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The Aviator Program

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Abstract

The International Cooperative Engagement Program for Polar Research (ICE-PPR) was established to provide a means for polar nations to collaborate in operations and Science and Technology (S&T) efforts. ICE-PPR represents an effort to share knowledge, resources, and opportunities for the benefit of all participants. Four working groups have been established, of which one, to be led by Canada and called Human Effectiveness, will address a range of challenges related to improving the effectiveness of humans operating in Polar Regions. The establishment of an Arctic human performance program of collaboration within ICE-PPR aligns well with the emerging requirements of the Royal Canadian Air Force's (RCAF), "The Aviator" program.

The objectives of a three day workshop were to clarify requirements and future collaboration in support of S&T for improving human effectiveness in polar conditions, and for improving "The Aviator" program, Aircraft Life Support Equipment (ALSE), search and rescue (SAR), and Aeromedical Evacuation (AE) capabilities and Aerospace Medicine (AM). The discussions focused on the "worst case" Arctic winter conditions such as, an ejection in mid-January high over the Arctic Archipelago.

The workshop resulted in the identification of 26 key research ideas under Protect, Preserve, & Restore Health (PPRH), SAR, AE, Air Effectiveness & Performance (AEP) and/or ALSE. These ideas support the continued collaboration of the Arctic human performance program within the ICE-PPR and the Canadian Armed Forces.

Résumé

Le programme d’action coopératif international en matière de recherche polaire (ICE-PPR) a été mis sur pied dans le but de donner aux États polaires l'occasion de collaborer lors d'opérations et d'efforts en science et technologie (S&T). ICE-PPR se veut un effort pour mettre en commun les connaissances, les ressources et les opportunités au bénéfice de tous les participants. Quatre groupes de travail ont été créés, dont celui de l'Efficacité humaine, dirigé par le Canada, qui étudiera les moyens de rendre les humains plus efficaces dans les opérations en régions polaires. La mise sur pied d'un programme collaboratif de performance humaine dans l'Arctique à l'intérieure du programme ICE-PPR cadre bien dans les exigences émergentes de l'Aviation royale canadienne (ARC), le programme Aviateur.

Les objectifs de l'atelier de trois jours étaient de clarifier les besoins et la collaboration future à l'appui de la S&T sur l'amélioration de l'efficacité humaine en conditions polaires et sur l'amélioration du programme Aviateur, de l'équipement de survie des aéronefs (ALSE), des capacités de recherche et sauvetage (SAR) et d'évacuation aérosanitaire, et de la médecine aérospatiale. Les discussions étaient axées sur les pires scénarios en conditions hivernales arctiques, comme une éjection à la mi-janvier loin au-dessus de l'archipel Arctique.

L'atelier a permis de dresser une liste de 26 idées de recherche clés touchant la protection, le maintien et le rétablissement de la santé (PPRH), la SAR, l'évacuation aérosanitaire, l'efficacité et la performance aériennes (AEP) et l'ALSE. Ces idées appuient la poursuite de la collaboration dans le cadre du programme de performance humaine dans l'Arctique au sein d’ICE-PPR et des Forces armées canadiennes.

Table of Contents

List of Tables

Overview

Workshop

From 15–17 January 2018, ADM S&T's Toronto Research Centre (TRC) hosted a three day workshop to canvas the International Cooperative Engagement Program for Polar Research (ICE-PPR) partner nations and selected members of the Royal Canadian Air Force (RCAF) operational community. The objectives were to clarify requirements and future collaboration in support of S&T for improving human effectiveness in polar conditions, and for improving the capabilities and effectiveness of the Royal Canadian Air Force's (RCAF) Aviation Life Support Equipment (ALSE), search and rescue (SAR), and Aeromedical Evacuation (AE) capabilities. The emphasis was placed upon the "worst case" Arctic winter conditions: an ejection in mid-January high over the Arctic Archipelago.

Context

The International Cooperative Engagement Program for Polar Research (ICE-PPR) was established to provide a means for polar nations to collaborate in operations and S&T efforts. ICE-PPR represents an effort to share knowledge, resources, and opportunities for the benefit of all participants. Four working groups have been established, of which one, to be led by Canada and called Human Effectiveness, will address a range of challenges related to improving the effectiveness of humans operating in Polar Regions. The establishment of an Arctic human performance program of collaboration within ICE-PPR aligns well with recent efforts of the Canadian Army and the emerging requirements of the RCAF. It is timely to include the development of Arctic requirements of the RCAF, RCN, SOF, and CA along with those of the other ICE-PPR nations in this workshop.

As S&T support to RCAF human effectiveness requirements transitions from 03aa "Human Effectiveness" within the Air Agile program to "The Aviator" program, it is important to ensure The Aviator responds appropriately to the RCAF's requirements. A significant component of these requirements relates to RCAF operations in the Arctic.

