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A WIN-WIN STRATEGY FOR THE GOVERNMENT OF CANADA: A PLAN FOR THE RCAF TO REDUCE GREENHOUSE GAS EMISSIONS WHILE REMAINING OPERATIONALLY EFFECTIVE

Major Kyle Welsh

JCSP 46

Solo Flight

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INTRODUCTION

Multiple studies published in peer-reviewed scientific journals have shown that human activity, primarily from the release of carbon dioxide (CO_2) during the combustion of fossil fuels, is causing global warming.[1] The earth's rising temperature has led to an increase in the number and severity of adverse weather events, warmer and more acidic oceans, less snow and ice cover, rising sea levels, floods, droughts, and wildfires.[2] The recommendations in Canada's Changing Climate Report supports the scientific consensus, that urgent, ambitious, and enduring action is required to avoid the negative impacts of climate change.[3]

The Government of Canada has committed to reducing GHG emissions, but the Royal Canadian Air Force (RCAF) currently does not have a strategy to do so. This paper will argue that the RCAF should implement a policy with short-, medium-, and long-term objectives to reduce its GHG emissions while attempting to maintain its operational effectiveness. This paper is not a policy in and of itself, but rather, an attempt to provide insight into the issue, highlight innovative solutions, and provide a framework to assist with the drafting of an official policy.

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[1] John Cook et al, "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-caused Global Warming," *Environmental Research Letters* (April 2016): 1-2, https://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002.

[2] Carbon Brief, "Mapped: How Climate Change Affects Extreme Weather Around the World," last modified 15 April 2020, https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world.

[3] Environment and Climate Change Canada, *Canada's Changing Climate Report* (Ottawa: 2019), 13, https://www.nrcan.gc.ca/maps-tools-publications/publications/climate-change-publications/canada-changing-climate-reports/canadas-changing-climate-report/21177.

This paper is divided into five sections. The first section will provide an overview of the international targets to reduce GHG emissions and highlight the RCAF's current situation with regards to GHG emissions. The second section will show that there are relatively easy steps to immediately reduce the RCAF's GHG emissions by making changes to standard operating procedures. The third section will argue that the RCAF needs to start using Sustainable Aviation Fuels (SAF) in order to further reduce GHG emissions in the short to medium-term. The fourth section will reveal that aircraft manufactures are moving away from the use of fossil fuels, so the RCAF's capability-based planning and infrastructure projects should incorporate this factor into their long-term plans. The fifth and final section of this paper will recommend a strategy for the RCAF to reduce its GHG emissions.

CLIMATE CHANGE CONCERNS

The effects of climate change are a concern for people around the world, and the international community has started to take action to address this issue. The most famous international climate change agreement is likely the 2016 Paris Climate Agreement.[4] The Paris Climate Agreement aims to keep global temperature rise this century to less than 2 degrees Celsius above pre-industrial levels, and to pursue ambitious efforts to limit the temperature increase to 1.5 degrees Celsius.[5] A significant aspect of the Paris Agreement is GHG emission targets. Oddly, specific recommendations for the aviation and shipping industries fell outside the scope of the Paris Agreement. Canada signed the Paris Climate

[4] The Paris Agreement was drafted between 30 November and 12 December 2015 in Le Bourget, France, signed on 22 April 2016 in New York City, and came into effect on 4 November 2016.
[5] United Nations, "The Paris Agreement," last modified 2015, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Agreement on 22 April 2016, ratified it on 5 October 2016, and it entered into force on 4 November 2016.[6]

Government of Canada Targets

The Government of Canada has enacted policies to meet or exceed the targets in the Paris Climate Agreement. As a federal government institution, the RCAF needs to develop a strategy that supports those policies. In 2016, the government released the Federal Sustainable Development Strategy, which outlines the government's goals and plans for clean growth, healthy ecosystems, and sustainable communities.[7] In November 2016, the Government of Canada established the Centre for Greening Government within the Treasury Board Secretariat to track and report emissions, coordinate government "greening efforts," and drive results.[8] In December 2017, the government released its Greening Government Strategy, which set ambitious targets to reduce GHG emissions from operations by 40% from 2005 levels by 2030, and 80% from 2005 levels by 2050.[9] Surprisingly, but consistent with other jurisdictions, some government GHG emissions are excluded from the Government of Canada's GHG emissions reduction targets "for safety and security reasons."[10] The National Safety and Security (NSS) exemptions apply to operational emissions from the Department of National Defence (DND), and thus,

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[6] United Nations, "United Nations Treaty Collections, Chapter XXVII, Environment, 7.d. Paris Agreement," last modified 31 March 2020, https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en.

[7] Environment and Climate Change Canada, "Federal Sustainable Development Strategy," last modified 6 November 2019, https://www.canada.ca/en/services/environment/conservation/sustainability/federal-sustainable-development-strategy.html

[8] Environment and Climate Change Canada, *Achieving a Sustainable Future: Progress Report on the 2016 to 2019 Federal Sustainable Development Strategy* (Ottawa: Environment and Climate Change, 2018), 22.

[9] Treasury Board of Canada Secretariat, "Greening Government Strategy," last modified 2 August 2019, https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html.

[10] Environment and Climate Change, *Achieving a Sustainable Future: Progress Report . . .*, 20.

