as it includes their Emergency Oxygen System (EOS), radio beacon, life raft, and assorted survival aids and is the primary interface between the aircrewmember and the seat.

After almost 40 years of service, the rising rate of Physiological Events (PE's), and the role of the NACES survival kit EOS as the primary fail-safe for PE's there was interest in enhancing the NACES EOS. The Enhanced Emergency Oxygen System (EEOS) for NACES is the result of a comprehensive development program to develop an EOS that offered almost triple the breathing time of the existing EOS while having minimal impact on volume of survival contents and maintaining all existing interfaces.

During the development of this multi-functional system numerous challenges were faced and overcome. Some of the design, analysis and qualification testing and developments include:

- The challenges of combining legacy specifications with modern user requirements
- Integrating multiple developmental items simultaneously
- Minimizing pack volume of survival aids
- Developing infrastructure for significantly higher charging volume for EEOS
- Planning a production process that would see more than 35 years of production retrofitted in less than 5 years

As East/West Industries looks back on EEOS it also looks forward to future opportunities to leverage lessons learned in EEOS for new applications.

Biographies

Mike Vetter is the Senior Director of Product Development at East/West Industries. Holding multiple roles over nearly 19 years at East/West, Mike has managed teams that develop industry leading safety and life support equipment in the Aerospace and Defense industry. He has also directly developed innovative and cost-effective products for his customers. Michael graduated with a B.S. in Mechanical Engineering from Rutgers University in 2005.

Jeff Walsh graduated from State University of NY at Stony Brook with a Bachelor of Engineering in Mechanical Engineering and is a licensed Professional Engineer of NY (2003). He has almost 40 years of experience developing innovative engineering solutions at East/West. Mr. Walsh developed both the original, SKU-10/A, and Enhanced, SKU-10A/A, NACES Survival Kits and has been the primary Point of Contact for all issues from the field and manufacturing floor. He has been the program manager on the CH-47 Mobility Box Troop Seat Program for Boeing, the E-2D Aerial Refueling Seat Replacement Program for Northrop Grumman, and Enhanced Emergency Oxygen System (EEOS) for NAVAIR.

Enabling Female Aircrew within the UK MOD

WO Matt Fields [1], Fl Lt Lucy Froome [1], Sqn Ldr Vicki Holt [1], Dr Erica Jackson [2]

[1]Royal Air Force, [2] Royal Air Force Centre of Aerospace Medicine

Abstract

Despite the UK Ministry of Defence (MOD) accepting the first female front-line pilot and navigator in 1991, and the first fast jet pilot in 1994, female aircrew remain a small minority of serving aircrew. Across the MOD, women comprise less than 5% of aircrew. North Atlantic Treaty Organisation (NATO) data indicates that across international members, general military populations are comprised of 13% female to 87% male.

Because of the male predominance within Defence historically, the evidence utilised to design, procure, and evaluate Aircrew Equipment Assembly (AEA) is principally borne of male data. NATO Scientific Community recognise there is a historic gender data gap and when female data has been collected, this has usually been as part of a specialist requirement. It is necessary to understand the specific requirements to support inclusion of female aircrew, particularly in the respect of health and equipment provision; this is likely best supported by standardisation of testing to routinely include female subjects (rather than special case studies) and disaggregate data by sex.

The RAF established the Enabling Female Aircrew Working Group (WG) in 2021, in part resulting from observations detailed by the Defence Committee report “Protecting those who Protect us: Women in the Armed Forces from Recruitment to Civilian Life”. In December 21, the MOD announced a ‘Level of Ambition’ for women to account for 30% of personnel recruited to the Armed Forces by 2030. To achieve this, it is important to address areas in which we can better support our serving women; female AEA and flying clothing is one of those areas. NATO Scientific Technical Organisation (STO) research on recruitment and retention of female personnel, indicated that retention levels are linked to the perceived degree of equity, and therefore to attain the desired recruitment levels, the military community need to understand what equity means to this cohort.

A recent tri-service survey of female aircrew has highlighted concerns relating to function and fit of AEA; specific issues include availability of smaller sizes, discomfort and distraction caused by ill-fitting AEA, a feeling of reduced worth and professionalism resulting from ill-fitting AEA, and compromised performance. A prior lack of consideration of female-specific issues, including menstruation and in-flight urination, has resulted in additional challenges for female aircrew.

We hypothesised that to provide equipment that better supported integration of our female aircrew and addressed their concerns on fit and function, an accurate database of current in-service aircrew was required to inform stakeholders of our ‘target audience’. Therefore, led by the RAF Centre of Aerospace Medicine (RAFCAM), we set about gathering the first tri-service female aircrew dataset. A total of 100 female aircrew were measured utilising 3D scanning technology, which not only provided body measurements but 3D images (avatars) to better understand the female shape.