The RCAF operates world-wide, 24/7, year round. Environmental extremes are encountered by crews working in the aircraft, and on the ground. The crews need to be able to operate in any conditions. In Canada in particular, those extremes include extreme cold conditions, and large expanses of cold water. Enabling crews to operate effectively in all conditions, and in particular in those peculiarly Canadian conditions, is a key demand of S&T by the RCAF. Additionally, the ability for crews to survive until rescued in the event of a mishap is a key aspect of RCAF operations in the Arctic, and is the focus of this workshop.

Objective

There were three main objectives for the workshop:

1. Identify potential areas of collaboration for S&T supporting the RCAF, the RCN, SOF, and the CA, in the Polar Regions, with the other participants in the ICE-PPR program.

2. Identify possible areas of S&T-related research to enhance the RCAF's operations, particularly with respect to:

    a. Aerospace medicine;

    b. ALSE; and

    c. SAR and AE operations.

3. Prioritize the requirements for action within The Aviator, for RCAF specific S&T in support of ALSE, SAR and AE operations, and for collaborative areas, within ICE-PPR.

Participants

Defence Research and Development Canada (DRDC)

- Wendy Sullivan-Kwantes, DRDC – Toronto Research Centre
- Dr. Stuart Grant, DRDC – Toronto Research Centre
- Allan Keefe, DRDC – Toronto Research Centre
- Dr. Philip Farrell, DRDC – Toronto Research Centre
- Dr. Fethi Bouak, DRDC – Toronto Research Centre
- Kevin Hofer, DRDC – Toronto Research Centre
- Michel Paul, DRDC – Toronto Research Centre
- Dr. Len Goodman, DRDC – Toronto Research Centre
- Dr. Mackenzie Glaholt, DRDC – Toronto Research Centre
- Dr. Craig Burrell, DRDC – Toronto Research Centre
- Vaughn Cosman, DRDC – Ottawa Research Centre
- Gregory Hunter, DRDC – Centre for Operational Research and Analysis

Royal Canadian Air Force (RCAF)

- Col Wright, RCAF Surgeon
- LCdr Neal, SO2 AE Advisor
- Maj McPhee, AM/SAR
- Maj Meurling, ALSE Requirements
- Col Proteau, CAOC/A3 Director Combined Air Operation Centre
- LCol Nelles, 1 CAD SSO SAR
- Sgt Aaron Reid Aviation Technician Chief

Other

- Maj Smith, Canadian Forces Environmental Medicine Establishment (CFEME), Toronto
- Capt Hirsimacki, Canadian Forces Environmental Medicine Establishment (CFEME), Toronto
- Tara Foster-Hunt, Director – Technical Airworthiness and Engineering Support (DTAES)
- Adrian Barber, Future Fighter ALSE (FFA)
- Hilda-Anne Troupe, Nutrition, J4 Strat Food Services
- Dr. Kevin Williams, Soldier Project Dir, Director of Science and Technology – Air (DSTA)

- Dr. Brian Stapes, Sailor Project Dir, Director of Science and Technology – Navy (DSTN)
- LCol Natale, Project Director, Health Protection, Force Employment (DGSTFE)
- LCol Stockermans, Concept Director, Canadian Forces Aerospace Warfare Centre (CFAWC)
- Debbie Kemp, Innovation, S&T Officer
- Patrick Mason, United States Office of Naval Research (USONR)
- Kari Kallinen, ICE-PPR Finland
- Jan Ivar Kåsin, ICE-PPR Norway
- Karl Friedl, U.S. Army Research Institute of Environmental Medicine (USARIEM)

Presentations—Day 1

Key points discussed during the presentations are summarized below. A copy of each presentation is available on the ICE-PPR portal which can be found at: https://sites.drdc-rddc.gc.ca/cop/ICE-PPR/SitePages/ICE-PPR%20Home.aspx.

Welcoming Address

Dr. Len Goodman opened the workshop by welcoming the participants and emphasizing the importance of the aim of the workshop.

S&T Formulation Process

Vaughn Cosman introduced the S&T Formulation process and the focus on making decisions that are based on supportive evidence. The Aviator currently has two components, the first of which is to protect, preserve, and restore the health of our people, especially our Canadian Armed Forces (CAF) and Royal Canadian Air Force (RCAF) members. A second component is to address the fitness for purpose of equipment and training intended to maximize the probability of survival and rescue of personnel, following incidents or accidents.

Mr. Cosman emphasized the importance of collaborating with allied nations. Collaboration will potentially lead to more efficient use of resources, improved results through greater sample sizes, and more rapid implementation of evidence based recommendations.

Health and Human Performance S&T Review

Wendy Sullivan-Kwantes presented a review of health and human performance for CAF Arctic operations.

