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CANADIAN
ARMED FORCES

CRESST

The Department of National Defence and Canadian Armed Forces

**Climate Resilience and Environmental
Sustainability Science and Technology**

Strategy



Canada 

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Foreword

Climate change is impacting and reshaping our interactions with the natural environment. It presents both immediate and long-term risks to defence, safety and security. The impacts of climate change, such as more frequent and severe natural and weather-related emergencies, are anticipated to grow and are already creating new challenges for the Department of National Defence (DND) and the Canadian Armed Forces (CAF). These challenges include more requests for CAF resources to respond to domestic emergencies, an increased need for Canadian military contributions internationally, and greater exposure of critical defence infrastructure and equipment to natural hazards. In response, DND/CAF aims to reduce our carbon emissions and protect our environment in line with Government of Canada commitments and objectives. Science and technology (S&T) is essential in providing the innovative solutions and knowledge advantage necessary to address these challenges.

To guide our S&T efforts to address climate change, I am pleased to introduce the DND/CAF Climate Resilience and Environmental Sustainability Science & Technology strategy (CRESST). Informed by contributions from across the Defence Team, the CRESST identifies areas of research to support DND/CAF efforts in meeting its climate change and sustainability targets. It presents three strategic objectives and related opportunities for action that outline how S&T can support our obligations to reduce our carbon emissions and protect our environment, while preparing for and adapting to a world transformed by climate change. As a guide to inform S&T investments, the CRESST will enable DND/CAF organizations to prioritize initiatives, more effectively leverage existing efforts and expertise, frame external collaborations and partnerships, and build the S&T resources needed across the department to support the Defence Team in attaining environmental objectives and creating a more climate-resilient force.

Climate change is changing the context in which DND/CAF operates. With the CRESST, we aim to inform and enable DND/CAF in delivering the S&T needed to face environmental challenges, while remaining steadfast in its commitment to achieve its mandate.



Dr. Jaspinder Komal
Assistant Deputy Minister (Defence Research and Development Canada)



Executive summary

Science and technology (S&T)¹ is essential to provide the technological and knowledge advantage necessary to aid the Department of National Defence (DND) and the Canadian Armed Forces (CAF), collectively referred to as DND/CAF, in preparing for the risks posed by climate change and developing environmentally sustainable operations. The Defence Climate Resilience and Environmental Sustainability Science & Technology strategy (hereafter referred to as, the Strategy, or CRESST) identifies ways in which S&T efforts can help in the mitigation of DND/CAF's environmental impacts, while also supporting the adaptation of its infrastructure, workforce, and all orders of business to become more sustainable and climate resilient. The Strategy will also enable DND/CAF to leverage S&T efforts in contributing to departmental and Government of Canada climate change and sustainability targets and commitments.

Encompassing a long-term perspective, the CRESST provides a guide towards opportunities for collaborative partnerships, knowledge exchange, and targeted defence research within three strategic objectives, all in the context of defence and security:

1. **Conduct research to enable climate change mitigation and environmental sustainability**, including in areas such as power and energy transition, pollution reduction, mitigation of environmental impacts, and informing procurement.
2. **Assess challenges, risks, and opportunities associated with the environment and climate change**, including through examining the impact on DND/CAF activities and forecasting energy needs and costs.
3. **Conduct research to support climate change adaptation and resilience**, focusing on technologies, methods and practices for adaptation, as well as Arctic-specific requirements.

To support the strategic objectives and their respective action areas, there are several enabling activities, expressed as foundational levers. These are supporting activities that are needed to help address existing institutional barriers, enable the S&T efforts, and contribute to the overall success of this Strategy. They include **partnerships, climate literacy, human resource considerations, and future program planning**.

In view of the government's Federal Sustainable Development Strategy² and climate priorities, there is already much work underway within DND/CAF, across government, as well as in collaboration with private industry, academia, Indigenous communities, and domestic and international partners and Allies, among others. Work under this Strategy will take those efforts into account, while assessing the S&T needs to address gaps in DND/CAF environmental considerations, prioritizing areas of strategic importance to inform new research activities and leveraging breakthrough S&T solutions or improvements to recalibrate as needed. This will help DND/CAF to continuously improve its environmental sustainability, while simultaneously preparing to meet the growing challenges of climate change. Further, the Defence Team will review the CRESST periodically to respond to evolving policies and priorities.

1. S&T comprise two types of scientific activities: research and development, and related scientific activities. See [Annex A](#) for full definitions of key terms.
2. [The Federal Sustainable Development Strategy](#) was created through a legislative mandate outset in the [Federal Sustainable Development Act](#).

Purpose

The DND/CAF Climate Resilience and Environmental Sustainability Science & Technology strategy (Strategy or CRESST herein) is the result of extensive internal departmental consultation, research, and analysis. It provides guidance to DND/CAF's S&T research, partnerships and innovation programs and capabilities toward reaching climate change and sustainability goals and targets. Further, it aims to leverage these S&T areas to contribute to DND/CAF efforts toward achieving related commitments made under the Greening Government Strategy³ and outlined within the departmental sustainable development strategy⁴ and Canada's defence policy.⁵ In addition, the CRESST will help to better inform the transformation and investment opportunities needed to build the future capacity, capabilities, and partnerships necessary for DND/CAF to address the impacts of climate change.

Given the scale, complexity and ubiquity of climate change, environmental challenges and potential impacts, this foundational Strategy captures a comprehensive overview of DND/CAF environmental interests as they pertain to S&T. The Strategy lays out areas of research aimed at the continued reduction of DND/CAF's environmental impacts, as well as adapting its infrastructure, workforce, readiness, and all orders of business to support environmental stewardship and climate resilience.⁶ The work will take into account existing S&T efforts across DND/CAF, as well as leveraging and building on internal expertise and partnerships within the Defence Team and across the Government of Canada. It will also include utilizing already established external networks and exploring new partnerships to leverage the knowledge and capacity of private industry, academia, and domestic and international partners, among others, as well as engaging and deepening relationships with Indigenous partners.

The Strategy encompasses a long-term perspective to facilitate DND/CAF considerations that require enduring S&T, to support the federal government's mandate of

reaching net-zero greenhouse gas emissions by 2050. As DND/CAF's environmental challenges and policy perspectives change over time, they will inform periodic updates to this Strategy. Future recalibration of the Strategy will permit its evolution to include new and/or strengthened priorities, feedback from partners and stakeholders, more specific prioritization of Canadian defence S&T efforts, all while aiming to support improving sustainability and identifying new gaps and opportunities.

A challenging climate

The effects of climate change increasingly present an existential and long-term threat to the global security environment. Populations depend on the natural environment for economic opportunities and sustenance and rely on predictable climate and weather to safeguard their homes and livelihoods. Degraded natural environments arising from climate change impacts and other human activities pose major threats to human safety and security, both directly (through natural disasters such as more frequent and intense heatwaves, floods, wildfires, storms, changes in precipitation, rising sea-levels, environmental toxicity, and loss of biodiversity)⁷ and indirectly (from climate related migration, political instability, food and water insecurity, trans-boundary resource disputes, disease transmission, etc.).⁸ Finally, these direct and indirect impacts are likely to increasingly act as threat multipliers by which underlying vulnerabilities or political tensions may be exacerbated – increasing the possibilities for armed conflict to arise.⁹

Canada is experiencing more intense and rapid global warming, relative to the global average. Canada's average rate of warming is approximately double that of the world, while the Arctic and Northern regions are

3. See Treasury Board Secretariat's [Greening Government Strategy](#).

4. See [Defence Energy and Environment Strategy 2020-2023](#)

5. See [Strong Secure Engaged](#), Canada's defence policy

6. **Climate resilience** involves the development of a system that is capable of performing its essential functions, while maintaining its ability to adapt, under the pressures of climate change. (See [Annex A](#))

7. United Nation's [IPCC's AR6 Climate Change 2021: The Physical Science Basis](#) describes how climate change has direct impacts on the natural environment.

8. The IPCC has identified, in detail, the ways humanity is facing climate change risks in [AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability](#).

9. The [UN has recognized climate change as a threat multiplier since 2009](#).

DIVERSE CHALLENGES OF CLIMATE CHANGE

As stated in Canada's National Adaptation Strategy, a specific climate change event can affect some groups differently depending on their identity, circumstance, and the community and region they live in. Climate change amplifies existing vulnerabilities and inequalities, which results in some populations experiencing climate change impacts more severely. This includes people with health conditions and disabilities, the very young or older adults, or people who experience structural inequity, poverty, isolation, or discrimination.

Marginalized populations, including low-income, underserved, racialized, or immigrant communities are also more likely to live in places that experience higher exposure to climate impacts like flood risk zones, as well as the neighbourhoods and buildings that are the hottest during heat waves.

In the North, climate change is happening faster than anywhere else in the country and is a daily, lived reality for remote communities, including Indigenous communities. The rapid change is causing far-reaching impacts to infrastructure, landscapes, ecosystems, water and ice systems, and traditional ways of life, which in turn affects Northerners' social, economic, and cultural well-being.¹⁰

warming at a rate of up to four times¹¹ that of the global average. This will very likely lead to faster and more extreme changes to our natural environment, relative to that of other regions.¹² These anticipated shifts will pose widespread and diverse challenges across the country. Regional challenges threaten development, the economy, and the safety of Canada's population. For example, sea-level rise will challenge coastal communities, thawing permafrost and sea-ice degradation threaten infrastructure and the traditional ways of life in

10. [Canada's National Adaptation Strategy](#) outlines a shared path to a more climate resilient Canada by setting out a common direction for preparing for climate change events.

11. [The Arctic has warmed nearly four times faster than the globe since 1979](#)

12. The 2019 report titled [Canada's Top Climate Change Risks](#) by the Canadian Council of Academies outlines some of the direct and indirect impacts expected from climate change in Canada, while warning a likely faster onset due to Canada's rising temperature exceeding that of the global average.

13. [Canada's National Adaptation Strategy](#) describes these anticipated impacts in detail.

14. See [Canada's Arctic and Northern Policy Framework](#).

15. [The Canadian Rangers](#) provide community liaison, youth outreach and instruction, support to CAF efforts such as search and rescue, as well as northern surveillance and security reporting.

the North, while more frequent and intense heat waves and other extreme weather are having particular impacts on urban communities.¹³ DND/CAF is being called upon to support Canada's more frequent emergency response needs, and therefore will need to understand, anticipate and adapt to these emerging challenges – as well as prepare itself to stand resilient against climate induced disruptions.