RCAF aircraft emissions are excluded from the national GHG reduction targets. That said, NSS emissions are included in the federal GHG emissions reports, and the Government of Canada has directed NSS organizations to develop strategies to decarbonize their fleets.[11]

Department of National Defence Direction

As a part of the federal government's plan to reduce GHG emissions, the DND released the Defence Energy and Environment Strategy (DEES) in 2017. All four DEES objectives relate to activities to reduce GHG emissions: less energy waste, cleaner energy, a reduced defence environmental footprint, and better-managed energy and environmental performance.[12] Canada's Defence Policy, *Strong, Secure, Engaged*, also makes several references to greening defence, including supporting DND/CAF efforts to reduce GHG emissions by 40 percent from the 2005 levels by 2030 and examining alternate energy options for operations.[13]

The DND is the largest GHG emitter in the Canadian federal government, and RCAF aircraft operations are the primary source of DND emissions.[14] According to the NSS exemptions details on the Treasury Board website, in Fiscal Year (FY) 2018-19, the DND NSS fleet emitted 734 kilotonnes (kt) of carbon dioxide equivalent (CO_2 eq), of which 587 kt CO_2 eq or 80% came from aircraft emissions.[15] In comparison to the

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[11] Treasury Board of Canada Secretariat, "Government of Canada's Greenhouse Gas Emissions Inventory," last modified 13 March 2020, https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/government-canada-greenhouse-gas-emissions-inventory.html.

[12] Department of National Defence, D2-394/2017E, D*efence Energy and Environment Strategy - Harnessing Defence Energy and Sustainability: Defence and the Road to the Future* (Ottawa: DND Canada, 2017), 3-4.

[13] Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy* (Ottawa: DND Canada, 2017), 76. SSE Initiatives: 101 and 102.

[14] Treasury Board of Canada Secretariat, "Government of Canada's Greenhouse Gas Emissions . . .

[15] Treasury Board of Canada Secretariat, "Government of Canada's Greenhouse Gas Emissions . . .

previous fiscal year, DND NSS emissions were up 8.4%, and aircraft emissions were up 7.1% this fiscal year. These figures show that the RCAF is a significant contributor to the federal government's overall GHG emissions, and the volume of emissions are trending in the wrong direction. Observant individuals probably have not overlooked these facts. To the detriment of the RCAF, it could be argued that a modest reduction of RCAF emissions could have a more significant effect than major reductions by all the other governmental departments combined. It would be wise for the RCAF to develop an emissions reduction strategy before it finds itself forced to take a specified course of action.

RCAF Environment & Operational Sustainability Program

The RCAF should invest the time, effort, and money to improve its understanding of the issues, publish policies, and foster a culture that seeks to reduce emissions. The RCAF *Campaign Plan v3.0* (signed 22 July 2019) removed *Sustainability* as a foundational element and rebranded it as the *RCAF Support to Departmental Sustainability and Environmental Stewardship* mission within the *Air & Space Support to the Enterprise* line of effort.[16] Objectives of the Sustainability and Environmental Stewardship mission include: greening RCAF operations and training, exploring sustainable energy to reduce GHG emissions, and developing sustainable culture, policy, doctrine, and education.[17] Two assigned tasks are (a) development of an *Environment and Operational Sustainability Program* (E&OS Program) to address a broad range of federal environment and sustainability policy issues, and (b) selectively explore and become an

[16] Department of National Defence, *RCAF Campaign Plan v3.0,* (Ottawa: DND Canada, 22 July 2019).
[17] *Ibid.*

early adopter of green technology where appropriate and feasible.[18] The RCAF has acknowledged the requirement to improve its sustainability, and one of the first logical steps would be to draft a policy that is focused on achieving emission reduction targets in a similar manner and degree to those of the government and aviation industry.

Civil Aviation Targets

The International Air Transport Association (IATA), an organization that represents the interests of the global airline industry, has established both emissions targets and a strategy to reduce GHG emissions.[19] Of note, the airline industry was the first industry to self-impose a GHG reduction strategy, and in many ways, the airline industry has a history of promoting fuel efficiency.[20] IATA developed the following voluntary and ambitious targets to reduce emissions in 2009:

- An average improvement in fuel efficiency of 1.5% per year from 2009 to 2020;
- A cap on net aviation CO_2 emissions from 2020 (carbon-neutral growth); and,
- Reducing net aviation CO_2 emissions to 50% of 2005 levels by 2050.[21]

IATA has also established several programs to assist airlines improve their environmental performance, including a carbon offset program, environmental assessment program, fuel and emissions database, and a cargo sustainability initiative.[22] These guidelines and programs have been accepted in principle by the airlines, but compliance is voluntary.

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[18] *Ibid.*

[19] IATA is composed of 230 airlines - totalling 93% of scheduled international traffic.

[20] IATA, "Historic Agreement on Carbon-neutral Growth," last modified 3 June 2013, https://www.iata.org/en/pressroom/pr/2013-06-03-05/.The aviation industry was the first industry to suggest a global approach to the application of a single market-based measure to manage its climate change impact, and it was the first to agree on global targets.

[21] IATA, "Halving Emissions by 2050: Aviation Brings its Targets to Copenhagen." IATA Press Release No: 54, last modified 8 December 2009, https://www.iata.org/en/pressroom/pr/2009-12-08-01/. The third target is the same as the Air Transport Action Group (ATAG).

[22] IATA, "Improving Environmental Performance," last accessed 22 March 2020, https://www.iata.org/en/programs/environment/.

The main incentives for airlines to reduce emissions are associated with lowering fuel costs and minimizing carbon taxes. These initiatives are noteworthy for the RCAF because the aviation industry is evolving to achieve their emission targets, and this will likely change global flight operations in the future.