The history of the CAF in the arctic:

1940s—focus on small scale projects

1950s—army decline in the arctic

1960s—increased interest in arctic due to Soviets

1990s—once again, army decline in the arctic

2000s—interest returned:

> 2013—opening of the Canadian Armed Forces Arctic Training Centre, Resolute Bay, Nunavut
>
> 2018—opening of Nanisivik Naval Facility
>
> 2018/2019—Royal Canadian Navy (RCN) Arctic Offshore Patrol Ships

The re-emergence of interest in the Arctic evolved from the Government of Canada's requirement to demonstrate sovereignty over the Canadian Arctic, and exercise CAF capabilities in the Arctic.

Health protection and human performance factors were investigated during four Arctic operations which took place in 2016 and 2017. Current findings indicate deficiencies in medical equipment, medical training requirements, evacuation procedures, cold weather clothing kit, cold wreathing training, as well as nutrition and combat rations (Sullivan-Kwantes, 2017).

Troops agree that more training is required before the advance arctic ops course and medical team should receive same training. Training needs to focus soldier pace during exercise and recognizing initial onset of cold weather injuries. A lack of activity while on arctic ops is also a concern as temperature in mitts and boots drop—increasing risk of frostbite/frost-nip. Although not currently being done, research is looking into making tools that require less manual dexterity (Sullivan-Kwantes, 2017).

Arctic Medicine Formulation

LCol Natale introduced the four key items that have been added to the Federal Arctic Science and Priorities list. The four items are:

- Examine methodologies to enhance and maintain peripheral blood flow
- Examine strategies to mitigate and treat Cold Weather Injuries (CWIs)
- Identify populations at risk for CWIs
- Examine strategies to treat conventional injuries in the cold

Aerospace Medicine S&T Requirements

Col Wright summarized the air program's key research points with emphasis placed on expanding arctic presence. Currently, the RCAF operates year-round in the Arctic There is a clear opportunity to adapt commercial solutions to fit the needs of the CAF and the RCAF.

Important considerations are fatigue countermeasures and real time physiological monitoring. It would be beneficial if interventions can be made "in the moment" thus, preventing problems (i.e., sleep and dehydration) from becoming detrimental to the health and performance of the crew. Retention of trained personnel within the RCAF is vital due to the small numbers and the time and resources dedicated to training, but there are currently few evidence-based standards, for determining fitness for employment.

The Surgeon General's Master S&T priorities list includes several areas of investigation of interest to the RCAF. For example, the integration of existing aircrew ALSE and acceleration protection garments into next generation fighter platform, and possibly vice versa, is important. Other nations have had adverse physiological outcomes in modern fighter aircraft, (e.g., hypoxia, acceleration atalectasis, and increased work of breathing) which have not been fully resolved. Canada's ability to contribute in this field is believed to have atrophied somewhat. Coupled with the fact that we don't know what the next fighter will be, the design and integration of ALSE and other crew protective equipment will be challenging.

The Aviator Program addresses four areas of concern from the Surgeon General's Master S&T priorities list:

- White Matter Hyperintensities: high altitude exposure increases this although there is uncertainty about its effect on long term health. Canada wants to get involved with this research.
- High Performance Aircraft Crew Neck and Back Troubles (to include Scoliosis Limits for Ejection Seat Equipped Aircraft).
- Hearing Conservation and communication optimization in aviation operations (to include defining the environment, and modernizing the test protocols and recommendations).
- Advanced Simulation in Aeromedical Training (AMT).

The Surgeon General's S&T list is updated every two or three years. It is expected to be reviewed in 2018. After that review, the Aviator Program may incorporate more areas of concern from the list.

RCAF Operations: Around the World Around the Clock

Col Proteau, CAOC Director, spoke in detail about the RCAF's support to Canadian Ops and Arctic Air Plan. The RCAF's domestic and international operations include:

- Community reach
- Delivering fuel supply
- Maintaining sovereignty operations
- Monitoring entry and exit of Canadian waters
- Humanitarian assistance (i.e., forest fires)
- Flood disaster assistance and prevention
- RCMP surveillance of narcotic growing operations
- Monitoring fisheries
- Combat, including ISR and kinetic operations

There is also a strong focus on the conduct of a major survivor rescue in response to a MAJAID event when local resources are insufficient. The RCAF must be prepared at any given time to move assets and personnel to remote areas, in the event of a MAJAID or environmental disaster. One scenario which the RCAF reviews periodically is rescuing and providing aid to a foreign aircraft which crashes in the Canadian High Arctic.

Questions were raised about how many standby launches the RCAF has. Depending on region and time, SAR alone has 2–5 per day. The RCAF maintain a 24/7 watch and personnel can be ready and deployed in 24 hours.

Leadership has an important role to play in fatigue risk management and training procedures. When new kit is introduced into the system but additional training is not provided, personnel will take it upon themselves to complete the extra learning tasks. However, when this occurs, the chain of command gets the sense that anything can be done without additional resources or time allocated. This is misleading, and obscures the realities of fatigue.