Canada's Arctic and Northern Policy Framework (ANPF)¹⁴ recognizes that climate change and an increasingly accessible Arctic are heightening international interest in the region and shaping Canada's security, now and in the decades ahead. The Arctic continues to emerge as an increasingly desirable region of opportunity, both by private companies and foreign states. Improved marine access and reduced permafrost are changing Arctic security dynamics, infrastructure integrity, navigation, sovereignty considerations, mineral and resource access, geostrategic and economic interests, and tourism.

DND/CAF, along with other government departments, contributes to various roles related to safety and security in the North such as through its search and rescue capabilities and an array of Canadian Ranger tasks or operations, including sovereignty patrols.¹⁵ Other related roles and tasks include the North American Aerospace Defense Command (NORAD) operations and exercises, CAF force projection, and space-based surveillance, among other core tasks that will require adapting to a changing environment. However, DND/CAF is already facing challenges in responding to the current level of demand, due to the vast territory, limited Arctic communications, infrastructure, and transportation routes, which force the CAF to rely heavily on limited logistical support from local communities or extended sustainment from southern Canada. Addressing these challenges will require increasingly robust northern infrastructure and transportation, as well as space and ground-based capabilities to improve surveillance, navigation command and control, and communications in remote areas.

In June 2022, the Government of Canada announced its plan to strengthen and advance the CAF's ability to protect Canada and North America from new and emerging aerospace threats through investments to modernize Canada's contributions to NORAD.¹⁶ These investments are primarily focused on the aerospace domain, and include augmented capabilities to improve surveillance systems of Canada's northern approaches, command and control, communications, air weapons systems, infrastructure and support capabilities, and S&T investment for the defence of North America. More broadly, these new investments will support the CAF's capacity for northern defence, safety, and security operations in general. S&T related to defence, safety and security will have a significant role in supporting these missions as the climate and geography evolve over the coming years and decades. DND/CAF will also continue to expand and deepen its relationships among Northern and Indigenous partners and communities. This will allow for holistic and effective S&T solutions for climate resilience that reflect unique regional and local climate change conditions and circumstances, including values and cultures.

DND/CAF recognizes that it is the largest contributor to greenhouse gas (GHG)¹⁷ emissions among federal government departments and agencies¹⁸ and, therefore, understands its contribution to the aforementioned risks and challenges. To demonstrate its capacity for leadership on climate change and environmental stewardship in the defence sector, DND/CAF aims to further mitigate¹⁹ its environmental impacts, including GHG emissions, while adapting²⁰ to withstand the climate-altered reality of the future. These activities will also support collaboration with international partners and Allies to collectively advance solutions for the

16. See [NORAD Modernization Announcement](#).

17. Greenhouse gases refer to those gases present in the atmosphere that trap heat energy, leading to global warming. Canada's [official greenhouse gas inventory](#) includes estimations for carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), nitrous trifluoride (NF₃), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

18. The [Government of Canada's Greenhouse Gas Emissions Inventory](#) states that DND/CAF emits the most CO₂ eq (equivalent) compared to other government departments.

19. Environmental impact mitigation is in reference to efforts to limit harm to natural systems, **climate change mitigation** is in reference to efforts that reduce and eliminate the human-made introduction of heat-trapping (greenhouse) gasses to the atmosphere (See [Annex A](#), for more detail).

20. **Climate adaptation** includes the measures taken to prevent or reduce the actual or expected impacts of climate change (See [Annex A](#), for more detail).

21. **Climate resilience** involves the development of a system that is capable of performing its essential functions, while maintaining its ability to adapt, under the pressures of climate change. (See [Annex A](#), for more detail).

22. Through the [Net Zero Accountability Act](#)'s framework, government departments are provided a guide to having neutral GHG emissions by 2050.

23. The Government of Canada is committed to several environmental objectives including building a circular economy (including the prohibition of single-use plastics), mitigating anthropogenic climate change with a commitment on the Paris Accord through the Pan-Canadian Framework on Clean Growth and Climate Change, contributing toward the UN Sustainable Development Goals, etc.

24. See [Strong, Secure, Engaged](#).

25. See the [Defence Energy and Environment Strategy](#).

26. Throughout this document, the term "sustainable" is in specific reference to environmental sustainability, whereas "operations" is in broad reference to all DND/CAF business operations – not strictly military operations unless stated.

27. See the [Greening Government Strategy](#).

benefit of all people, such as through Canada's commitment to establish and host in Montreal the NATO Climate Change and Security Centre of Excellence. Furthermore, efforts to enhance the DND/CAF's environmental stewardship will continue to contribute to the long-term health and wellbeing of military members and surrounding communities. S&T plays a critical role in providing the innovative solutions and knowledge necessary to develop the defence capabilities and adaptations required for more climate change resilient²¹ operations and activities.

Policies and progress

The Government of Canada plans to transition to net-zero carbon and climate resilient operations by 2050,²² while also reducing environmental impacts beyond carbon. This includes reducing waste and offering greater protections for water resources and biodiversity.²³ Canada's defence policy²⁴ and the departmental sustainable development strategy²⁵ outline commitments and provide frameworks for managing energy and environmental activities in support of an environmentally sustainable²⁶ and modern military. The departmental sustainable development strategy in particular, fulfills the requirement to support the priorities within the Federal Sustainable Development Strategy and achieve targets set out in the Greening Government Strategy.²⁷

In support of these strategies, departmental initiatives are already underway that will place DND/CAF on track to meet its 2025 target of reducing GHG emissions from

Defence Team buildings and commercial light-duty vehicle fleet by 40 percent of 2005 levels. For example, DND/CAF has made strides in efforts to become environmentally sustainable in its activities, such as ensuring that 43 percent of its light-duty vehicle fleet purchases were hybrid and/or electric vehicles (2021-2022), reducing contaminated sites' liability by 12.6 percent (2021-2022), and instituting requirements for new construction and major recapitalization projects to meet net-zero emissions and resiliency requirements.

In addition, many existing defence S&T projects are also contributing to meet departmental targets. For example, under the Defence and Security S&T Program,²⁸ Defence Research and Development Canada (DRDC) has undertaken projects such as strategic sustainment 2.0,²⁹ marine mammal mitigation,³⁰ scoping environmental compliance, reducing the environmental footprint of munitions in training and operations,³¹ and advancing



28. See the [Defence and Security Science and Technology \(DSST\) program](#).

29. DND/CAF has conducted scientific reporting on power and energy requirements with recommendations to become more efficient, more environmentally sustainable, more energy independent, and meeting future operational requirements without compromising capabilities.

30. See how [DND/CAF works with industry to protect marine mammals](#).

31. DRDC has examined a range of measures to [reduce the environmental impacts from munitions](#) on the environment.

32. For example, the Advanced Microgrids towards Arctic Zero Emissions (AMAZE) project is funded through the Greening Government Fund program, led by DND/CAF in collaboration with Natural Resources Canada CanmetENERGY and the National Research Council Canada. The project targets GHG reductions at remote northern and Arctic federal facilities with a focus on the North Warning System through an innovative integrated systems approach that will include alternative energy options, for example, variable speed generators, thermal energy management, renewable energy systems and advanced microgrid controls.

33. Canada's national safety and security (NSS) fleet is comprised of aircraft, marine vessels and tactical land vehicles from DND/CAF, the Royal Canadian Mounted Police and the Canadian Coast Guard. Treasury Board's Greening Government Strategy requires that government's NSS fleet will use more environmentally friendly technologies and low-carbon fuels when available, affordable, and operationally feasible.

projects within the power and energy domain to mitigate fossil fuel use across military environments,³² among other initiatives. Research like this seeks to enable more energy efficient and environmentally sustainable operations, while enhancing operational resilience and versatility.

As we approach the 2050 target of net-zero GHG emissions, the challenges in reducing emissions are expected to grow. The Greening Government Strategy now includes the National Safety and Security (NSS) fleet,³³ which may require the adoption of clean energy alternatives and strategies, while providing effective operational capability. As the largest energy user within the federal government, the Defence Team has an opportunity to drive a more environmentally sustainable energy industry in Canada by participating in Government of Canada initiatives to develop the alternative energy sector.

Framing forward momentum

Addressing climate challenges and meeting environmental and energy targets will require S&T effort to provide the technological and knowledge advantage necessary to aid DND/CAF in preparing for future risks, mitigating its environmental impacts, and adapting its infrastructure, workforce, and all orders of business to become more sustainable and climate resilient. Larger than any one institution, these efforts will require utilizing the partnerships that have already been established and continuing to build collaboration with other government departments, the private sector, Indigenous governments, academic institutions, provincial, territorial, and international partners, including Five Eyes and NATO Allies, to collaborate and coordinate efforts on defence and environmental research. The CRESST outlines an approach that considers these needs, supports commitments and targets set within DND/CAF and Government of Canada policies, and takes into account existing S&T efforts and initiatives. The work advanced under the CRESST will adhere to the following principles:

Guiding principles

1. Prioritize operational capabilities, which must be maintained and/or enhanced while pursuing and implementing environmental research and sustainability solutions.
2. Support targets and commitments outlined in the departmental sustainable development strategy and Canada's defence policy, as well as coordinating with other internal environmental, defence, safety and security policies and direction.
3. Align with Government of Canada policy related to the environment and climate change, in particular the Greening Government Strategy,³⁴ Canada's Arctic and Northern Policy Framework,³⁵ Federal Sustainable Development Strategy,³⁶ Climate Science 2050³⁷ and the Pan-Canadian Framework on Clean Growth and Climate Change.³⁸
4. Align with the Defence Open Science Action Plan³⁹ and open science principles – people, transparency, inclusiveness, collaboration, and sustainability – where possible to solve the complex issues related to the environment and security research, while also properly safeguarding research, innovation and related partnerships.

The CRESST includes three strategic objectives for defence S&T that align with existing DND and Government of Canada policies:⁴⁰

1. Conduct research to enable climate change mitigation and environmental sustainability;
2. Assess challenges, risks, and opportunities associated with the environment and climate change; and,
3. Conduct research to support climate change adaptation and resilience.