The Requirement for a Proactive Policy

The RCAF Environmental Program supports regulatory compliance, but it needs to evolve to include an aircraft GHG emissions policy. Moreover, some risks could threaten RCAF operations if a strategy to reduce emissions is not self-imposed. Canada's Greening Government policy is a priority of the current Canadian federal government, and more importantly, there is broad public support to address global warming. As such, there is a *political risk* that the NSS exemptions could become a public interest issue, subject to political debate, and then targeted in an arbitrary or penalizing manner. Secondly, there is a *social* risk of failing to reduce emissions because environmental groups could conduct adverse public relations campaigns against RCAF emissions. Third, there are *financial* risks associated with increasing oil prices and carbon taxes.[23] If the RCAF does not use its initiative to reduce emissions, the government may impose targets and timelines that hinder the RCAF's operational effectiveness. As will be described throughout this paper, the RCAF can mitigate these risks by fostering a sustainable culture, applying best practices, using alternative energy sources, adopting new technologies, and embracing other innovative processes.

EFFICIENT FLIGHT OPERATIONS

[23] The current situation is an exception - OPEC's increased oil supply combined with the decreased demand due to the effects of COVID-19 - which has resulted in decreased oil prices.

The RCAF should take action to reduce its GHG emissions immediately. Western allies and private industry have already implemented measures to reduce their fuel use; hence, the RCAF should follow suit and apply similar practices. Although there will be costs associated with implementing change, it stands to reason that the short-term objectives will result in cost savings. As will be shown, the RCAF can begin to reduce emissions by fostering sustainable culture and applying best practices.

Efficient Flight Operations – The United States Air Force

The RCAF should adopt some of the procedures that have recently been endorsed by the United States Air Force (USAF). The USAF established the Energy Analysis Task Force (EATF) in 2010 to conduct comprehensive qualitative and quantitative research in order to reduce investment risks by identifying and removing barriers to the implementation of projects and programs.[24] In September 2018, the EATF published a *Line Operations Efficiency Analysis* report about the USAF C17 Globemaster fleet - one of the USAF's and RCAF's largest consumers of aviation fuel.[25] The EATF report provided eight recommendations to improve mission effectiveness, and identified five secondary aspects to be potential opportunities for improvement.[26] Almost all of the EATF recommendations, such as simultaneous engine starts, flying at optimum cruise altitudes and speeds, and reduced engines taxi after landing, apply to RCAF CC177 operations. Moreover, these recommendations would also be applicable to the other RCAF fleets. Revisions to aircraft standard operating procedures can be implemented in a

[24] Department of the [United States] Air Force. *C-17 Line Operations Efficiency Analysis*. (Arlington, Virginia, 2018), iv.
[25] *Ibid.*
[26] *Ibid.*, iv-v.

relatively quick timeline to reduce emissions and increase the operational effectiveness of the RCAF flight operations.

Efficient Flight Operations – The Airline Industry

The airlines also have techniques to reduce fuel consumption that could be adopted by the RCAF. Airlines, as corporations that have a vested interest in maximizing profits, actively pursue initiatives to improve efficiencies. To that end, Airbus (and likely other Original Equipment Manufactures) have produced publications on how to operate their aircraft as efficiently as possible with the use of a cost index.[27] Although the airlines are driven to increase shareholder value, and some activities, such as tankering fuel or flying faster to make block times, which could result in additional emissions, airlines are generally focused on reducing fuel burn.[28] In comparison to airline operations, the cost index concept may be more advantageous for military (air mobility) operations because flexibility exists among routes and flight timings.

Simulators

The RCAF should promote the use of simulators and flight training devices. Simulators offer a high degree of realistic training in a controlled environment without the use of fossil fuels. As a result of the high fidelity of modern simulators, most airlines and some newer military fleets (e.g. F35 Lightning II, C130J Hercules, C17 Globemaster

[27] Airbus, "Getting to Grips with The Cost Index," last modified May 1998, https://ansperformance.eu/library/airbus-cost-index.pdf.

[28] Vinicius Ayello Deo, Flavio Silvestre, & Mauricio Morales. "The Benefits of Tankering Considering Cost Index Flying and Optional Refuelling Stops." *Journal of Air Transport Management* 82 (2020): 1-2, https://www.sciencedirect.com/science/article/pii/S0969699718302692?via%3Dihub.

III, etc.) conduct initial flight training almost entirely with simulators.[29] Most RCAF fleets have embraced the use of simulators, but there is room for improvement. For example, RCAF CC177 crews conduct their initial qualification courses and quarterly refresher training in USAF flight simulators; however, unlike the USAF, the Canadian CC177 crews complete the remainder of their flight training in the actual aircraft. Astonishingly, the RCAF does not have a CC177 Globemaster simulator - the aircraft that has the highest fuel burn per hour of flight, and nor does the RCAF have simulators for the CC150 Airbus and the CH149 Cormorant fleets.[30] Simulators are also more cost-effective in the long-run because simulator Operations and Maintenance (O&M) costs are significantly less than aircraft O&M costs.[31] The RCAF should take advantage of technological solutions, such as simulators, to help reduce GHG emissions.