Concept Development—Human Effectiveness

LCol Stockermans presented concept developments for human effectiveness. The Canadian Forces Aerospace Warfare Centre (CFAWC) will be the engine of Airforce transformation. CFAWC will become the centre of excellence for airpower development, including Concept Development and Experimentation (CD&E) and Lessons Learned (LL). In addition, CFAWC will develop and maintain the Air Force air power knowledge repository and coordinate efforts to provide advanced synthetic environment, modelling, and simulation services to assist CD&E requirements definition, operational test (OT&E) and evaluation and mission rehearsal.

Examples of projects include:

- Canadian Vertical Lift Autonomy Demonstrator (CVLAD) aims to reduce human errors and increase operational effectiveness associated with RW ops in DVE.
- CD&E was approached by 2 AEW concerning their interest in procuring a UAS to conduct airfield security, surveillance and reconnaissance. This is in direct support of FAOC Annex 1.11: "Capabilities that enable the establishment of and concurrent operation from expeditionary airfields—including those in austere environments and with limited host-nation assistance—should be developed."
- High Altitude Pseudo Satellite (HAPS) aims to provide a local "satellite type" capability which will provide a persistent presence that is affordable.

During the discussion, it was noted that Urban Search and Rescue (USAR) can be crucial in arctic conditions (i.e., patrol) however, battery issues exist and more testing is required in cold-weather conditions.

There is also an opportunity to exploit cell phone usage in regions where service is limited or non-existent. Search aircraft may be able to trigger a missing person's mobile phone, whether there is no mobile phone service. Systems exist to trigger cell phones without service in emergency situation but they are not currently available in Canada.

CFAWC also pairs up with start-up companies, for example:

1. Labforge Inc., endorsed by the Build in Canada Innovation Program (BCIP), is designing wireless sensors with artificial intelligence (AI) that can track objects within a perimeter to identify patterns and detect anomalies in the pattern. Testing still needs to be done to determine if the sensors will work in arctic conditions.

2. Pression Inc. is developing commercialized compression technology to improve blood flow in pilots.

Lastly, it was noted that HS1 (heat sensors on satellites) can only detect objects on the surface, not under the ice. This is important to consider while operating in the Arctic.

Ejection/Survival Training

Sgt Aaron Reid discussed ejection in the arctic, the hazards and survivability. Three ejections from CF18s have occurred in the Arctic and all pilots survived. All three ejections occurred in sub-Arctic (Inuvik, Yellowknife) locations, near support, at low altitude. There are three types of ejections (low, medium, high). A high ejection involves free fall in low oxygen, low temperature conditions. The relatively long exposure time to cold conditions means a pilot not warmly clothed and equipped, has diminished probability of survival to rescue.

Aviation Life Support Equipment (ALSE) is crucial for survival, but the current ALSE suite is not likely capable of keeping individuals alive till rescued, in the High Arctic. The anti-exposure immersion suit is not designed for extreme cold. The winter clothing (jacket and snow pants) intended to be worn on top of the pilot's G-suit are extremely uncomfortable and need to be taken off in order to gain access to flight suit contents. In an ejection, there are many steps to prepare for the ejection including a list of actions to complete before ejecting. Pilots do not have time to fiddle with their equipment and/clothing.

Furthermore, the personal locating beacon (PLB) is ineffective in the arctic cold due to battery life and the difficulty in manipulating the controls. Although an arctic survival kit can be dropped off to the pilot, it may be difficult to locate the drop area It could also take a long time for the drop of the survival kit to occur.

A discussion about "how often do pilots sweat in winter gear before ejection" indicated that although the F-18s have temperature control, there is a lot of sweating due to G-loads and manoeuvring of the aircraft. With the current ALSE, the survival rate depends on whether the pilot is mobile, approximately 24 hours with gear at temperatures below -30˚C.

ALSE Equipment Demonstration

Capt Hirsimacki demonstrated current ALSE equipment. Survival clothing packed for pilots in case of ejection is no more than standard issue winter kit. This was identified as substandard for any military personnel on controlled winter exercises, so particularly ill-suited for aircrew after departing their aircraft. The main concerns about the current equipment, particularly in arctic temperatures, include: the risk for cold weather injuries when removing gloves to open equipment. The energy in the food consists mainly of corn syrup. Lighting fires with matches is not always feasible in the High Arctic, and fuel is not widely available on the Arctic Archipelago, so cooking and warming by fire are not reasonable options.