34. See Canada's [Greening Government Strategy](#).

35. See Canada's [Arctic and Northern Policy Framework](#).

36. See Canada's [Federal Sustainable Development Strategy](#).

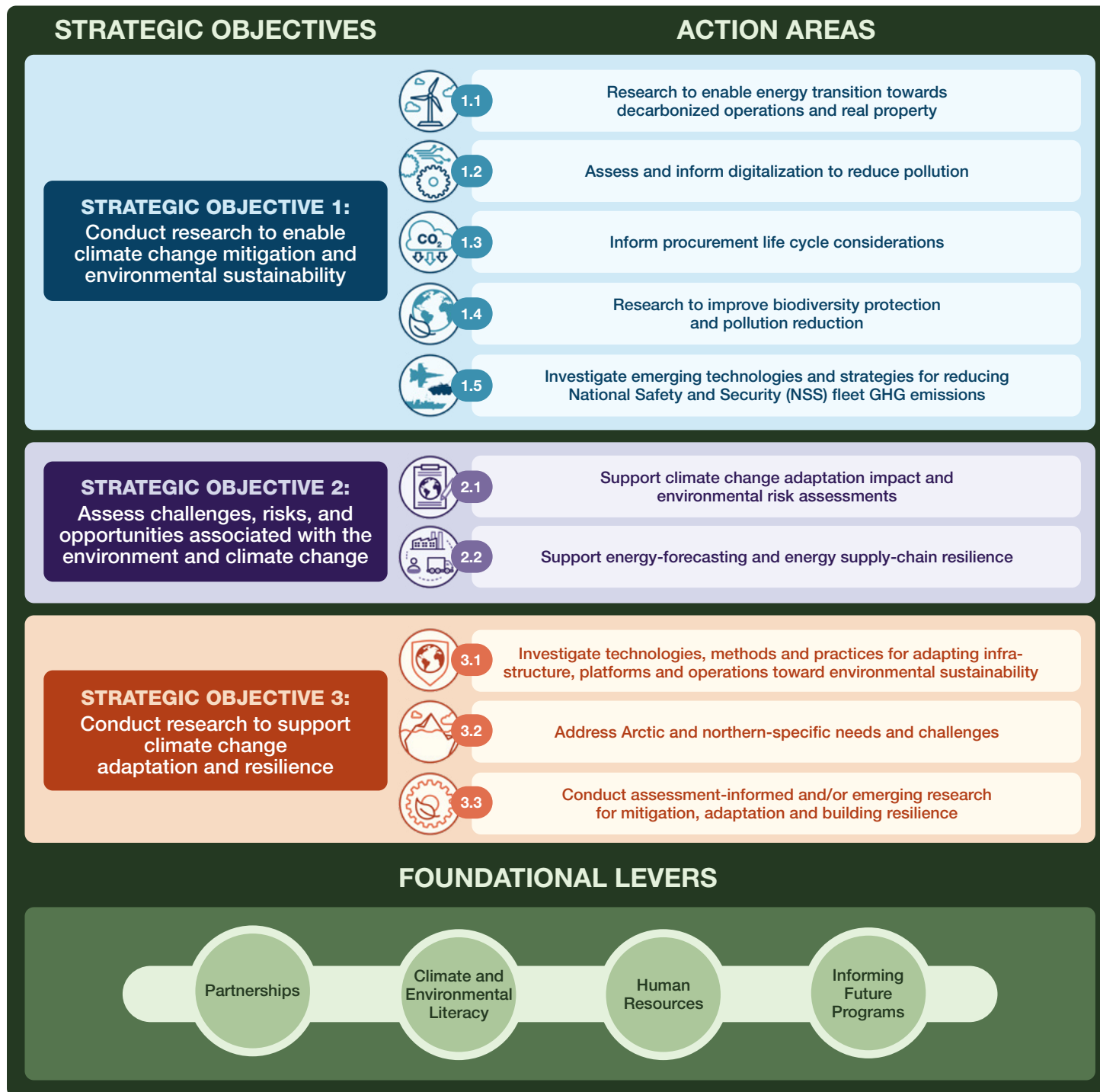
37. [Climate Science 2050: Advancing Science and Knowledge on Climate Change](#) is a national synthesis that was undertaken to better understand the breadth of climate change science and knowledge needs that exist in Canada.

38. See the [Pan-Canadian Framework on Clean Growth and Climate Change](#).

39. See the [DND/CAF Open Science Action Plan](#).

40. Examples of policies include: [Defence Energy and Environment Strategy](#) (DEES), [Strong, Secure, Engaged](#) (SSE), [Greening Government Strategy](#) (GGS), etc.

Each strategic objective has action areas that will guide S&T activities in support of 2050 net-zero GHG emissions and environmental targets, in alignment with the mission and operational mandate of DND/CAF. In addition, actions under the foundational levers will aim to address institutional barriers and undertake enabling activities to advance the work under the action areas, adopt the related S&T solutions, and achieve the overall success of the Strategy. These elements and the development of this Strategy were informed by extensive consultation within DND/CAF through surveys, internal feedback and continuous expert input, as well as federal consultation and significant research and analysis of federal and international policies, strategies, and initiatives.⁴¹



Strategic objective 1

Conduct research to enable climate change mitigation and environmental sustainability

Climate change, pollution,⁴² and efforts to mitigate their effects pose a series of formidable challenges, such as the social, cultural, economic, and technological transformations required to reach net-zero GHG emissions. Consequently, research to facilitate measures aimed at reducing environmental impacts must become a greater priority. This includes potentially de-risking⁴³ the resulting technologies and solutions for exploitation by the Defence Team. Further, this work also presents opportunities to open new pathways to research partnerships, both within and outside of DND/CAF. The following five action areas identify the opportunities for research under strategic objective 1:

- 1.1 Research to enable energy transition towards decarbonized operations and real property;
- 1.2 Assess and inform digitalization to reduce pollution;
- 1.3 Inform procurement life cycle considerations;
- 1.4 Research to improve biodiversity protection and pollution reduction; and,
- 1.5 Investigate emerging technologies and strategies for reducing National Safety and Security (NSS) fleet GHG emissions.

41. For example, [NATO's \(2022\) Climate Change and Security Impact Assessment](#), [UK \(2021\) Ministry of Defence Climate Change and Sustainability Strategic Approach](#), [NZ \(2019\) Ministry of Defence Responding to the Climate Crisis](#), [US \(2021\) Department of Defense Climate Adaptation Plan](#), etc.

42. According to the [UNEP Global Environmental Outlook 6 \(2019\)](#), human pollution has increased to the point at which it has become the greatest threat to human health, and drastically compromises humanity's ability to become equally more prosperous.

43. De-risking, in this context, may include field trials and/or evaluation processes that reduce the uncertainty of function/efficiency/effectiveness for the adoption of new technologies or systems that may be considered for use by DND/CAF.

1.1



Research to enable energy transition towards decarbonized operations and real property

DND/CAF is the largest user of energy and the single largest emitter of GHGs in the federal government. Given that emissions from real property and commercial light-duty fleets have been reduced by 36 percent from 2005 levels as of 2022,⁴⁴ the endeavour to further cut facilities' emissions is expected to become increasingly challenging and will require more innovative solutions. In addition, DND/CAF is examining potential reductions from military operations and exercises. DND/CAF has worked with other federal departments to create new capabilities in response to departmental requirements, harnessing and building upon this existing expertise and research could further inform solutions.⁴⁵



This hydronic heat distribution system was retrofitted at CFB Kingston to decrease energy consumption and fossil fuel dependence, as part of the IDEaS Green Heat challenge.

POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

Research in this area could include support for investigating more ways base/wing renewable energy projects might be implemented, to improve DND/CAF's overall energy security. Research specific to DND/CAF's real property portfolio, in conjunction with external infrastructure expertise, could include support for the implementation of energy storage solutions for bases, the utilization of carbon pricing schemes, improving environmental data collection and analytics,⁴⁶ and implementing systems and processes that further increase energy efficiency.

Another line of effort is investigating and testing emerging practices and technologies that will position remote or isolated defence installations to meet 2050 net-zero targets. This may include continuing existing efforts, as well as further exploring research in technologies such as small modular reactors, low and zero carbon fuels, mobile or rapidly deployable battery storage technologies, and compact and mobile renewable power generation solutions. On a more tactical level, this could include research initiatives that promote sustainable remote camps and operations, aimed at improving CAF members' comfort, safety, and survivability in the field.⁴⁷ As the equipment needs of CAF members continue to evolve, consideration should be given to the ways various forms of equipment waste can be reduced while promoting ergonomic benefits.

1.2



Assess and inform digitalization to reduce pollution

The digital transformation of society has drastically increased the efficiency and productivity of many systems and created entirely new ones. Yet there are still many aspects of business operations that rely on physical media, records, and equipment. The reliance on physical materials can be inefficient and impose environmental costs that could be reduced or eliminated with digital processes. Investigating the opportunities to further digitalize^{48,49} processes could produce an effective and efficient means of decoupling⁵⁰ environmental impacts from operations. The continuous and rapid rise in the adoption of digital technologies also presents potential opportunities to further offset environmental costs, particularly when the digitalization of an activity enhances experiences, such as through leveraging certain advantages of virtual operations and training environments over physical ones. Furthermore, increased availability of data for digital analysis may produce the comprehensive evidence-base needed to better inform public policy decisions.

Digital technologies also have an environmental impact, such as through the draw on natural resources, the consumption of energy and contribution to GHG emissions, and the generation of e-waste.⁵¹ Therefore the value added of digital transformation⁵² must consider both environmental costs and benefits. It will be important to continue existing work and further develop partnerships in this area,⁵³ with added focus toward reducing environmental costs.

POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

Research could be undertaken on the digitalization of processes and training, particularly assessing the feasibility of simulation technologies to digitalize military exercises. Furthermore, the capture of appropriate baseline data, development of newer modelling techniques, and integration of artificial intelligence (AI) could advance climate change impact analysis, environmental monitoring and sustainability, and improve environmental cost analysis from procurements as they pertain to defence activities. This includes, for example, tracking platform fossil fuel consumption as a function of operating profile to develop modelling that can inform practices for more efficient usage. Building from existing efforts, planning for digital transformation would also benefit from an assessment of its enabling requirements and underlying costs, such as assessing data gaps and integrating the environmental costs of data centres, the use of rare earth minerals, computer and cloud processing, and other infrastructure requirements. This transformation could include the sharing of environmentally relevant data and models among departments, academia, private industry, and international partners where feasible. Knowledge and understanding of how to leverage such data and technologies to improve efficiency and assess various impacts on DND/CAF is needed to better provide leaders and decision-makers with informed options.

44. As per the Treasury Board Secretariat's [Greenhouse Gas Emissions Inventory](#).

45. [Natural Resources Canada](#) and other agencies such as the [National Research Council Canada](#) have a number of programs and research priorities with regard to energy and infrastructure that pertain to the greening needs of DND/CAF.

46. The [DND/CAF Data Strategy](#) promotes objectives related to enhancing the Defence Team's data driven capabilities and generating value from data.

47. Akin to defence S&T projects such as Advanced Sustainable Secure Energy Technologies – Camp Power and Energy or the Innovation for Defence Excellence and Security (IDEaS) program Pop Up City Contest.

48. Digitization: The conversion of analog data and information to digital form.

49. Digitalization: The transformation of business and operational processes through the application of digital technologies.