SUSTAINABLE AVIATION FUELS

Improving flight efficiency can reduce emissions, but the RCAF will also need to utilize alternative energy sources in order to achieve meaningful GHG reductions. Sustainable Aviation Fuels (SAF), which is essentially a substitute for traditional jet fuels, is a crucial component of the aviation industry's plan to reduce GHG emissions.[32] Rather than being produced from petroleum, SAF is produced from sustainable "feedstocks,"

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[29] Jason Stark, "Motion – Is There a Requirement in Large Fixed-wing Aviation Simulators?" (Joint Command and Staff College Course Paper, Canadian Forces College, 2010) 5-7.

[30] David Strong, "RCAF Environmental & Operational Sustainability Program: Concept and Policy Discussion" (lecture, 1CAD, Winnipeg, MB, 24 September 2019), with permission.

[31] U.S. Federal Aviation Administration, *Office of Aviation Policy, Plans, Economic Values for FAA Investment and Regulatory Decisions, A Guide* (Washington, 2015), 6-5. Fuel expenses remain one of the major components of an airline operational cost, and depending on the aircraft, it generally accounts for 20% to 70% of its total flight cost.

[32] Canada's Biojet Supply Chain Initiative, "Considerations for the Application of a Biojet Sustainability Standard in the Aviation Sector," Last modified 2019, https://cbsci.ca/themencode-pdf-viewer-sc/?tnc_pvfw=ZmlsZT1odHRwczovL2Nic2NpLmNhL3dwLWNvbnRlbnQvdXBsb2Fkcy9DQlNDSS1TdXN0YWluYWJpbGl0eS1TdGFuZGFyZC1SZXBvcnQtMjAxOS1zcHJlYWRzLnBkZiZzZXR0aW5ncz0wMDExMDAxMTExMDExMTExMSZsYW5nPWVuLVVT#page=&zoom=page-fit&pagemode=bookmarks.

such as waste oils from a biological origin, agri residues, or non-fossil CO_2.[33] SAF is considered to be a "drop-in fuel" (meaning that it can be blended with traditional jet fuel), but there is optimism that SAF will eventually replace traditional jet fuels.[34] The most impressive aspect of SAF is that it requires no special infrastructure, equipment, or engine modifications – it merely replaces traditional fossil fuels.[35]

SAF reduces carbon emissions by lowering the concentration of aromatic hydrocarbons in jet fuel. Traditional jet fuels have between 15 to 25% aromatic content, but aircraft engines only require a minimum of 8% aromatic hydrocarbon in order to function properly.[36] Most SAF contain no aromatic material. By blending SAF with traditional jet fuel, the aromatic content can be reduced to less than 10%.[37] At least one study has shown there to be a 40% decrease in carbon and particulate matter emissions with a 50:50 blend of SAF and conventional jet fuel, and another study found that the lifecycle emissions from SAF can be up to 80% lower than traditional jet fuel.[38] As long as the SAF meets both the technical specifications and sustainability criteria, the aviation industry appears to be willing to consider any feedstock-technology combinations.[39]

SAF in Canada

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[33] SkyNRG, "Sustainable Aviation Fuel," last accessed 22 March 2020, https://skynrg.com/sustainable-aviation-fuel/saf/; Merriam-Webster. "Feedstock," last accessed 22 March 2020, https://www.merriam-webster.com/dictionary/feedstock.

[34] IATA. *IATA Sustainable Aviation Fuel Roadmap* (Montreal: 2015), 62-64. https://www.iata.org/en/programs/workgroups/mita/.

[35] IATA, "Sustainable Aviation Fuel: Fact Sheet," last modified May 2019, https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-fact-sheet-2019.pdf

[36] Carey Fredericks, "RCAF Jumps on Green Bandwagon with Biofuels Test Flight," Wings, last modified 30 May 2012, https://www.wingsmagazine.com/rcaf-jumps-on-green-bandwagon-with-biofuel-test-flight-7176/.

[37] *Ibid*.

[38] Carey Fredericks, "RCAF Jumps on Green Bandwagon with Biofuels Test Flight . . .; IATA, "Sustainable Aviation Fuel: Fact Sheet . . .

[39] IATA, "Sustainable Aviation Fuels: Fact Sheet 2," last accessed 23 March 2020, https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-technical-certifications.pdf.

SAF is an emerging energy source, and the airline industry is working to develop and promote the SAF industry.[40] In fact, both Air Canada and WestJet have supported initiatives to advance Canada's SAF industry.[41] IATA predicts that the SAF industry will be self-sufficient once it is used to power at least 2% of all flights.[42] The SAF industry is already producing 15 million litres per year, and construction is underway for the industry to produce 1.7 billion litres per year. It is predicted that the "tipping point" will occur when the industry produces 7 billion litres per year – which could happen as early as 2025.[43] The Government of Canada, through the National Resource Council, is overseeing a competition to develop the Canadian SAF industry, so it is likely just a matter of time until SAF becomes common practice across Canada.

Several militaries have started to use SAF on a routine basis; however, the RCAF has minimal experience using it. For example, the Royal Netherland's Air Force (RNAF) commenced SAF trails with their F16 Falcon fleet in 2016, and they have been using SAF–blended fuels at the Leeuwarden Air Base since January 2019.[44] In comparison, the RCAF conducted a single test flight with biofuels in a "legacy" CC130H Hercules aircraft on 30 May 2012.[45] The flight test successfully demonstrated the use of biofuels, but the RCAF has almost done nothing else with SAF. As the SAF industry continues to grow, so

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[40] IATA, "IATA - Sustainable Aviation Fuels (SAF)," last accessed 22 March 2020, https://www.iata.org/en/programs/environment/sustainable-aviation-fuels/.