ALSE Requirements

Maj Meurling and Tara Foster-Hunt provided an overview of ALSE requirements. ALSE is used for the protection of life, promotion of survival and prevention of injury. Some of the challenges of ALSE, as presented by Maj Meurling, are related to the management of ALSE. Often there is no or inadequate oversight on issues related to ALSE standards (i.e., hearing protection—rules are approximately 40 years old) and ALSE training requirements. Procurement issues may stand in the way of updating equipment and there has historically been a lack of funding to support procurement. Maj Meurling emphasized that current kits are not functioning as they should as environments have changed and updates are required. Areas for improvement include: equipment with better thermal management, communication, and environmental protection, equipment that is compatible with existing RCAF equipment (either ALSE or the aircraft itself), better fabrics (waterproof, breathable, fireproof), and ability for power generation while in cold conditions. These areas need to be addressed as Canada is currently purchasing new aircrafts but outfitting crews with old equipment that has not always been evaluated satisfactorily for compatibility with the new aircraft.

Tara's presentation drew focus to the challenges of the certification and qualification of equipment. The TAM (Technical airworthiness manual) dictates much of the decision making when it comes to equipment. Equipment must pass an integration test to determine whether it works or not, but this does not determine compatibility with aircraft. There are plenty of requests for changes to be made across the fleets; however, many are not addressed due to priority rating. Unfortunately, for a change to be deemed as high priority there sometimes has to have been a detrimental incident that occurred to a person.

Presentations—Day 2

Introduction—Review

Len Goodman welcomed the presenters and audience to day two of the workshop and provided a brief review of events so far.

RCAF-SAR Operations, FWSAR Overview (New, Changed Capabilities)

LCol Nelles delivered a presentation on RCAF-SAR operations and an overview of FWSAR. Under "SAR OPs: Response Management," the CAF and RCAF are responsible for aeronautical search and rescue efforts as well as a coordinated aeronautical and maritime SAR response system.

When it comes to SAR Ops in the Arctic, several challenges have been identified beyond the expected challenges of cold, wind, snow and ice. These can include operating from sea level to 6–8,000 foot mountain peaks and ridges,[1] searching through areas of thick vegetation to searching in areas of no vegetation, and dealing with wildlife that actively hunt humans. In addition, perpetual periods of darkness hinder search and rescue efforts and night vision goggles (NVGs) do not always bridge the gap.

SAR resources are currently staged from five main bases in the South, due to the relatively high population density and resultant response requirement for that area. A response to the North Pole will take a rotary wing aircraft several days to reach, assuming there are no mechanical difficulties during the trip.

Current SAR response posture is 30 minutes in daylight (normal working hours) and 2 hours outside of that period. In a 2-hour response scenario, a SAR crew can get airborne within 30 minutes. The main effort is directed towards search and anticipating the duration of the search. If a search is anticipated as "short," then more time can be spent on preparing the rescue, however, the timings vary case by case.

Of the next-generation technology that will be onboard the new Fixed Wing aircraft, CC295 (FWSAR CC295), synthetic aperture radar is new and unproven. SAR techniques may have to change to exploit these new capabilities. The goal is by 2020, there will a new training school located in Comox. Here, new crews will be trained on the new FWSAR CC295.

The SAR techs train to jump with medical equipment, auxiliary medical kits (depending on number and type of injury) and personal survival items. There are pre-rigged toboggans clam-shelled together with supplies (i.e., tents, clothing, and food) that can be deployed by parachute. The crew determines when the best conditions are for a jump. Night jumps are ideally supported by flares. It should be noted that the parachute penetration speed is 25 knots and SAR techs must hit the ground after the parachutes have stopped their speed to the slowest it can go; therefore jumps must take place from sufficient altitude to allow the slowing of the descent. Currently, there are 151 SAR techs in filled line positions. They are operating at 75% trained effective strength (TES). The career of a SAR tech lasts approximately 15 years, as parachuting and other high-injury activities are a part of the task. SAR techs collectively not only

[1] The highest peak in Eastern Canada is in Nunavut, at approximately 9000 (Ellesmere Island), as well as the highest vertical drop in the world (Baffin Island).

suffer from physical strains but, mental stress, and the Road to Mental Readiness (R2MR) program has been well received by the SAR tech community.

Aeromedical Evacuation

Col Wright gave a presentation on CAF Aeromedical Evacuation (AE). Aeromedical evacuations are mainly done for CAF members, as civilians have their own AE / air ambulance services. In contrast, SAR is done mainly for civilians. Challenges with handling patients in the Arctic mostly revolve around time and distance to response—eight hour flight to Alert and another 20 minutes to collect patient and return to Trenton. Ordinarily a crew change would be required. A tactical plan is important (how and where will patient be moved) for any evacuation in northern conditions as stabilizing patient in the cold is difficult and moving a patient across snow and ice is very risky.

Currently, there are no forward AE deployed in the north because the requirement is low (very few troops permanently in the Arctic). The RCAF aircrew receive no training on AE whereas the medical crew receives some training on AE along with some aircrew training. In Trenton, there are approximately 25 members that are trained in AE. When required, physicians are pulled from other resources and often they are not trained to work in an environment (i.e., aircraft, cold weather) so the AE crew also has to be mindful of the physician's health and safety, in addition to the work required for the evacuation.