50. According to the [OECD](#), the "term decoupling refers to breaking the link between 'environmental bads' and 'economic goods.'"

51. UNEP [The growing footprint of digitalization](#).

52. Digital transformation: The process of using digital technologies to create or modify culture, user experiences and processes. Learn more by accessing the [CAF Digital Campaign Plan](#).

53. See the [DND/CAF Data Strategy](#).

1.3



Inform procurement life cycle considerations

The direct impacts of climate change, such as the expected increased frequency and intensity of extreme weather, may be a determining factor for the performance requirements of new platforms or equipment. Furthermore, new supplies or equipment come with what are often disregarded environmental costs, known as externalities. These environmental externalities have associated impacts through various forms of environmental degradation, which are frequently overlooked despite their very real economic and/or societal costs. Pollutant pricing mechanisms are designed to account for such externalities, in an effort to reflect the true cost pollution has on society and to make polluters pay. In the case of carbon emissions, the price of these externalities is known as the social cost of carbon.⁵⁴ It determines how the price on carbon pollution is fixed when using a levy mechanism. For organizations that rely heavily on fossil fuels, this means that, as the price of carbon pollution rises, the cost of operating could rise considerably.⁵⁵

The operational emissions of a given piece of equipment are known as scope 1 (e.g., an organization's emissions from vehicles, furnaces, etc.), while scope 2 are indirect emissions associated with purchased energy (e.g., emissions produced at the power plant that provides electricity to an organization), and scope 3⁵⁶ are all the emissions in the supply chain outside the control of an organization.⁵⁷ Research that supports the life cycle impacts from procurement could reduce long-term environmental impacts and dollar costs. Knowledge of the measurements for scopes 1, 2, and 3 involved in the life cycle of procured equipment enable DND/CAF to make informed decisions and conduct more accurate emissions forecasting for procured goods, particularly with respect to large procurements, such as new platforms or fleets.⁵⁸

POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

S&T expertise is needed to support the definition of requirements and greening procurement practices of capital projects. This would help to ensure that typical environmental externalities are considered in a product's life cycle. For example, this could include the development of decision-making tools which support appropriate GHG emissions calculations. This can also include researching the use of more efficient materials for equipment and investigating materials for equipment that have lower carbon emission manufacturing processes. Implementing Treasury Board Secretariat requirements related to carbon disclosure for major procurement will help the Defence Team understand the impacts of their purchases. These considerations can have the added benefit of making environmentally sustainable options more cost competitive.

54. [Social cost of carbon](#) is a metric that calculates the socio-economic costs from additional CO2 emitted, which is useful in quantifying overall cost savings associated with carbon emission reductions.

55. According to the [federal carbon pollution pricing benchmark](#), the price on carbon is anticipated to rise in \$15 per year increments from \$50/tonne in 2022 to \$170/tonne in 2030.

56. Scope 3 emissions are, essentially, the scope 1 and 2 emissions from an outside organization in a supply chain.

57. The [Government of Canada's Greenhouse Gas Emissions Inventory](#) states "the Government of Canada will reduce absolute scope 1 and scope 2 GHG emissions by 40 percent by 2025 and at least 90 percent below 2005 levels by 2050."

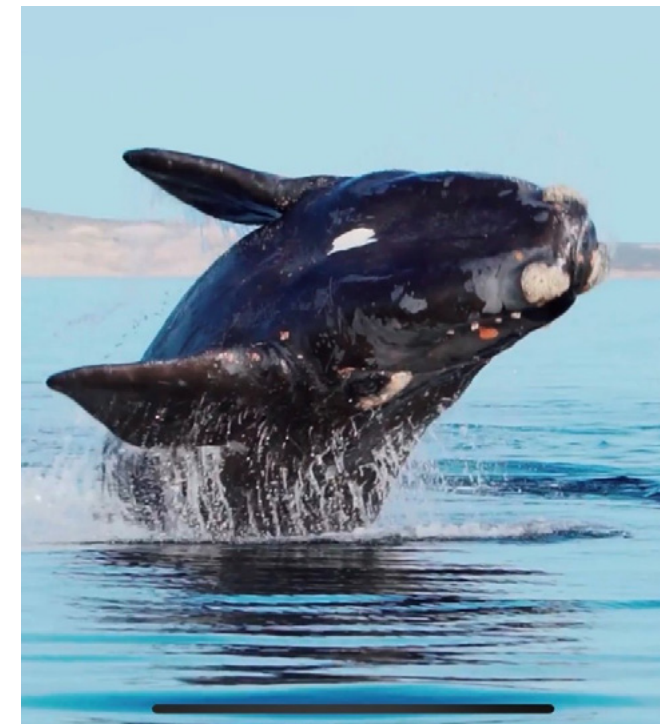
58. [Defence Administrative Orders and Directives 3015-0](#) mandates the commitment of DND/CAF to integrate environmental considerations into Material Acquisition & Support decision making processes and practices in a manner that supports the concept of sustainable development.

1.4



Research to improve biodiversity protection and pollution reduction

While endeavours to mitigate and adapt to climate change are important, research is also needed to continuously improve the overall environmental sustainability of operations. Climate change is often touted as one of the greatest threats to human security; however, biodiversity loss and pollution are also major threats and often intersect with factors driving climate change.⁵⁹ Building partnerships with other government departments on research in areas that protect biodiversity and reduce pollutants is also key to sustainable operations and environmental stewardship.



POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

This action area highlights current and future efforts to mitigate and reduce the overall environmental impacts of DND/CAF at home and abroad. This includes considering continued research into the following: the development of environmentally sustainable munitions,⁶⁰ sustainable range and training area (RTAs), noise pollution, marine mammal impact mitigation,⁶¹ as well as proposed research on materials for sustainability. Specific examples include research on understanding the ecotoxicity⁶² and environmental fate of munitions constituents, identifying the source of contamination in RTAs (weapons systems, training operations, etc.), developing solutions to mitigate environmental impacts (such as appropriate mitigation and remediation methods for contaminated RTAs), tools to manage environmental risks, new range design concepts, and developing new, greener munitions constituents.

Another potential area of consideration includes providing support or analysis as needed for land reclamation projects and innovative waste management solutions, which can carry a multitude of environmental benefits and promote a circular economy⁶³ within DND/CAF. Furthermore, other areas of research include exploring methods that reduce biofouling⁶⁴ of equipment and vehicles to minimize the transportation and spread of invasive species. In addition, the Defence Team and its S&T partners can further investigate the optimal ways for the CAF to perform its duties with a social licence,⁶⁵ without compromising its capabilities. This would allow DND/CAF to exercise its due diligence, avoid costly lawsuits and remediation processes,⁶⁶ and stay compliant with the *National Defence Act*, the *Canadian Environmental Protection Act*, and other legislation.⁶⁷ It would also help Canada honour commitments such as those under the UN Convention on Biological Diversity.

59. The [UN describes human insecurity](#) as arising from multiple factors, of which climate change can be such a factor with major destabilizing effects on people.

60. DRDC proved the ability to create more [environmentally sustainable munitions](#) that outperformed standard munitions, easing the environmental pressures on ranges and training areas.

61. [Research](#) aimed at the development of tools for the CAF to utilize in order to mitigate the impact of active sonar broadcasting on marine mammals, when conducting training. This helps uphold the CAF's obligation to ensure marine mammal protections, such as those under the [Species at Risk Act](#).

62. Ecotoxicity refers to the potential of external stressors (chemical, physical, biological) to impact an ecosystem.

63. The [circular economy](#) retains and recovers as much value as possible from resources by reusing, repairing, refurbishing, remanufacturing, repurposing, or recycling products and materials.

64. Biofouling is the accumulation of undesirable organisms, leading to a decreased functional capacity for an affected piece of equipment.

65. The [social licence to operate](#), or simply "social licence," is the acceptance of an organization and its activities by local communities and stakeholders.

66. Since 2003, DND/CAF has spent \$4.76 billion on remediation of contaminated sites such as the Distant Early Warning (DEW) Line.

67. DND/CAF is subject to environmental legislation such as the [Impact Assessment Act](#), the [Fisheries Act](#), the [Migratory Birds Convention Act](#), the [Species at Risk Act](#), etc., with penalties for contravention ranging from the thousands to millions of dollars.

1.5

Investigate emerging technologies and strategies for reducing National Safety and Security (NSS) fleet GHG emissions

NSS fleet emissions are accounted for as part of the effort to meet a net-zero 2050 target. DND/CAF will need to consider how to provide the NSS fleet with the capabilities needed, while reducing the carbon emissions to net-zero. S&T will have an ongoing role to play in supporting the decarbonization efforts of military platforms, whether it is the provision of research and advice for planning or testing new NSS fleet platforms.

OPERATIONAL FLEET DECARBONIZATION

The Greening Government Strategy requires NSS fleets, which include the Royal Canadian Navy (RCN), the Royal Canadian Air Force (RCAF), and the Canadian Army (CA), to each develop an operational fleet decarbonization plan. These plans will set out the department's path toward net-zero greenhouse gas emissions by 2050.