[41] COPA, "YVR Takes a Green Leap Forward: Sustainable Aviation Fuels Initiative Announced," *COPA Flight Magazine*, February 2020, 27.

[42] IATA. "Sustainable Aviation Fuel - Fueling the Future of Flying," last modified 12 December 2019, https://docs.google.com/document/d/1ynwb-_GW64BvbdtqhTD6kVmPBbV4yfqy/edit#.

[43] *Ibid*.

[44] SkyNRG, "2016, July 29th – Royal Netherlands Air Force first to operate F-16 Fighting Falcon on Sustainable Aviation Fuel, Supplied by SkyNRG," last modified 25 May 2019, https://skynrg.com/track-records/july-29th-2016-royal-netherlands-air-force-first-to-operate-f-16-fighting-falcon-on-sustainable-aviation-fuel-supplied-by-skynrg/; SkyNRG, "2019, January 16th – Royal Netherlands Air Force Operates Her F-16 Fighting Falcons on SAF," last modified 9 May 2019, https://skynrg.com/track-records/january-16th-2019-royal-netherlands-air-force-operates-her-f-16-fighting-falcons-on-saf/.

[45] Carey Fredericks, "RCAF Jumps on Green Bandwagon with Biofuels Test Flight . . .

should the RCAF desire to use it. SAF is expected to be the single greatest way to reduce GHG emissions with current aircraft engines, so in the medium-term, the RCAF should start using SAF to reduce emissions with its current aircraft fleets.

Biofuel Concerns

Food security and biodiversity are legitimate concerns, so IATA has developed a "meta standard" to define the principles and criteria for sustainability.[46] Biofuel feedstocks are often derived from crops that have uses in the food, feed, and fibre sectors, so the SAF industry must not exacerbate food insecurity. The impact of changing land-use is another concern because changes can alter natural ecosystems and biodiversity, which is a common concern throughout the entire agricultural system. To address these concerns, IATA's meta standard has established a mandatory minimum level of sustainability based upon principles related to maintaining carbon stocks, biodiversity conservation, soil management, sustainable water use, and air quality.[47] IATA has also established three levels of sustainability based upon a SAF meta standard score. The entire SAF supply chain is evaluated against the meta standard to ensure that the fuel is sustainable and does not create undesirable second or third-order effects. Sustainability schemes, such as IATA's meta standard, seek to address these concerns and ensure that reductions in GHG emissions do not have unwanted consequences. Regardless of the chosen alternative energy source, the RCAF needs to ensure that undesired consequences are mitigated or avoided.

Medium-term Objectives

[46] IATA. *IATA Sustainable Aviation Fuel Roadmap . . .*
[47] *Ibid.*

Over 40 airlines and a few western Air Forces have started to use SAF to reduce their emissions, and its time for the RCAF to start adopting this practice.[48] The Treasury Board Secretariat has directed NSS organizations to decarbonize their fleets, and it appears that SAF is going to be the most effective method of reducing emissions until alternative energy sources and aircraft propulsion systems are developed.[49] Understanding that it will take decades for the RCAF to augment or replace its current aircraft fleets with green technology, the RCAF should use SAF in order to reduce its GHG emissions in the short to medium-term.

HORIZON SCANNING

Modern aircraft are more fuel-efficient than their predecessors, and therefore the RCAF/DND should acquire newer aircraft to lower its emissions and improve its operational effectiveness. A study by the International Council on Clean Transportation (ICCT) into commercial aircraft fuel efficiency reported that the average fuel burn of new aircraft fell approximately 45% from 1968 to 2014 - a compounded annual reduction rate of 1.3%.[50] Improvements in fuel efficiency are expected to continue with the introduction of more efficient aircraft and engine designs. This likely explains why commercial airlines operate newer aircraft. To put this into context, Air Canada's average fleet age is 13.2 years, while the RCAF average fleet age is 32.3 years.[51] Understanding that newer aircraft are more fuel-efficient and that the RCAF operates an older fleet, the RCAF can significantly reduce its GHG emissions and improve its operational efficiency by

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[48] IATA. "IATA - Sustainable Aviation Fuels (SAF) . . .

[49] Treasury Board of Canada Secretariat, "Government of Canada's Greenhouse Gas Emissions . . .

[50] Anastasia Kharina, and Daniel Rutherford, "Fuel Efficiency Trends for New Commercial Jet Aircraft:1960 to 2014," *International Council on Clean Transportation*, last modified 3 August 2015, https://theicct.org/publications/fuel-efficiency-trends-new-commercial-jet-aircraft-1960-2014. iii.

[51] Airfleets. "Average Fleet Age - Air Canada Fleet Details." Last accessed 29 March 2020, https://www.airfleets.net/ageflotte/Air%20Canada.htm.

updating its aircraft. A direct comparison can be made between the C130 Hercules models – the latest CC130J Hercules can fly up to 40% further, 40% higher, 21% faster than the "legacy" CC130 Hercules models that are still being operated by many RCAF Search and Rescue squadrons.[52] In addition to higher operating costs and reduced serviceability levels of older aircraft, delays to Canada's military procurement projects are hampering the government's plan to reduce GHG emissions.[53] Modernizing fleets is likely the most effective way for the RCAF to reduce its GHG emissions in the medium to long-term.