The data is being utilised to create a range of flying clothing which will better consider the female form, as well as to inform the future cockpit design. Specific clothing ranges being progressed include the Future Aircrew Clothing System (FACS) 1-piece suit and the Immersion

Protection Garment (IPG). Additional AEA evaluation includes RAFCAM trials of in-flight urination device, Skydrate; as well as lighter weight ballistic plate options, and female shape considerations for aircrew body armour, and G-protection.

Biographies

Squadron Leader Vicki Holt joined the RAF in 2006 as a Weapons Systems Officer. She conducted operational tours on the Tornado GR4 until 2013, before moving across to ISTAR platforms. She has specialised in safety and risk, in 2019 gaining a MSc in Aviation Safety and Human Factors from Cranfield University. Now working as a Requirements Manager within Air Capability, Holt is responsible for ensuring that female aircrew considerations are incorporated to all future Aircrew Systems procurement projects.

Warrant Officer Matt Fields joined the RAF in 1995 as an Engineer specialising in the Aircrew Systems field. After a varied career working on almost every aircraft type, and working in specialist roles such as Accident Investigation, and Trials and Development, he is now the Air Command Warrant Officer for the Aircrew Systems Specialisation. Passionate about providing appropriate life-saving equipment for all aircrew, he has led the engineering element of the Enabling Female Aircrew activity by trying to eliminate the 'data gap' for legacy Aircrew Equipment through retrospective research and trials activity. This work is enabling appropriate risk awareness for Aviation Duty Holders and will help shape modification of current assets and inform future procurement activity.

Flight Lieutenant Lucy Froome joined the RAF in 2000 as a Navigator, following a brief career in teaching. She was streamed onto the Nimrod MR2, and spent 5 years carrying out maritime operations from the north of Scotland, and overland recce operations in the Middle East. Her subsequent tour as staff on the Operational Conversion Unit included responsibility as the Station Weapons Officer and as SME for the Link 16 (tactical data link) project. Froome reluctantly resigned her commission on maternity grounds as her husband, a Tornado pilot, was posted away, making family logistics unmanageable. Froome rejoined as a part-time Reservist in 2022 to work on the Enabling Female Aircrew project, determined to help improve the environment for female aircrew today.

Dr Erica Jackson joined MOD in 2019, as a Civilian Medical Officer in RAF Centre of Aerospace Medicine (CAM). Erica has more than 15 years post-graduate experience including significant acute medical practice within NHS, and private sector and post-graduate qualification in Occupational Medicine. Her continued appetite for Occupational Medicine led her to Aviation Medicine, where she now works within RAF CAM as the tri-service Aviation Medicine lead for female aircrew projects. She directs independent test and evaluation research as part of Aircrew Equipment and Integration Group (AEIG) RAF CAM. Erica has recently led research on the lived experience of female aircrew and the first tri-service anthropometric survey for in-service female aircrew, with the aim of supporting aircrew diversity and inclusion.

A study into improving the fit of the Lightweight Coverall (LWC) for the female form. Assessing the benefits of a female size roll compared to the current unisex sizing.

Norma Staples, Jennifer Makinson, Survitec Aerospace and Defence, Ellesmere Port

Abstract

Following customer feedback, it became evident that female pilots are compromising on the fit of their Aircrew Flight Equipment (AFE) due to the existing global unisex size rolls. We have worked to identify these fit issues and developed ways to improve the fit of the LWC for the female form.

This paper outlines the lessons learned from an industry perspective and details the process that Survitec Group are adopting to meet the challenge of designing, developing and fitting the Female LWC as well as creating a female specific size roll. This paper also outlines how the study will develop in the future ensuring we meet the female user needs and develop a fully qualified product.

Biography

Norma Staples has over 40 years of experience in designing Aircrew Flight Equipment across major defence programmes such as Eurofighter Typhoon, F-35 Lightning II, which include cold weather clothing, coveralls, immersion suits, with her specialty being anti-G suit design. Norma developed the size rolls for these programs, both of which have less than 2% special measure demands. Norma is an industry leader in sizing, fitting and pattern design.

Jennifer Makinson has 6 years of experience working across the fashion, aerospace and defence industries. Having worked for Survitec for 3 years, Jennifer's main focus of work has been the design and qualification of the F-16 Viper Aircrew Flight Equipment. Jennifer has also worked across several platforms, including F-35 and KF-21 design projects.