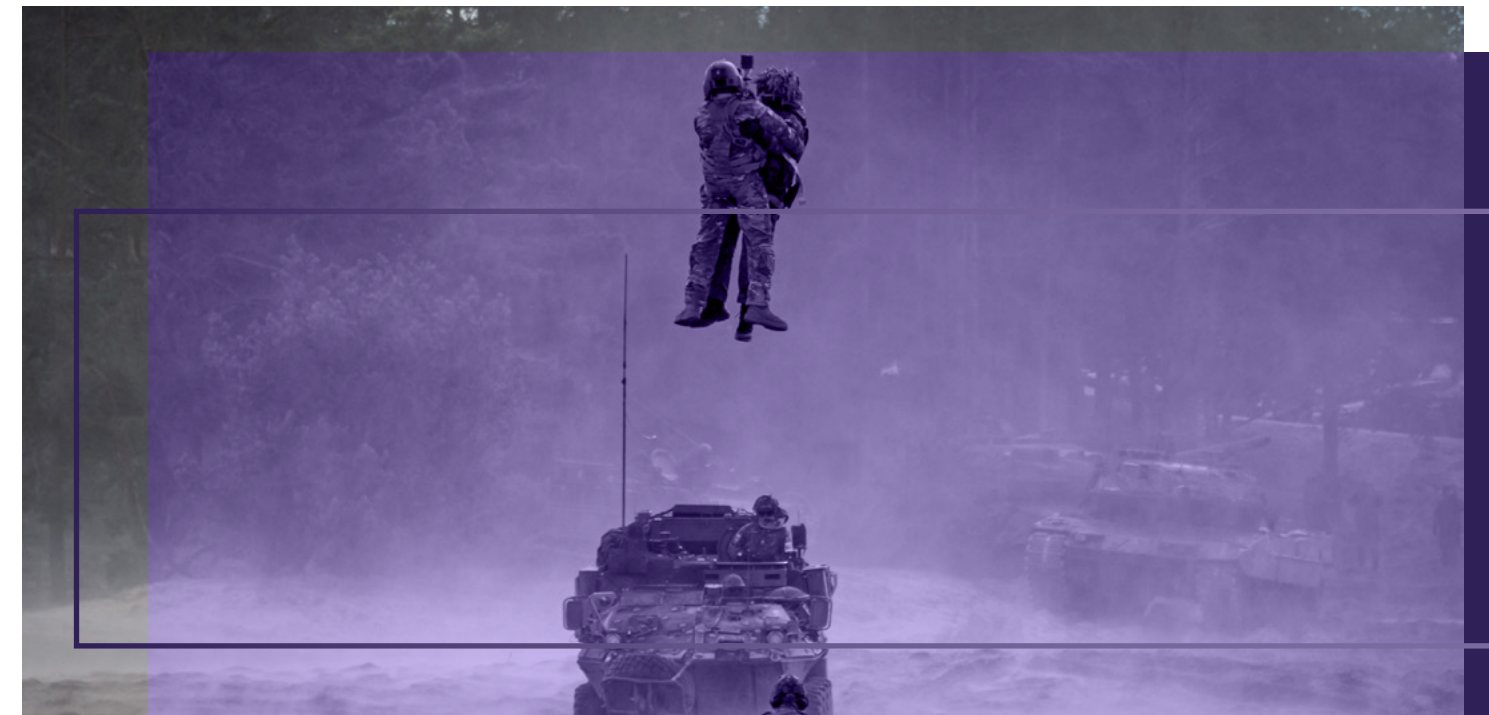
The RCN, RCAF and CA work jointly with DND's Assistant Deputy Minister (Materiel) to develop targets aimed to enhance operational fleet decarbonization and climate resilience. Preliminary lines of effort include the use of renewable fuels, optimizing operations to improve energy efficiency, integrating decarbonization efforts into procurement and fleet sustainment, and fostering collaborative partnerships to further R&D projects that contribute to decarbonization and climate resilience.

POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

Progress toward net-zero emissions by 2050 requires consideration of several emerging elements. DND/CAF has initiated efforts in conducting robust analysis of fleet-specific emissions data to provide the insights needed for efficient planning. Energy efficient planning will also likely include ways of exploiting energy management systems, data analytics, digital twins, further testing sustainable aviation fuels or low-carbon fuels,⁶⁸ and investigating efficiency gains, such as those sought through route-optimization technologies.

There may be opportunities to reduce emissions of existing platforms and equipment when they are undergoing planned retrofitting, until replacement with non-carbon emitting technologies becomes viable. Investigating potential solutions and technologies will require a coordinated effort from researchers. Further, it is recognized that it is not always feasible to retrofit a platform. Therefore, targeted efforts are also needed during the procurement process to invest in more environmentally sustainable platforms from the outset including new platform builds being planned by the department. Defence researchers could supplement existing procurement expertise with the development of decision-making tools that aid in consistent assessment of the effectiveness of carbon mitigation through planned retrofits, long term carbon offsets, or purchasing new platforms to inform statements of requirements for energy efficient new procurements.

S&T already plays a pivotal role in the development and innovation of platform technologies that support progress toward net-zero targets. This includes researching the use of more sustainable fuels and efficiency-improving technologies as a necessary step in the eventual reduction of fossil fuel dependence in the NSS fleet. S&T collaboration with partnering nations will also be instrumental in informing the next-generation, interoperable vehicle platforms whose climate impact has been mitigated, while considering a Canadian context that supports the needs of existing decarbonization planning efforts.



Strategic objective 2

Assess challenges, risks, and opportunities associated with the environment and climate change

As efforts progress to mitigate climate change and better understand its implications for human security, the need for research on this topic is expected to increase. Climate change is impacting every aspect of departmental activities and military operations, as well as the very nature of the defence and security sectors. Whether it is learning how to reach net-zero emissions, understanding how to adapt infrastructure, vehicle platforms, and human resources to become resilient to various environmental impacts, or maintaining awareness of how climate change is destabilizing nations and global trade systems, scientific assessments of such problems can be paramount to making well-informed decisions. The following two action areas are prioritized to promote optimization of scientific research required for facilitating or generating assessments related to the environment:



2.1 Support climate change adaptation impact and environmental risk assessments; and,



2.2 Support energy-forecasting and energy supply-chain resilience.

68. Leveraging sustainable aviation fuels/low-carbon fuels is one potential way to reduce near-term carbon emissions on the path to electrification. As such, the Royal Canadian Airforce Aviation Fuels Working Group has [advanced the development of a sustainable aviation fuels strategy](#).



2.1

Support climate change adaptation impact and environmental risk assessments

Changes to the natural environment as a result of climate change are occurring at an unprecedented rate. Furthermore, non-climate change-related environmental risks, such as earthquakes and tsunamis, continue to pose a danger to communities. Consideration of these overlapping risks is necessary to assess security and emergency management requirements in order to fully support preparedness and resilience. Effectively addressing these risks and their potential impacts requires a comprehensive and accurate understanding of the risks climate change and the environment pose to people, communities, infrastructure, equipment, supply chains, and geopolitics.



POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

Prioritizing climate risks in DND/CAF requires the translation of climate models into risk assessments for infrastructure, vehicle platforms, programs, human security, community safety, and human resource planning over various geographical and time scales. This could support collaboration and discussion in international defence science and intelligence-related fora. Undertaking this work requires research support and partnerships that can facilitate initiatives such as the development of a climate change adaptation risk assessment framework for programs, military operations, infrastructure, and vehicle platforms. This could also include research on human resource impacts from changing roles and missions including the staffing and recruitment implications of having an increased presence in Canada's north, better understanding physical performance in arctic conditions, and minimizing physical and mental health risks from operating for extended durations in extreme environments. Increasingly, research is needed to fill in the gaps of climate science that will improve the understanding of how climate change impacts will impose challenges to the defence sector.

Ongoing research will also be required to understand how climate change will impact defence activities and the environmental risks of training, including but not limited to mission sets, training environments, life cycle management of assets, the environmental fate of munitions constituents, and the onset of subsequent shifts in human resource needs. A specific example of such climate change-induced environmental risks for the near-term includes drier ranges and training areas (RTAs) that may preclude the use of pyrotechnic munitions because of increased wildfire risks. Conversely, flooded RTAs could increase the spread of toxic munitions constituents that elevate environmental risks, which could result in calls for a moratorium on such constituents. Both scenarios would mandate a change to training and/or munitions systems.

Finally, the evaluation of existing climate adaptation assessment tools is needed for their potential application in a defence context. The use of such tools can be augmented with other pre-existing efforts for stakeholder analysis, such as workshops, survey tools, and wargame exercises.

ADAPTATION STRATEGIES FOR THE CANADIAN ARMY

The effects of climate change are posing a mounting threat to security, both domestically and abroad. The Director Land Environment and the Canadian Army Land Warfare Centre worked with DRDC's Centre for Operational Research and Analysis to research the threats posed by climate change to Canadian Army operations and to develop potential adaptation strategies to reduce those threats. This threat and adaptation assessment was followed by research aimed at prioritizing the identified threats and related solutions. Through a mixed qualitative-quantitative approach, DRDC worked with subject matter experts from the Canadian Army, as well as other key stakeholder organizations, to discern priority climate adaptation strategies for the Army to

consider. Findings concluded that the top three priority areas for climate adaptation planning should include:

- Canadian Army bases and supporting areas;
- Preparing for increases in domestic humanitarian assistance and disaster relief operations; and,
- Adapting for a stronger Canadian Army presence in the Arctic.

Such research provides scientific support for the Canadian Army to appropriately plan its approach to enhancing its climate resilience well into the future.



2.2

Support energy-forecasting and energy supply-chain resilience

Systems and processes require energy to function. Given the need to substantially reduce the dependence on carbon emitting processes, it is important to effectively forecast future energy needs and systematically plan for a transition away from fossil fuel energy sources. Envisioning new energy pathways⁶⁹ for DND/CAF infrastructure and operations will require analysis of future energy needs, availability of renewable energy sources and technologies, and the infrastructure changes needed to embed them across various jurisdictions. The infrastructure development required for this transition will take time to design and build. Therefore, a comprehensive understanding of likely future energy pathways will help facilitate an effective and optimized transition.



POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:




In efforts to mitigate environmental impacts, DND/CAF can expect substantial changes in the way the department and military acquire and consume energy. As the transition away from fossil fuels takes place, DND/CAF will need to understand how the energy transition will impact its military operations, infrastructure, NSS fleets, and ways of doing business. This includes consideration of how DND/CAF will replace fossil fuels with electricity or low-carbon fuel alternatives, while also understanding the energy requirements for, and environmental impacts of, its digitalized processes, and emerging weapon and training platforms. This further includes developing a greater understanding of future access to the critical resources and components that will be needed for future operations. Therefore, it will be prudent to provide research and analysis for DND/CAF as to what its future energy needs will be, how energy may be acquired, and what it may cost across Canada, as well as understanding the risks associated to the resilience of new energy supply-chains. In instances where cost-conscious energy efficiency gains are exhausted and no suitable clean energy alternative exists, long-term carbon offset or carbon removal solutions will need to be explored. Research into these areas can provide assessments that will help ensure DND/CAF meets its climate obligation of net-zero carbon emissions by the year 2050 through an appropriate and optimized energy transition, while equipping decision-makers with the necessary knowledge and tools to plan for future energy needs.



Strategic objective 3

Conduct research to support climate change adaptation and resilience

The effects of climate change have already begun to take hold and are becoming apparent, especially in Canada's Arctic. Even under the optimistic scenario of reducing global carbon production to achieve net-zero by 2050, societies will be required to sufficiently adapt in order to avert the worst outcomes of climate change. Building from strategic objective 2, research will be required to understand how communities can best adapt, as well as develop technologies and practices required to improve the resilience of physical property, including critical infrastructure. The concepts of climate adaptation and resilience apply not only to the Defence Team and related stakeholders, but also to how DND/CAF can promote resilience within the communities they are expected to serve (see details in the Centre for Security Science text box, below). Under strategic objective 3, the following three action areas have been determined:

-  **3.1** Investigate technologies, methods, and practices for adapting infrastructure, platforms and operations toward environmental sustainability;
-  **3.2** Address Arctic and northern-specific needs and challenges; and,
-  **3.3** Conduct assessment-informed and/or emerging research for mitigation, adaptation and building resilience.