Electric Aircraft

Aircraft manufactures have recognized that the Paris Agreement targets cannot be achieved using current technology. Instead, alternative propulsion systems, such as electric and hybrid-electric aircraft, will be required for the aviation industry to meet the climate agreement targets.[54] On 11 December 2019, a 1956 de Havilland Beaver refitted with an electric motor flew around southern Vancouver Island. This was a historic occasion because it was the first electrically-powered commercial passenger aircraft flight.[55] The Vancouver-based airline, Harbour Air, expects to have a Transport Canada-

[52] Lockheed Martin, "C-130J Super Hercules: One Aircraft, Many Capabilities," (2018): 10-12, https://www.lockheedmartin.com/en-us/products/c130.html; Lockheed Martin, *C-130J Super Hercules: Whatever the Situation, We'll Be There* (Marietta, GA: n.d.), 1-2. https://www.lockheedmartin.com/content/dam/lockheed-martin/aero/documents/C-130J/C130JPocketGuide.pdf.

[53] A. Sokri, "Optimal Replacement of Military Aircraft: An Economic Approach," *Defence and Peace Economics 22:6* (2011): 651-653, https://doi.org/10.1080/10242694.2011.577958; The Congress of the United States Congressional Budget Office, *Aging and the Costs of Operating and Maintaining Military Equipment* (Washington: Government Printing Office, August 2001), 29-32.

[54] Airbus, "Electric Flight: Bringing Zero-emission Technology to Aviation," last modified 2020, https://www.airbus.com/innovation/future-technology/electric-flight.html.

[55] Howard Slutsken, "Harbour Air Makes History With Electric-powered Beaver Flight," *Skies Magazine*, last modified 10 December 2019, https://www.skiesmag.com/news/harbour-air-makes-history-with-electric-powered-beaver-flight/.

certified electric aircraft in operation before the end of 2022.[56] Airbus is also working on a large hybrid aircraft, with the goal of producing a zero-emission commercial aircraft within the next 20 years.[57] The initial hurdles with electric aircraft are associated with battery weight and establishing aviation standards; however, aircraft manufactures are advancing this technology faster than expected.[58] Strategic level planners need to understand and incorporate electrically powered aircraft into their capability-based planning processes in order for the RCAF to achieve meaningful GHG emissions.

Solar-Powered Aircraft

Solar-powered aircraft are also making notable improvements and will likely become a platform of choice for Remotely Piloted Aircraft Systems (RPAS) and satellite augmentation. The Solar Impulse and Airbus Zephyr are two noteworthy examples. Between March 2015 and July 2016, Solar Impulse 2, a two-person aircraft, flew around the world on solar power. The power for the Solar Impulse 2 comes from 17,248 photovoltaic solar cells - each one roughly the thickness of a human hair - that cover the aircraft's wings and fuselage.[59] These cells use sunlight to power the engine and charge the lithium batteries during the day, thereby allowing the batteries to power the engines throughout the night. The Airbus Zephyr Stratosphere High Altitude Pseudo-Satellite (S HAPS), is an inhabited solar-powered aircraft that operates at an average altitude of

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[56] Steve Drinkwater, "Electric Beaver Flies: The Dawn of a New Age in Aviation," *COPA Flight Magazine*, January 2020, 10.

[57] Airbus, "E-Fan X: A Giant Leap Towards Zero-emission Flight," last modified 2020, https://www.airbus.com/innovation/future-technology/electric-flight/e-fan-x.html.

[58] Howard Slutsken, "Harbour Air Makes History With Electric-powered Beaver Flight," *Skies Magazine*, last modified 10 December 2019, https://www.skiesmag.com/news/harbour-air-makes-history-with-electric-powered-beaver-flight/; "From E-Fan to E-Fan X," YouTube video, 1:43, Posted by "Airbus," 6 February 2020, https://www.youtube.com/watch?v=AfkWQL8Ziac.

[59] Maya Wei-Haas, "Inside the First Solar-powered Flight Around the World," *Smithsonian Magazine*, last modified 31 January 2018, https://www.smithsonianmag.com/innovation/inside-first-solar-powered-flight-around-world-180968000/.

70,000 feet. Between 11 July to 9 August 2018, the Zephyr S HAPS completed the longest duration flight ever made - 26 days straight, and models show that the aircraft is capable of a continuous flight up to 100 days.[60] The adoption of solar-powered aircraft would be an entirely new capability for the RCAF and would help overcome one of military aviation's most significant challenges – persistence.

Airships

Airships are making a come back. Unlike blimps, airships have rigid structures and usable internal spaces, such as work areas, cargo compartments, and crew quarters. Airships could provide several unique capabilities because they can remain airborne for weeks at a time, but their distinct advantage is in terms of its cargo transport capability. More than ten years ago, Lockheed Martin developed and flew an airship demonstrator that could be scaled up to three, five, or seven times the size.[61] To put this in perspective, Lockheed's P-791 airship can transport almost everything in the Canadian military's inventory - including main battle tanks, or upwards of three hundred sea containers.[62] Airships offer additional cargo capacity with significant reductions in fuel consumption compared to conventional aircraft. Airships also have an advantage over cargo aircraft because they do not require a runway. In some ways, airships have more in common with container ships rather than aircraft; however, airships are faster and can go almost anywhere in the world. Airships are only employable in permissive environments, but

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[60] Airbus, "Zephyr Datasheet," last accessed 1 April 2020, https://www.airbus.com/defence/uav/zephyr.html.

[61] Lockheed Martin, "Hybrid Airship: Revolutionizing Remote Transport" last accessed 1 April 2020, https://www.lockheedmartin.com/en-us/products/hybrid-airship.html.