There can be issues with unfamiliarity of the aircraft and performing intensive care procedures on a patient in a dark, crammed space with occasional turbulence, and loud conditions making communication difficult. Similarly, if specialized equipment such as ultrasound is required, the AE crew on board the aircraft would have to have proper training to operate the equipment and make a diagnose. The major issue with specialized AE equipment is that it must pass the airworthiness testing. Training in these types of conditions is crucial and simulation training contributes significantly, and could contribute more.

The CAF is presently working on interoperability with the "five eyes" nations. Although credentialing issues exist among the different nations regarding training, drugs, and equipment, generally, the spectrum of care is similar and there has been great success with operating with current five allies.

Nutrition

Hilda-Ann Troupe, from Strat J4 Food Svcs, provided an overview on the role of nutrition and its impact on performance and injury prevention. There is currently minimal research related to the nutritional needs of the RCAF or ground crew and whether they differ from the needs of the general population—most of the research focus has been on the Army.

Strat J4 Food Svcs sets standards and policy on feeding for all CAF feeding platforms. They are responsible for ensuring these standards reflect the nutritional requirements of military personnel (may be different from the general population.) Environmental conditions must be taken into consideration when developing nutrition programs. Military personnel work in unpredictable environments with varied work levels and durations. To accommodate military schedule, it is necessary to have food available between meals and provide flight crew with snacks (i.e., paratrooper bar) so they are not skipping full meals. Proper nutrition and hydration will improve performance and effectiveness.

Cold Exposure Survival Model—A Hypothermia Decision Aid to Support Cold Weather Operations

Allan Keefe delivered a presentation on the cold exposure survival model (CESM). CESM is a computational model to predict survivability based on hypothermia, assuming the individual has a normal physiological response to cold. The survival model only predicts 36 hours out and cannot account for cold shock and other variables, as they are too complicated to model at this point. CESM cannot be relied upon as a decision aid for termination of SAR efforts and/or reinforce early efforts.

Survival rafts, as well as kit for the arctic, should be designed as if they are being used by older individuals with arthritic pain—this is to minimize the complexity and the dexterity required to use the equipment. It should be assumed that injuries will occur during the departure from the aircraft or the unscheduled landing. For example, it is unlikely that a pilot could eject from a CF18 in January at 30,000 feet and sustain no loss of dexterity following landing. Survival equipment should be designed so that individuals can use it, with a diminished level of strength and dexterity.

The Encumbered Aviator

Allan Keefe provided an overview on the concept of the encumbered aviator. This discussion was held in DRDC Toronto's Comprehensive Ergonomics Tools and Techniques (CETT) lab. A 3D modelling tool is used to create models for shaping and sizing equipment (i.e., helmets). Models of hands can help in the design and development of gloves. The goal is to understand asymmetries and where bulk sits on the body as well as how the bulk affects an aviator's performance. This goal can be supported by using 3D scans of the aviator while wearing gear. The 3D modelling system can predict body size under the gear.

A future project will look at how load affects soldier gait. This can be done by completing 3D scans of feet and comparing the gait of soldiers in neutral stance (without gear) and in loaded stance (wearing gear). Current research will focus on scanned dynamic foot movement to provide a more accurate measure of foot size/orientation change during movement.

Army Human Effectiveness Program—Arctic

Dr. Kevin Williams presented his project, human system performance (HSP) and gave an overview of DRDC's Next Soldier S&T Project. The intention is to evaluate the limitations of soldier carrying power supply for future soldier system. There is a requirement to develop lighter equipment, exoskeleton technology and integrate physiological monitoring. More research is needed on musculoskeletal injuries and how kits/operations relate to (may contribute to) these types of injuries.

Biosensors/Wearables

Dr. Karl Friedl and Dr. Craig Burrell delivered a presentation on biosensors and wearables. Soldiers are the ideal candidates for testing equipment because they are extremely critical of poor design, yet innovative and find new ways to get things done. They can be strong players in advocating for change.

Biosensors/wearables are an effective physiological monitoring tool and can help in the evaluation of the impact of new equipment and tactics on soldier performance. Physiological monitoring in arctic conditions can inform acquisition planning and soldier system development by providing quantitative data on equipment performance: temperatures in boots and gloves under different conditions, for example.

The question of when to test or employ wearables should be considered. For example, should it only occur during training and not in operations, to avoid information overload or distraction? There are certain elements that a researcher can monitor but there are elements which cannot yet be monitored and which a soldier must take responsibility for noticing (i.e., hunger).

Conclusions

The following table organizes the research ideas that were identified by the participants. The categories include; Protect, Preserve, Restore Health (PPRHP, Search and Rescue (SAR), Air Effectiveness and Performance (AEP), and Aviation Life Support Equipment (ALSE). The blue shading indicates projects related to the RCAF Surgeon. The red shading indicates project potential.