69. Energy pathways, in this context, refer to the flow of energy between producer and consumer.



CENTRE FOR SECURITY SCIENCE

The Centre for Security Science (CSS) is a dedicated centre related to public safety and national security within Defence Research and Development Canada (DRDC). CSS manages the Canadian Safety and Security Program (CSSP) in partnership with Public Safety Canada and collaborates with stakeholders across all levels of government, as well as with academia, industry, and Indigenous organizations. CSS addresses a broad range of public safety and security priorities across six lines of effort:

1. Preparedness and resilience;
2. First responders;
3. Border security;
4. Surveillance, intelligence and interdiction;
5. Critical infrastructure resilience; and
6. Chemical, biological, radiological, nuclear, and explosive security.

These six lines of effort provide support to anticipating challenges and risks associated with the environment and climate change, as well as conducting climate change adaptation and resilience research. For example, CSS leads *Investing in disaster reduction for resilience* initiatives which contribute to the development of adaptation projects for a number of biohazards and natural hazards, such as an earthquake early-warning system and nature-based solutions to coastal flooding. Through its initiatives, CSS has also contributed to supporting rural and remote community resilience by increasing situational awareness of key infrastructure, such as ice roads, as well as with S&T investments that enable communities to adopt emergency management tools and strategies in the face of evolving public safety and security events. These evidence-based approaches leverage both data-driven technologies and traditional knowledge to provide context appropriate solutions.



3.1

Investigate technologies, methods, and practices for adapting infrastructure, platforms and operations toward environmental sustainability

The scale and intensity of environmental issues facing the world warrants a holistic approach to the exploration of solutions. Non-technological solutions can be effective in reducing environmental impacts, such as through reducing or reusing before opting to recycle materials. The ways in which organizations conduct their operations and evolve their processes can produce great gains in both efficiency and effectiveness.



Source: Weapons systems- DRDC-Valcartier Research Centre

Trials for the identification and quantification of gaseous and particulate emissions of pyrotechnics.

POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

Research under this action area will focus on creative solutions to DND/CAF business processes and operations to define a future of environmentally sustainable operations, while providing a comparable or improved level of military effectiveness. This includes permitting a greater level of conceptual research and exploration of ideas with a higher likelihood of failure, yet which may lead to breakthrough understandings of sustainable defence operations.

Research may be conducted to investigate new methods for training, conducting operations, RTA management, human resource management and logistics, and conceptualizing security in ways that are more environmentally sustainable. This opens opportunities to increase environmental awareness and build a more sustainable and climate resilient fighting force capacity in the mid- and long-term future.

3.2

Address Arctic and northern-specific needs and challenges

The Arctic encompasses approximately 40 percent of Canada's land area and requires special consideration, as it is experiencing warming at a rate of up to four times the global average.⁷⁰ This rapid warming is reshaping the North at a rate unprecedented in human history. For example, accelerated permafrost degradation and receding sea ice are altering the accessibility of the region. This is changing the ways of life for northerners, disrupting traditional practices, and challenging livelihoods.⁷¹ In addition, environmental impacts for remote communities are linked to negative health outcomes such as an increased prevalence of poor nutrition, obesity, and diabetes; vector-borne, water-borne, and foodborne diseases; cardiovascular disease; respiratory issues; and mental health issues.⁷² Other growing considerations for the North include its geostrategic importance, increases in human activity, and more easily accessible resources. DND/CAF research activities, including related NORAD modernization and continental defence initiatives, will have to carefully consider the people who inhabit the land, the evolving role of the CAF in the North, as well as the direction of the Government of Canada.



POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

DND/CAF's need to operate in the North necessitates research into the adaptations required for a rapidly changing climate and operating in cold environments. Furthermore, DND/CAF also has an obligation to serve the people of the North. This includes ensuring that Defence Team activities, research, and investments align with the needs and vision of local residents and reflect the unique regional and local climate change conditions and circumstances, including values and cultures. Therefore, special interest should be given to research that provides benefits to the North, as set forth in the Inuit Nunangat Policy and Canada's Arctic and Northern Policy Framework.

The Government of Canada is committed to advancing reconciliation and renewing its relationship with Indigenous Peoples through the acknowledgement of modern treaties, land claims, and by upholding Indigenous rights. DND/CAF is committed to engaging with First Nation, Métis, and Inuit groups to ensure research is informed by Indigenous Knowledge Systems where possible. The Defence Team will need to communicate and consult with Indigenous groups, Territorial Governments, Canadian Rangers, and northern inhabitants concerning the planning, implementation, and outcomes of its defence related S&T activities in the North.

The broad research intersections for defence include Arctic-specific infrastructure development, GHG mitigation, capacity for adaptation, modelling permafrost and coastal changes, understanding and reducing environmental impacts of operations, enabling military mobility in arctic conditions (including large-scale search and rescue), supply chain management, testing new surveillance technologies, vehicle and weapon systems testing, and energy logistics, cultural and societal sensitivities, human resource capacity and implications,⁷³ among many others.

3.3

Conduct assessment-informed and/or emerging research for mitigation, adaptation and building resilience

Every year, researchers around the world produce data and information that adds to a growing library of highly valuable baseline knowledge. As this knowledge base grows and improves, better modelling, methods, and practices emerge. Learning from assessments and research is pivotal to all sciences, but it is also highly relevant for the application of knowledge to climate adaptation and resilience building.



POTENTIAL OPPORTUNITIES FOR DEFENCE SCIENCE AND TECHNOLOGY:

DND/CAF can utilize the findings from internal and/or external scientific resources to translate climate projections into direct or indirect impacts on defence, in order to prepare reliable methods, practices, and technologies to adapt and become climate resilient. With the appropriate data and knowledge collected, research options should be explored to facilitate the adaptation of human resource requirements (including a scientifically informed plan to manage human resources for domestic responses), the adaptation and resilience of military infrastructure, and the development of more sustainable practices and military technologies. For example, the use of emerging AI technologies could provide novel methods in addressing climate change, including more robust analysis and insights for modelling and understanding climate change impacts or the impacts of potential mitigation and adaptation measures.



70. As climate science continues to develop and improve, newer estimates of regional heating indicate the Arctic is warming up to [four times the global average](#).

71. For example, loss of permafrost is jeopardizing aircraft runways and shorter, warmer winters are weakening ice-roads, both compromising the predictability of availability of goods and services in some locations. Traditional Inuit and First Nations' ways of life are compromised through less predictable and stable sea-ice and terrain for hunting and fishing, as well as other traditional ecosystem-dependent subsistence activities.

72. See literature synthesis regarding the [health impacts climate change has on rural and remote communities](#).

73. These implications would include those required for maintaining an increased CAF presence including medical and logistical requirements, as well as any supporting research facilities.

Foundational levers

Greater investment from across DND/CAF will be needed to enable the Defence Team in increasing the overall awareness, buy-in, resources and capacity to achieve goals relating to the environment. In addition, related activities should apply an intersectional lens, including applying frameworks and principles of Gender-based Analysis Plus (GBA Plus)⁷⁴ and the quality-of-life indicators.⁷⁵ Finally, any resulting activities will also benefit from utilizing and enhancing existing strengths, such as DND/CAF's institutional knowledge, partnerships, expertise, and programs. In consideration of these requirements, the foundational levers are comprised of enabling activities in areas such as partnerships, climate literacy, human resources, and informing future programs. While these enablers are not necessarily S&T activities, their aim is to support and enhance the S&T efforts needed for each action area and increase the adoption of broader environmental considerations. Addressing the foundational levers will allow for increased preparedness to cope with the onset of greater impacts emanating from climate change, facilitate efforts toward achieving the Government of Canada's overarching environmental objectives,⁷⁶ and support the overall success of the CRESST.

Partnerships

Efforts to mitigate and adapt to the impacts of climate change are larger than those which can be undertaken by any one institution. Continuing and furthering collaboration opportunities through strategic partnerships – with other government departments, private industry, Indigenous governments and organizations, academic institutions, provincial, territorial, and international partners and Allies – will be necessary to share and coordinate efforts. Promoting a range of partnerships will facilitate the establishment of common standards,⁷⁷ models, methodologies, tools, encourage burden and risk sharing, and improve systems interoperability.

The Defence Team will look to leverage new and existing partnerships in three ways:

1. Enhance and develop partnerships within Canada – among other government departments, academia, Indigenous Peoples, including Knowledge Holders, provinces and territories, and the private sector – to foster climate change and environmental research that ensures unique defence circumstances are addressed.
2. Leverage and contribute to international scientific fora for guiding, coordinating, and developing scientific knowledge on climate change mitigation, adaptation, and environmental sustainability practices in defence and security.
3. Build on existing international partnerships and develop new ones to communicate, establish, collaborate, and enhance Canadian leadership on climate change and security and related S&T expertise and practices.

Special focus will be devoted to defence and environment research consortiums⁷⁸ such as the NATO Climate Change and Security Centre of Excellence (CCASCOE), with Canada as the framework nation. Leadership on this initiative aligns closely with Canadian priorities of pursuing partnerships to adapt to the impacts of a changing climate⁷⁹ and maintaining a strong contribution to NATO.⁸⁰ This COE promises to be a hub of expertise for decision makers, military officials, and relevant civilian practitioners to develop, enhance, and share knowledge on the impacts of climate change on security. Greater S&T support to the CCASCOE will help increase the capacity to adapt to the changing climate and contribute to NATO's goal of reducing the climate and environmental impacts of military activities.

74. [The principles of Gender-based Analysis Plus \(GBA plus\)](#) include: an intersectional integrated approach; evidence-based analysis; recognition of the evolution of societal norms and the facilitation of the deconstruction of assumptions and biases.

75. See [Stats Canada's Quality of Life Hub](#).

76. The Government of Canada is committed to several environmental objectives including building a circular economy, mitigating anthropogenic climate change with the Pan-Canadian Framework on Clean Growth and Climate Change, contributing toward the UN Sustainable Development Goals, etc.

77. See [Beyond Disclosure: Driving Performance & Trust in ESG](#) to learn how standardization and harmonization can create better outcomes and build trust in Environmental, Social and Governance performance.

78. Other such organizations include the International Military Council for Climate and Security (IMCCS), International Cooperative Engagement Program for Polar Research (ICE-PPR), The Technical Cooperation Program (TTCP), and the Global Military Advisory Council on Climate Change (GMACCC).