Cardiovascular function during the ovarian cycle: implications for female fast-jet pilots

Dr Vicky Edwards, Dr Karen Robertson, Dr Alec Stevenson, Dr Vivienne Lee, QinetiQ,

Abstract

A pilot is exposed to G-acceleration (+Gz) when their aircraft turns or changes speed, which poses a challenge to the cardiovascular system. As Gz acceleration increases, blood pressure at the head falls whilst blood volume rises in the lower limbs. This provokes a baroreflex response - a series of actions that the body takes to restore blood pressure, preventing the pilot from losing consciousness. The vast majority of G-tolerance research has been conducted in males, however recent anecdotal reports from female fast-jet pilots suggest a degraded G-tolerance during menstruation, posing a safety concern during this time. Indeed, hormonal fluctuations across the menstrual or contraceptive cycle may affect blood pressure control, periodically reducing G-tolerance. With female representation in aviation increasing, understanding the influence of female physiology on performance and safety is important. The aims of this review were to conduct a literature review to investigate whether the menstrual cycle and the use of hormonal contraception may affect blood pressure, heart rate and the baroreflex response and interpret these findings in relation to G-tolerance. Research investigating hormonal contraception suggested that oestrogen, one of the main sex hormones, augments the baroreflex response, which is likely to increase G-tolerance by improving blood pressure control. Therefore it may be possible that during phases when oestrogen is low (i.e., during menstruation), G-tolerance may be reduced. Despite this, the quality of menstrual cycle and contraceptive research is generally poor, and findings are therefore ambiguous. Equally, the menstrual cycle and G-tolerance are highly individualised, and there are many other factors which influence day-to-day flying. Regardless, it should be acknowledged that in female pilots, G-tolerance may fluctuate throughout their menstrual or hormonal cycle.

Biography

Vicky is a physiologist at QinetiQ working within the flight physiology team in areas such as acceleration and altitude research. Her PhD involved investigating the physiology and nutrition of army officer cadets undergoing the 44-week arduous training course at Sandhurst. She has a passion for female physiology and is invested in increasing female representation in research.

Applying Human-Centered Design Methods to the Challenge of In-Flight Bladder Relief

Samantha Burdett [1], Jason Lesser [1], Dr. Katrina Colucci-Chang [2], Kim Hallet [1]

[1] Triton Systems Inc., [2] Human Systems Engineering, Naval Air Station Patuxent River

ABSTRACT

Complex user needs are found at the intersection of safety and job performance. This is particularly so for military aviators who need to remain safe while utilizing in-flight bladder relief systems during mission operations. The availability of new bladder relief solutions is a top priority within global military aviation. The technical brief aims to demonstrate how the application of human-centered design (HCD) methods was critical to the development of two in-flight bladder relief systems. HCD diverges from traditional design such that all design assumptions must be continually validated with users in the loop at every step. The solutions described are an active pump-based system to support long-duration missions, and a passive garment to support missions that require restrictive survival gear. The specific goals were to design safe, comfortable, and accessible solutions for female aviators and secondarily to develop a compatible design for male aviators.

Findings are shared from interviews with subject matter experts (SMEs) in the form of a workspace analysis to frame how military aviators operate within their domain, their critical tasks, and equipment constraints. A series of usability studies are described with varying degrees of fidelity and the utility therein for increasing testing efficiency and efficacy and access to SMEs during critical design-test-build cycles. Data collected from SMEs via a survey instrument during usability testing demonstrates quantitative improvements to the bladder relief solution over time with each iteration cycle involving SME feedback.

Insights generated during reoccurring dialogues with SMEs showed a need for two distinct solutions to overcome the challenge of in-flight bladder relief for military aviators. Additional takeaways identified the fit of interfacing components, comfort during long-term wear, and increasing user confidence that the system will not leak to be critical for increasing likelihood of adoption and beneficial use by aviators.

Biographies

Samantha Burdett is the Product Development Lead in the Human Systems group at Triton Systems, Inc. in Chelmsford, Massachusetts, USA. Ms. Burdett's expertise spans testing, project integration, and program success. She currently serves as the lead for the production transition of a low-cost in-flight bladder relief system focusing on the needs of military aviators. The system was designed and verified to be compatible with multiple flight gear configurations and aviation environments, and to remain comfortable for extended use. She has also served as the test lead and systems engineer leading the design verification, including MIL-standard testing, for a variety of solutions to improve the safety and performance of operators in industrial environments. Prior to joining Triton Systems, Ms. Burdett worked as a mission assurance and quality assurance engineer in the aerospace industry, primarily working on the NOAA GOES-R satellites SEISS instruments.