Table 1: *Aviator Research Projects.*

Research ideas	**PPRH**	**SAR**	**AEP**	**ALSE**	**Priority**	**Project Details**
Fatigue Countermeasures	X					SAR (search phase)
White Matter Hyper-intensity	X					Part of the Aviator Program. To better define the underlying pathophysiology, as well as cognitive, and performance decrements associated with WMH.
Hearing Conservation & Communication Optimisation	X		X			Part of the Aviator Program. To include defining the environment, and modernizing the test protocols and recommendations.
Scoliosis Prevention	X					Leveraging FSAR/HSP work
Nutrition, Hydration & Dehydration	X			X		To examine the effects of nutrition on cognition and flight performance.
Life Raft	X	X				To evaluate Cold Exposure Survival Model (CESM) as a SAR decision aid and training tool.
Neck & Back Pain	X					Continue from 03aa
Aircrew cognitive performance in the cold	X		X			To assess any cognitive impairments for aircrew due to extreme cold temperatures in the cockpit
Aviation Medical Standards	X					To rationalize medical screening standards focused on assessing risk for medical conditions.
Advanced Simulation in Aeromedical Training (AMT)			X			To adapt AMT policy and regimen and determine optimal balance between live and virtual training.
Integrating ALSE into Next Generation Fighter				X		Research into the physiological integration of ALSE, OBOs, and acceleration protection in the context of Canada's new fighter platform.
ALSE Survival Equipment and Clothing Upgrade				X		Fabric, thermal protection, equipment integration, power generation, upgrade of survival gear, physiological sensors, task analysis, new way to package survival gear, equipment that accounts for diminished dexterity and injury,
ALSE/Crewed Survival Equipment						Stoves, and fuels (see ICE-PPR report)

Research ideas	PPRH	SAR	AEP	ALSE	Priority	Project Details
Wearable Sensors/Technologies	X	X	X	X		Soldier Systems Effectiveness Project (02ab)
Logistics for SAR Operations to Remote		X				Reliable communication. Ready deployable fuel supply to remote locations not serviced by regulated fuel supplier
Automatic Dependent Surveillance-Broadcast (ADS-B)		X				To provide radar-like information at a much lower cost than radar. Using ADS-B, we have extended our air traffic surveillance to cover 4 million square kilometers of airspace.
ISR Capabilities		X				Improve remote sensing and identification of distress sights.
Pilot Safety		X				Automatic deployment of seat post ejection and activation of Personal Locator Beacon —unconscious pilots are unable to deploy
Intervention Aids			X	X		Decision aides can help keep operator on track, and assist when needed (ex. Help survivor prioritize survival techniques and procedures)
Real Time Physiological Assessments		X				
R2MR for RCAF						To expand elements of an R2MR resiliency package, with a focus on resiliency programming in support of air operations.
Task analysis for physical & psychological demands for SAR		X				Typically have shorter career because of physical demand. Assess job to see where modifications can be made to prolong career
Nutrition						Baseline nutrition effect on Air crew for : survivability, performance, resilience, cognitive performance and injury risk, energy requirements of air force personnel including air and ground crew;
Equipment Integration		x		x		Equipment integration for SAR & ALSE to increase efficiency and survival
Diagnosis and Treatment of Frostbite/nip and other cold injuries						
Local Knowledge / Indigenous Culture and Practices						Assess and incorporate local knowledge into training and education of personnel.

References

Sullivan-Kwantes, W. (2017, May). *Health Risks & Human Performance S&T for CAF Arctic Ops* PowerPoint presentation at the CAATC & Health & HP workshop, Toronto, ON.

Annex A Workshop Schedule

The following tables summarize the workshop timings.

Table A.1: *Aviator Workshop Agenda.*

Day 1—15 January 18		
TIME	**OBJECTIVE**	**FORMAT**
1300–1315	**Welcome Address**	CD, CO CFEME
1315–1330	**SESSION 1—*Introduction & Background*** - Workshop objectives & approach - Participant introductions & expectations	Facilitator-led
1330–1340	**S&T Formulation Process**	Vaughn Cosman
1340-–1425	**Health & Human Performance S&T review**	Wendy Sullivan-Kwantes, TRC LCol Natale
1425–1445	**Aerospace Medicine S&T Requirements**	Col Wright RCAF Surg
BREAK 1445–1500 hrs		
1500–1530	**RCAF Operations: Around the World Around the Clock**	Col Proteau 1 CAD CAOC Dir
1530–1550	**Concept Development—Human Effectiveness**	LCol Ray Stockermans
1550–1610	**Ejection/Survival Training**	Sgt Aaron Reid 4 Wing Cold Lake
1610–1630	**ALSE Equipment Demonstration**	Capt Hirsimacki CFEME
1630–1700	**ALSE Requirements** - Current SOCDs, SORs, UORs - Long range objectives	Maj Meurling, Tara Foster-Hunt DAR 6, DTAES
1700–1730	Day One Summary, Wrap Up, Questions	Facilitator led