79. "Building a cleaner, greener future will require a sustained and collaborative effort from all of us. As Minister, I expect you to seek opportunities within your portfolio to support our whole-of-government effort to reduce emissions, create clean jobs and address the climate-related challenges communities are already facing." ([Minister of National Defence Mandate Letter](#))

80. For example, Canada is leading jointly with Norway, Denmark and the Netherlands to develop recommendations for an S&T Collaborative Programme of Work on climate change and security for the COE.

Essentially, the CCASCOE is expected to support NATO's work on climate change and security,⁸¹ provide Allies, partners, and other relevant stakeholders with a central location to pool their knowledge and develop effective responses to the security impacts of climate change, as well as provide a platform to engage with diverse global actors and entities addressing elements of this same challenge. In developing and sharing research within such a forum, DND/CAF will be positioned to distribute defence and security research findings more widely, as appropriate, and better collaborate with Five Eyes, NATO Allies, and global partners. These partnerships could further provide opportunities for collaboration on new technologies and practices requiring standardization across NATO member states.

The Defence Team currently possesses environmental research expertise, which can be augmented through partnerships and focused on environmental research requirements. For example, in partnership with other government departments, existing power and energy researchers are improving the sustainability of Arctic facilities by reducing fossil fuel use and GHGs.⁸² The Defence Team also possesses tools and programs, such as the Innovation for Defence Excellence and Security (IDEaS) program, which can be leveraged to find solutions through collaboration with private industry and innovators in areas where the Defence Team itself may be missing specific expertise and research capacity.⁸³

INNOVATION IN DEFENCE EXCELLENCE AND SECURITY (IDEaS) PROGRAM SUPPORT FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

The Department of National Defence established the Innovation in Defence Excellence and Security (IDEaS) program in April 2018, with \$1.6 billion in funding mechanisms over two decades, to assist Canadian innovators in solving defence and security challenges. IDEaS partners with innovators or researchers to support promising ideas from the concept stage, through prototype testing and capability development. This type of partnership enables Canadian innovation and allows Canada to maintain technological advantage in the defence sector. The IDEaS program is undertaking numerous environmental initiatives that will support the Defence Team in achieving its climate change and sustainability objectives.

One related theme within IDEaS projects is reducing environmental impacts, including GHG emissions. For example, the Pop Up City contest, Green Heat test drive, and Less GHGs on the Seas calls for proposals are all aimed at increasing the efficiency of operations through better energy management and reduced fossil fuel consumption.

Under the Sea: Real-time Detection of Marine Mammals during Sonar Operations is another call for proposals that is aimed at improving situational awareness of marine mammal presence to minimize the risk of harm from naval active sonar operations, supporting the overall Government of Canada's Oceans Protection Plan.

IDEaS projects also aim to address climate change related considerations in the Arctic. For example, the Human Performance in Extreme Climatic Environments call for proposal sought research and solutions that enable human operators to perform tasks in extreme conditions, both in terms of physical and psychological conditioning aspects. Other calls for proposals such as A Cold Wind Blows: Seeking Smaller, Ruggedized Wind Turbines for the Arctic, Full Spectrum Communications in the Arctic, and Sub-zero Infrastructure, Security, and Sensors: Safekeeping assets in the Arctic were geared toward improving operating capability, addressing energy challenges, or adapting to the evolving security environment in the Arctic. These projects fund research required to address the probable realities of the future operating environment of the CAF, while promoting the opportunities to develop more environmentally sustainable operations.

81. **Climate change and security** implies a notion that certain aspects of [climate change impacts are of concern to defence institutions](#). See [Annex A](#), for more detail.

82. The [AMAZE project](#) is a collaborative project that seeks to reduce the reliance on fossil fuels in the Arctic.

83. See [Defence IDEaS](#)

Climate and environmental literacy

A key lever to the collective success of this Strategy is rooted in the knowledge and awareness of the Defence Team and its stakeholders with regard to climate and environmental impacts and their consequences. Consequences include those that immediately impact the physical environment, human health, and broader climate, as well as those with longer-term impacts on defence and security that challenge strategic, operational, and tactical planning. Integration of climate change and security considerations are pivotal to mobilizing DND/CAF in achieving climate objectives, engaging stakeholders, reducing the impacts of climate change, mitigating the environmental impacts of its activities, and adapting to the climate-impacted security environment.

DND/CAF should explore change management⁸⁴ as a mechanism to further promote efforts that enable and encourage climate and environmental literacy amongst all its members, including with regard to members' understanding of environmental challenges, climate change, and their impacts on defence considerations. Continuing to deliver climate and environmental literacy courses for appropriate DND managers and CAF leadership could further instill an understanding of environmental resource planning. Defence Team researchers and personnel may also benefit from courses to better understand the environmental connections to their own work and thus harness their intellectual capabilities toward related outcomes, while maintaining priorities driven by DND/CAF requirements.

In addition to building climate and environmental awareness within the Defence Team, DND/CAF may need to consider how to better communicate and share environmental research findings, both internally and externally, with other government departments and international fora. This includes the possibility of creating specific training or informational materials to further facilitate the transfer of S&T knowledge and research information within this field. Finally, DND/CAF should consider how to best provide the S&T tools, decision support and technological recommendations needed to meet environmental risks and challenges.



Human Resources

Greater investment in human resource capacities will further support the implementation of this Strategy and prepare the Defence Team to respond to the challenges at the nexus of climate change, the environment, and defence and security. It will be necessary to leverage the existing DND/CAF environmental community, its research, contracts, governance, and external partnerships. However, this effort will also require building human capital to develop and promote programs, provide leadership, and conduct research in areas that contribute to the greater effort of addressing defence interests regarding climate change. This could include consideration of pre-existing talent and programs, whether through talent management, training and skills development, or support for new research opportunities where employees could widen their expertise, develop their skills and experience, as well as branch out and form new collaborative endeavours. It could include creating new scientific leadership positions to guide environmental research expertise within the Defence Team, as well as hiring new experts, such as those with a specific expertise in environmental research planning.

Bolstering the existing expertise in the Defence Team could enable the department to better assist international defence organizations to develop their strategies and plans for addressing environmental challenges and climate change. This could include providing more scientific analysis and advice, supplemental research and modelling, scientific methods and tools, scenario development and wargaming, and other forms of consultation. The CAF's knowledge and practical expertise on climate change and the environment should also be leveraged, while taking into account that existing resources are already operating at maximum capacity and additional resources may be needed. Building a platform to share the wealth of institutional knowledge would facilitate pragmatic and relevant environmental research planning across DND/CAF. Collaboration with social and behavioural scientists will also be key in planning for and informing communication, awareness-building and cooperation across the Defence Team.



84. "Change management" is the development of a framework to facilitate management of the human resource aspects of organizational change.

Informing future programs

Comprehensive, accurate, and up-to-date information and research findings can be effective in informing defence programs and planning, as well as supporting the justification for related investments. Greater funding and investment will enable DND/CAF to fully undertake the related research and activities. This includes pursuing and planning activities that consider and build on existing efforts and governance structures where possible, prioritizing S&T activities focused on areas of strategic importance, and pursuing steady, incremental progress, while leveraging breakthrough S&T solutions or improvements. Further related research findings and outcomes will contribute to the growing knowledge within DND/CAF of environmental issues. This will subsequently build the evidence base needed to further guide and incorporate environmental considerations within S&T programs and planning, as well as inform the direction of future initiatives and programs across Defence. For example, it could inform activities such as developing access to, and understanding of, energy data and associated energy-use reduction strategies, researching how to reduce the environmental impacts from military training and operations, and advising on promising new environmentally sustainable technologies.

Planning related efforts and activities also requires acknowledgement that climate change can affect some people and groups differently and more severely than others depending on their identity, circumstance, and location. Diverse perspectives and approaches will aid in more effective, innovative, dynamic and resilient research and solutions.⁸⁵ Consequently, actions pursued under this Strategy will consider an intersectional lens, including applying principles and frameworks such as GBA Plus. For example, activities under this Strategy would apply primarily to the fields of science, technology, engineering, and mathematics (STEM) within which certain groups tend to be underrepresented including women and people with disabilities. Increasing the representation of such groups in STEM would be encouraged to the maximum extent possible through best proactive management practices by the public service. Other examples would include tailoring policy approaches and engagement principles, to ensure as much as possible, that they are culturally and linguistically relevant or ensuring that new or modified infrastructure is designed with a dual- or multi-purpose approach in mind that holds long-term, socio-economic benefits for Indigenous and Northern communities, from both a physical infrastructure perspective and procurement and jobs creation perspective. In addition, related actions and initiatives will aim to uphold the rights of Indigenous Peoples, including constitutional, treaty, and inherent rights to own, use, develop, control, conserve and protect the environment of their lands, territories, and resources in accordance with the standards set out in the United Nations Declaration on the Rights of Indigenous Peoples.⁸⁶



85. How Canada sees [inclusion and respect for diversity](#).

86. The [United Nations Declaration on the Rights of Indigenous Peoples](#) is implemented in Canada under the federal statute called the [United Nations Declaration on the Rights of Indigenous Peoples Act](#).

Horizons

Climate change and environmental considerations require a long-term outlook to manage the goal-oriented pathway set out by the Government of Canada. This Strategy provides a guiding framework and a comprehensive overview of S&T activities that can be applied to meet the urgency of climate change concerns, by assessing the S&T needs gaps in DND/CAF environmental considerations, identifying current environmental research strengths, and coordinating and aligning to the progress of DND/CAF and the Government of Canada's environmental and climate change policy direction.

Progress toward environmental goals is already underway via several varied activities noted through the consultation to inform this Strategy. The path forward will require building on existing efforts, lessons learned, and successes, while re-assessing gaps and pursuing new activities to address them. In addition, future government priorities and needs will be used to adjust and recalibrate the Strategy as needed.

Framed by the net-zero 2050 legislation, Government of Canada environmental goals, and targets set by the departmental sustainable development strategy, S&T efforts for DND/CAF should broadly focus over the following three horizons noting that these activities are not strictly linear and may take place concurrently as well as overlap temporally:



HORIZON 1: 1-5 YEARS

Programs and initiatives with short-term results that align with long-term objectives, including:

- S&T support to climate and environment assessments;
- de-risking new technologies and strategies for exploitation;
- evaluating infrastructure, equipment and technologies for their environmental impacts;
- S&T tools and advice to aid environmental analysis for large procurements;
- establishing new research objectives and initiatives; and,
- supporting the completion of current GHG mitigation plans with data collection and analysis, among other activities.