Jason Lasser is a Human Factors Engineer and Industrial Designer at Triton Systems, Inc. in Chelmsford, Massachusetts, USA. Mr. Lasser's focus is on improving the performance, usability, and adoption of physical and digital solutions for military operators. He has developed a range of products and solutions that utilize intuitive form factors to reduce cognitive load and integrate with existing technologies in the domain environment while improving quality of life for all users. Mr. Lasser pulls from his interdisciplinary background to design and fabricate prototypes and then leads usability studies with subject matter experts to verify and validate potential solutions. His portfolio includes physical & digital interfaces, electromechanical systems, diagnostic and therapeutic devices, and ergonomic tools for operators in medical, consumer and industrial fields.

Dr. Katrina Colucci-Chang is a biomedical engineer and project manager at the Naval Air Station Patuxent River, also known as NAS Pax River, located in St. Mary's County, Maryland, USA on the Chesapeake Bay near the mouth of the Patuxent River. She works in the Body Mounted and Survival Systems Branch which is under the Human Systems Engineering Department. She got her Bachelors in Bioengineering from George Mason University and her Ph.D. from Virginia Polytechnic Institute and State University (i.e. Virginia Tech). She has attended various conferences such as SAFE Symposium, Modern Day Marine, and Warrior East. She presented her paper "Impact of Training on Successful Use of Bladder Relief Systems" at the 2023 at the 61st Annual SAFE Symposium.

Kim Hallett is a Certified Professional Ergonomist and the Manager of Human Factors Engineering at Triton Systems, Inc. in Chelmsford, Massachusetts, USA. Ms. Hallett's passion is collaborating with fellow innovators to transform back-of-the-envelope dreams into safe, useful, inclusive, and accessible products. She specializes in the design of equipment that improves the workplace for operators working in challenging environments. Ms. Hallett's expertise is applying universal design principles aimed at increasing inclusion and access within historically homogenous workplaces. This has been proven through her work leading the development of two separate in-flight bladder relief systems for assigned-female-at-birth (AFAB) military aviators as well as a simulation system for training military combat medics on procedures that will improve health outcomes for AFAB warfighters in theater.

Lessons Learned: Adapting NASA technology for Female Military Aircrew

Mark R. Harvie, President, Omni Defense Technologies

Abstract

Omni's new SlimPad brings technology developed for NASA astronauts and the Artemis and Orion missions to Female Military Aircrew with a low-profile, disposable In-Flight Bladder Relief option.

Developing the NASA pad posed significant engineering challenges, requiring a solution that could function effectively in microgravity without relying on gravity for operation. Collaborating with female engineers, pilots, and astronauts, Omni overcame these obstacles to create a pad suitable for space missions.

Adapting this technology for use in fighter jets presents additional hurdles. Originally conceived for NASA's in-suit Waste Management System in microgravity, Omni's SlimPad needs to integrate seamlessly with the unique demands of sitting in ejection seats while maintaining effectiveness in providing discreet bladder relief.

Through innovative design and rigorous testing, Omni is in the process of merging elements of the NASA Pad with existing technologies to create the SKYDRATE SlimPad:

- Gravity-independent, not reliant on ejection seat angle
- Gel human interface adhesive technology for a secure, leakproof fit
- Easy removal with no residual adhesive.

Amidst the focus on enhancing pilot performance and lethality, hydration emerges as a critical factor. The SlimPad not only offers bladder relief but also encourages hydration, improving G-force tolerance, mental acuity, and situational awareness. By addressing a crucial gender divide in military aircraft, this technology will allow pilots to concentrate on mission objectives instead of on their next pit stop.

Biography

Mark Harvie is the President / CEO of Omni Defense Technologies Pilot, Senior Research and Development Engineer of Bio-Medical, Mechanical and Electromechanical systems for the past 43 years. Principle Investigator on successful Phase I, Phase II, Phase II Enhancement and Phase III SBIR, BAA, TEMP and RTOC Military contracts for the past 23 years.
Designed Aircrew Flight Equipment for the Air Force, Navy and Army and has been Program Manager for 4 Safe-to-Fly certifications with the Air Force and Navy. Holds 16 US patents with patents pending – 12 of which are for automated bladder relief system designs that are currently used in products purchased by the US and Foreign Military, NASA and Veterans Administration.
Harvie is a pilot with more than 48 years of complex and experimental aircraft experience, with 2,227 hours logged to date. He is personally aware of space limitations and bladder discomfort in flight and has tested and conducted in-flight trials and clinical trials on products developed. 40+

years' experience in setting up manufacturing and quality management systems for the production of the products including Military Certification with Production Readiness Review.