[62] "P-791 Hybrid Air Vehicle" YouTube video, 3:21, posted by "Skunk Works – Lockheed Martin," 24 August 2010, https://www.youtube.com/watch?v=CKAyJ3zKTus&feature=youtu.be&list=PLqa9423Jd9MoFhb4B6crNz-shr6yIE7eh.

they are an innovative solution to conduct air mobility operations with lower emissions, and they would be an entirely new capability in terms of their ability to be operational support hubs.

Long-term Objectives

The aviation industry is changing in many ways for many reasons, so strategic level planners need to understand these changes and how they can be incorporated in the future. Canada's Defence Policy (SSE) is a long-term plan to modernize the Canadian Armed Forces, and it calls for the military to reduce its GHG emissions; however, this policy does not explicitly state how to do so. It is up to the strategic level commanders and their staff to determine how best to accomplish this. Modernizing the RCAF fleets will take a considerable amount of time and money, but these investments are necessary to reduce emissions and remain operationally effective in the future.

RECOMMENDATIONS

The RCAF can reduce aircraft GHG emissions without impacting its operational effectiveness with detailed planning, managed investments, and diligent execution. Most of the solutions will come from private industry, so the RCAF should track how the aviation industry is evolving and adopt the best practices and green technologies to reduce its emissions while improving its operational effectiveness. In order to achieve meaningful reduction targets, the RCAF's emission policy should include immediate, medium, and long-term objectives. This approach should satisfy the RCAF's mandated and moral obligation to reduce GHG emissions, while at the same time, helping to mitigate political, social, or economic risks associated with its operational emissions.

RCAF Emission Targets

The RCAF emissions reduction strategy should start by identifying GHG emission targets and then describe a robust plan to meet or exceed those targets. Self-imposing targets is advantageous because it should help avoid unfavourable targets from being enacted by the government. Instead of developing unique targets, the RCAF must establish targets that support the federal government objectives and are similar to the aviation industry. The Greening Government targets (a reduction of GHG emissions by 40% from 2005 levels by 2030, and 80% relative to 2005 levels by 2050) are likely too aggressive for the RCAF, but the RCAF could work towards the IATA targets.[63] The RCAF has already missed IATA's first target deadline. However, the RCAF could accept the second target (a cap on net aviation CO_2 emissions from 2020), and work towards achieving the third target (a reduction in net aviation CO_2 emissions of 50% by 2050 relative to 2005 levels).[64] The RCAF emitted approximately ??? kt CO_2 eq in 2005, so a 50% reduction would equate to a cap of ??? kt CO_2 eq emissions in 2050, which is ??% reduction from last year's emissions.[65] Achieving this target will require an immediate, aggressive, and long-term strategy.

A Win-Win Strategy

The Commander of the RCAF should direct his/her staff to continue studying the issues and draft a policy to reduce emissions while remaining operationally effective. Decreasing operational output is not an option and nor is it financially feasible to replace

[63] Airbus, "Electric Flight: Bringing Zero-emission Technology to Aviation," last modified 2020, https://www.airbus.com/innovation/future-technology/electric-flight.html. Airbus committed to the targets set by the Paris Climate Agreement; however, Airbus believes that those targets cannot be achieved using existing technologies.

[64] IATA, "Halving Emissions by 2050 . . .. The first target was an average improvement in fuel efficiency of 1.5% per year from 2009 to 2020.

[65] The author was unable to obtain the 2005 emissions data before the submission deadline due to COVID-19 workplace restrictions at 1 Canadian Air Division.

all of the aircraft fleets with the green technologies this decade, so the policy should include short-, medium-, and long-term objectives to meet or exceed the emission target(s). The required changes will impact almost every aspect of RCAF air operations, so in a similar way that Gen Vance championed Operation HONOUR, the Commander of the RCAF could champion the emissions reduction strategy in order to highlight its importance and help foster a sustainable organizational culture.

1 Canadian Air Division (1CAD), as the RCAF operational headquarters, will play a pivotal role in managing the policies and programs to reduce aircraft emissions. The 1CAD Readiness section, with its Standards and Evaluation Teams, should be tasked to review and oversee the implementation of best practices for each aircraft fleet. Similar to IATA, 1CAD should also develop programs to help each fleet to improve their environmental performance, manage an emissions database, and improve passenger/cargo loads. Some RCAF policies also need to be rewritten to account for the prioritization of GHG emission reductions. For example, the RCAF's *Minimum Time for Fuel Available* (MTFA) policy directs pilots to minimize airframe hours at the expense of higher fuel usage because it was assessed that "airframe hours are considerably more expensive than aviation fuel."[66] These types of policies fail to account for the environmental costs of GHG emissions, and it is these types of policies that can be revised to reduce the RCAF's GHG emissions immediately.

In the medium-term, and in alignment with the RCAF's Campaign Plan objective to be an early adopter of green technology, the RCAF should start to use biofuels.[67] The

[66] Department of National Defence, *RCAF Flight Operations Manual, section 2.4.3.5, Fuel Tankering – CC-130/CC-130J/CC-144/CC-150/CC-177* (Winnipeg: 1 Canadian Air Division, 2020), 261.

[67] David Strong, "RCAF Environmental & Operational Sustainability Program: Concept and Policy Discussion" (lecture, 1CAD, Winnipeg, MB, 24 September 2019), with permission.