HORIZON 2: 5-10 YEARS

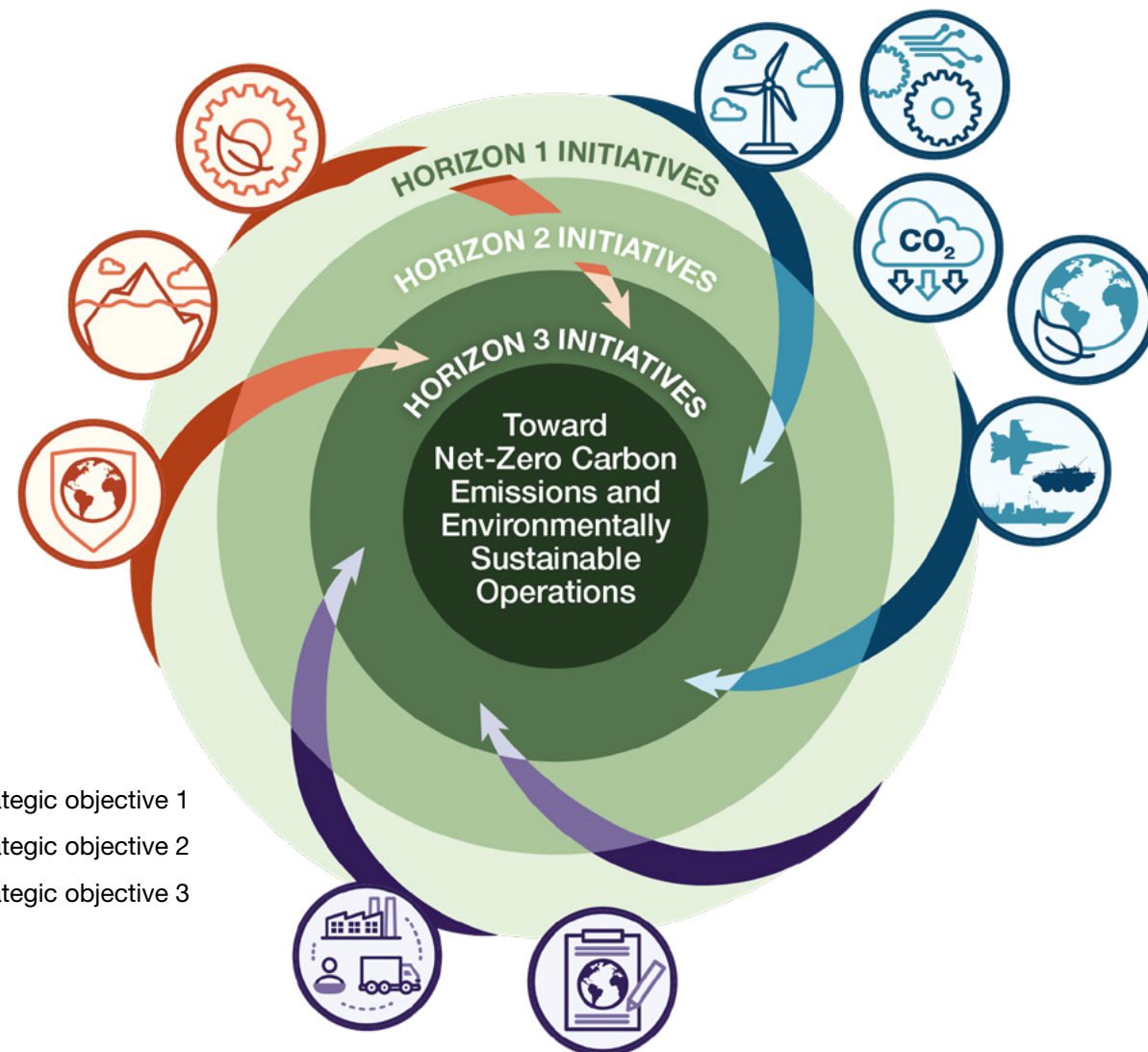
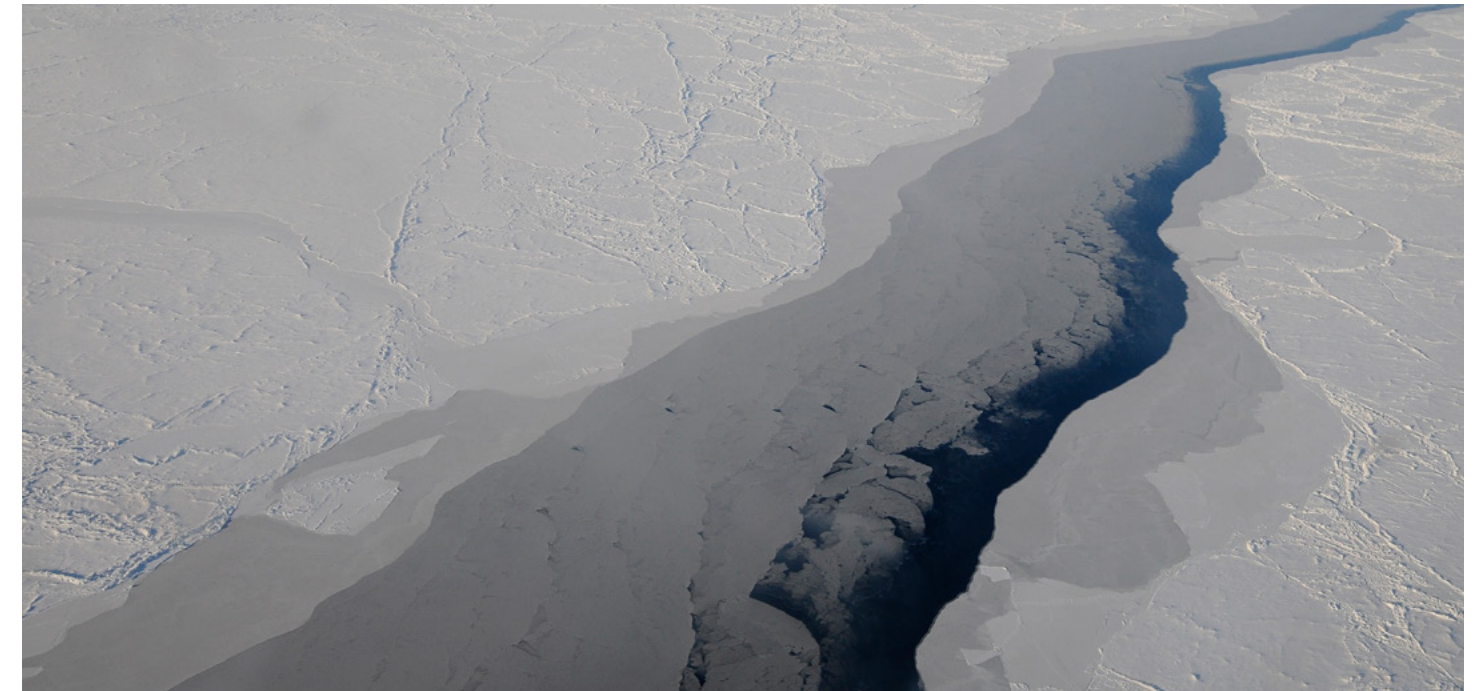
Research and planning to build the environmental S&T capability and capacity required to meet future environmental needs and achieve emissions abatement targets set forth on the path to net-zero, including:

- development of environmental expertise; and,
- support implementation of more environmentally sustainable training and exercises, among other activities.

HORIZON 3: 10+ YEARS

Efforts that will mitigate GHG emissions to net-zero and prepare DND/CAF for the world leading up to the year 2050, including:

- the progressive research and advancement of more environmentally sustainable equipment, weaponry, and NSS fleets;
- environment and climate-conscious practices; and,
- facilitate integration of emerging energy technology solutions, among others.



The path ahead

The climate and environmental challenges facing Canada and the world are complex and multi-faceted, with their effects growing in frequency and intensity. DND/CAF is faced with increasing demands to respond to the impacts of natural disasters and extreme weather events, while essential defence infrastructure and equipment are put at risk by the changing climate. To anticipate and prepare for these impacts, it is necessary to build the resiliency to adapt to a fluctuating natural and security environment, while concurrently undertaking efforts in climate change mitigation and environmental sustainability. Doing this will require comprehensive, innovative, and practical S&T solutions that enable climate action, while maintaining or increasing operational capabilities to meet the mandate for DND/CAF.

New environmental considerations and challenges will emerge over time, as will related priorities for the Government of Canada. To ensure the CRESST maintains support for evolving policies,⁸⁷ and the priorities and the needs of DND/CAF, this Strategy will be reviewed periodically through consultation and assessment of related S&T initiatives. This includes monitoring S&T efforts under this Strategy to help ensure that they support Government of Canada and departmental policy direction and goals, as well as encouraging the progress of related partnerships. Defence, safety and security S&T is fundamental to understanding the environmental threats of today and tomorrow and producing the knowledge and technology solutions necessary to respond. Ultimately, this Strategy provides the foundation to guide defence S&T resources in directions that will maintain and improve the climate resilience and environmental stewardship of DND/CAF for the benefit of Canadians.

87. For example, policies designed to evolve such as the [National Adaptation Strategy](#) and [Climate Science 2050](#).

Annex A

Key terms (definitions)

Climate adaptation: refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. ([IPCC AR3 WG2, pg. 879](#))

Climate change: “long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun’s activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil, and gas.” ([United Nations, Government of Canada](#))

Climate change mitigation: “human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).” ([United Nations Intergovernmental Panel on Climate Change, SYAR5 Glossary, p. 125](#))

Climate change and security: The study or idea of climate change and security is a response to the increased demand toward understanding the security implications of climate change. In the context of defence institutions, this means understanding the following: (1) changes to the strategic environment, (2) impacts on defence installations and assets, (3) impacts on missions and operations, and (4) defence institutions’ resilience and preparedness. ([NATO’s Climate Change & Security Impact Assessment, 2022](#))

Climate resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while maintaining the capacity for adaptation, learning, and transformation. ([Government of Canada](#))

Digitalization: The transformation of business and operational processes through the application of digital technologies.

Greenhouse gas: gases present in the atmosphere that trap heat energy, leading to global warming. Canada’s [official greenhouse gas inventory](#) includes estimations for carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), nitrous trifluoride (NF₃), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

Science and technology (S&T): comprise two types of scientific activities: research and development, and related scientific activities. They can be defined as all systematic activities directly related to the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. ([Statistics Canada, 2022](#))

Sustainability: Throughout this document, the term “sustainable” is in specific reference to environmental sustainability, whereas “operations” is in broad reference to all DND/CAF business activities – not strictly military operations unless stated. Sustainability is aligned with the principles presented in the [Federal Sustainable Development Act](#), which states that it is important to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. ([Federal Sustainable Development Act](#), Principles 5b)