Day 2—16 January		
TIME	**OBJECTIVE**	**FORMAT**
0800–0815	**Introduction, Review**	Facilitator led
0815–0845	**RCAF – SAR OPERATIONS, FWSAR Overview (New, Changed Capabilities)**	LCol Nelles A3 SAR
0845–0945	**RCAF – SAR Training / SAR Requirements**	Maj McPhee, DAR 2
0945–1015	**Aeromedical** - Aeromedical Evacuation Operations Familiarization - Equipment deficiencies/Research Requirements	Col Wright RCAF Surgeon
BREAK 1015–1030		
1030–1100	**Nutrition**	Hilda-Ann Troupe J4 Strat Food Services
1100–1130	**Cold Exposure Survival Model – A Hypothermia Decision Aid to Support Cold Weather Operations.**	Allan Keefe TRC
1130–1200	**Army Human Effectiveness Program – Arctic**	Dr Kevin Williams DSTAr
LUNCH 12:00–13:00		
1300–1400	**Biosensors/Wearables**	Dr Friedl Dr Burrell
1400–1500	**Identification, Prioritization, Discussion of Issues and Requirements Generation**	Small group Discussion
BREAK 1500–1530		
1530–1600	**Summary, Collation of Issues and Requirements**	Facilitator-led

Annex B PowerPoint Presentations

The PowerPoint presentations are provided as attachments. Please request the documents, along with this Reference Document.

DOCUMENT CONTROL DATA

*Security markings for the title, authors, abstract and keywords must be entered when the document is sensitive

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12. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Use semi-colon as a delimiter.)

Aircrew; Cold weather operation

13. ABSTRACT (When available in the document, the French version of the abstract must be included here.)

The International Cooperative Engagement Program for Polar Research (ICE-PPR) was established to provide a means for polar nations to collaborate in operations and Science and Technology (S&T) efforts. ICE-PPR represents an effort to share knowledge, resources, and opportunities for the benefit of all participants. Four working groups have been established, of which one, to be led by Canada and called Human Effectiveness, will address a range of challenges related to improving the effectiveness of humans operating in Polar Regions. The establishment of an Arctic human performance program of collaboration within ICE-PPR aligns well with the emerging requirements of the Royal Canadian Air Force's (RCAF), "The Aviator" program.

The objectives of a three day workshop were to clarify requirements and future collaboration in support of S&T for improving human effectiveness in polar conditions, and for improving "The Aviator" program, Aircraft Life Support Equipment (ALSE), search and rescue (SAR), and Aeromedical Evacuation (AE) capabilities and Aerospace Medicine (AM). The discussions focused on the "worst case" Arctic winter conditions such as, an ejection in mid-January high over the Arctic Archipelago.

The workshop resulted in the identification of 26 key research ideas under Protect, Preserve, & Restore Health (PPRH), SAR, AE, Air Effectiveness & Performance (AEP) and/or ALSE. These ideas support the continued collaboration of the Arctic human performance program within the ICE-PPR and the Canadian Armed Forces.

Le programme d'action coopératif international en matière de recherche polaire (ICE-PPR) a été mis sur pied dans le but de donner aux États polaires l'occasion de collaborer lors d'opérations et d'efforts en science et technologie (S&T). ICE-PPR se veut un effort pour mettre en commun les connaissances, les ressources et les opportunités au bénéfice de tous les participants. Quatre groupes de travail ont été créés, dont celui de l'Efficacité humaine, dirigé par le Canada, qui étudiera les moyens de rendre les humains plus efficaces dans les opérations en régions polaires. La mise sur pied d'un programme collaboratif de performance humaine dans l'Arctique à l'intérieure du programme ICE-PPR cadre bien dans les exigences émergentes de l'Aviation royale canadienne (ARC), le programme Aviateur.

Les objectifs de l'atelier de trois jours étaient de clarifier les besoins et la collaboration future à l'appui de la S&T sur l'amélioration de l'efficacité humaine en conditions polaires et sur l'amélioration du programme Aviateur, de l'équipement de survie des aéronefs (ALSE), des capacités de recherche et sauvetage (SAR) et d'évacuation aérosanitaire, et de la médecine aérospatiale. Les discussions étaient axées sur les pires scénarios en conditions hivernales arctiques, comme une éjection à la mi-janvier loin au-dessus de l'archipel Arctique.

L'atelier a permis de dresser une liste de 26 idées de recherche clés touchant la protection, le maintien et le rétablissement de la santé (PPRH), la SAR, l'évacuation aérosanitaire, l'efficacité et la performance aériennes (AEP) et l'ALSE. Ces idées appuient la poursuite de la collaboration dans le cadre du programme de performance humaine dans l'Arctique au sein d'ICE-PPR et des Forces armées canadiennes.