RCAF could start by establishing 8 Wing Trenton as the centre of excellence for SAF within the RCAF, and then mandate the other air wings to use SAF-blended fuels. 8 Wing Trenton is the most logical choice because it uses more fuel than any other wing in Canada and because it is centrally located between a few of Canada's busiest airports. Of the total fuel consumed by RCAF Wings during FY2018-19, 8 Wing Trenton accounted for 110.77 million litres of the RCAF's total fuel consumption of 226.7 million litres, or 48.9%.[68] Introducing the use of SAF at 8 Wing would be an effective way for the RCAF to cut its GHG emissions quickly. The Vancouver International Airport's BioPortYVR project was formed to increase the availability of SAF within Canada, and this shows that busy airports can help facilitate the use of alternative fuel sources in Canada.[69]

The aviation industry is transitioning towards alternate energy sources, so the RCAF should have a plan to transition with it. It is clear that beyond incremental improvements to aircraft engines and designs, future aircraft will have different propulsion systems and energy courses. Specific recommendations include replacing conventional aircraft engines with electronic motors, acquiring solar-powered RPAS fleets to augment or replace long-range patrol aircraft, and augmenting air mobility fleets with airships. Over time the RCAF must adopt green technologies and modernize its aircraft in order to achieve meaningful GHG emission reductions.

Resourcing

Transitioning from fossil fuels to clean energy will require significant investments. For starters, this will be a costly undertaking, so the costs need to forecasted,

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[68] *Ibid*.

[69] COPA, "YVR Takes a Green Leap Forward: Sustainable Aviation Fuels Initiative Announced," *COPA Flight Magazine*, February 2020, 26.

funded, and managed appropriately. Replacing aircraft engines or entire aircraft fleets will be expensive, but the RCAF has approximately 30 years to spread the cost before the 2050 emission target deadline. Moreover, aircraft will reach the end of their life expectancy over the next 30 years, and the replacement platforms will typically incorporate the latest advancements in green technology. If the government wants to reduce emissions and maintain the RCAF's operational output, then the government will have to provide additional funding. Unfortunately, most of the alternative energy sources are still in their infancy, so it impossible to provide a financial assessment of transitioning to alternative energy sources at this time.

The RCAF also must ensure that the transition to green energy results in a net benefit to the environment. Almost all manufacturing processes have some form of unwanted by-products, and this is undoubtedly true for the production, consumption, and disposal of energy products. For example, if batteries are chosen to replace jet fuel, then there must be a net-benefit for using battery-power. The intent is not to reduce GHG emissions at the expense of polluting the ground and waterways. In a similar way that the USAF assesses its "operational energy," the RCAF should conduct assessments to minimize harmful environmental effects and improve its operational effectiveness.[70]

The RCAF will also need to update its infrastructure throughout the transition away from fossil fuels. For example, fuel depots, in-ground fueling, and fuel bowsers will likely need to be supplemented or replaced with SAF equipment and electrical charging stations. Considering that infrastructure projects take years to complete and that facilities

[70] Roberto Guerrero, "Operational Energy Data is the New Weapon of the US Air Force," last modified 25 October 2018, https://www.defensenews.com/opinion/commentary/2018/10/25/operational-energy-data-is-the-new-weapon-of-the-us-air-force/.

exist for decades, the evolution of the aviation industry needs to be incorporated in today's infrastructure plans for tomorrow's operations.

The adoption of green technology will also require new forms of education and training. Traditional trades will need to evolve to incorporate new technologies, and there may even be the requirement for new trades. For example, pilots will need to learn how to operate new systems and deal with emergencies that currently do not exist, and aircraft technicians will need to learn how to repair and replace new aircraft systems. The RCAF emissions reduction strategy will need to incorporate adequate resources to ensure that members have the knowledge, skill, and attitude to capitalize upon the green technology.

Impact to Operations

Reducing GHG emissions will result in some positive and negative impact to operations. The recommended changes will require dedicated teams to conduct assessments, draft policies, and implement change, and thus, the units that the personnel are drawn from to conduct these tasks will arguably be less effective. In a similar fashion to the constraints with electric vehicles, it will take time for green infrastructure to be established at airports across the country and around the world (e.g. charging stations). There will also be a reduced operational effectiveness during the transition between traditional and environmentally friendly aircraft because personnel will require training and experience to become proficient on new aircraft. There is a potential that some of the new platforms will initially be less powerful or have a less usable payload; however, these deficiencies should be solved with advancements in green energy. The increase in operational output should come in the form of efficiency and new capabilities (e.g. the persistence of solar-powered RPAS and the cargo capacity of airships). There is a risk of

reduced operational effectiveness, particularly during the transition towards greener fleets, but there should increased operational effectiveness in the long-run.

Conclusion

The RCAF has a mandated and moral obligation to reduce its greenhouse gas emissions. This will not be an easy undertaking, but the RCAF should take this opportunity to develop an effective strategy to do so. As shown, the RCAF can reduce its reliance on traditional jet fuels by fostering a sustainable culture, applying best practices, using alternative energy sources, adopting new technologies, and embracing other innovative processes. These changes require a deliberate, phased, and synchronized approach. In line with the Canadian Special Operations Force Command's (CANSOFCOM)'s strategic thinking, "innovation is about creating change and establishing the future on our own terms."[71] The RCAF can and should seize the initiative to develop policies and programs to proactively reduce GHG emissions now and in the future.

[71] Department of National Defence, D2-426/2020, *Beyond the Horizon: A Strategy for Canada's Special Operations Forces in an Evolving Security Environment* (Ottawa: DND Canada, 2019), 31.

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