National Defence | Défense nationale

Canadian Forces College | Collège des Forces Canadiennes

WAR IS BUT A GAME OF NUMBERS: OPTIMIZATION STRATEGIES TO INCREASE OPERATIONAL EFFICIENCY AND EFFECTIVENESS

Major Craig Greeley

JCSP 50

PCEMI n° 50

Service Paper

Étude militaire

Canada

CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 50 - PCEMI n° 50
2023 - 2024

Service Paper – Étude militaire

WAR IS BUT A GAME OF NUMBERS: OPTIMIZATION STRATEGIES TO INCREASE OPERATIONAL EFFICIENCY AND EFFECTIVENESS

Major Craig Greeley

WAR IS BUT A GAME OF NUMBERS: OPTIMIZATION STRATEGIES TO INCREASE OPERATIONAL EFFICIENCY AND EFFECTIVENESS

AIM

1. The aim of this service paper is to describe and outline some of the benefits of optimization strategies that can be utilized to improve the operational output of the Royal Canadian Air Force (RCAF). With known problems of recruitment and retention within the Canadian Armed Forces (CAF)[1], such strategies within the RCAF can permit a reduction in the cost and person-hours to complete maintenance, increase both serviceability and availability and increase the operational ability of the RCAF.[2] These improvements aim to address the fundamental doctrinal issues of the Air Force and aviation in general that include its fragility and support dependency. [3] With applications in numerous areas, this service paper provides justification for additional research and consideration for a new Section to support RCAF activities. With applicability that expands beyond the RCAF to include aspects of a Joint and Coalition environment, additional justification is provided for consideration of an increased scope beyond just a single CAF service.

INTRODUCTION

2. The RCAF and CAF at large are experiencing challenges for both recruitment[4] and retention[5], resulting in thousands of vacant positions that limit organizational output and operational effectiveness.[6] The Defence Renewal Charter identified these challenges and a high-level framework across numerous domains to address such concerns.[7] However, since this time, the RCAF, as well as the other Services within the CAF, have added new capabilities, such as a new Fixed Wing Search and Rescue aircraft[8], as well as planned for others, such as the F35 Lightning.[9] The result has been an ineffective ability to address the problems identified in the

---

[1] Murray Brewster and Richard Raycraft, "Military Personnel Shortage Will Get Worse before It Gets Better, Top Soldier Says," CBC, October 6, 2022, https://www.cbc.ca/news/politics/eyre-shortage-directive-1.6608107.

[2] M. Verhoeff, W. Verhagen, and R. Curran, "Maximizing Operational Readiness in Military Aviation by Optimizing Flight and Maintenance Planning," 2015, 943, https://www.sciencedirect.com/science/article/pii/S2352146515002355?via%3Dihub.

[3] National Defence, *Royal Canadian Air Force Doctrine* (Ottawa: Department of National Defense, 2016), 13–14, https://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-368-2016-eng.pdf.

[4] Major A S Waraich, "CAF Policy Considerations Related to the Recruitment and Retention of Millennials" (Minister of National Defense, May 12, 2014), 2, https://www.cfc.forces.gc.ca/259/290/301/305/waraich.pdf.

[5] Kim Bériault, "Retention in the Canadian Armed Forces: A Complex Problem That Requires Active and Continued Management" (Minister of National Defense, 2021), 4, https://www.cfc.forces.gc.ca/259/290/23/286/Beriault.pdf.

[6] Scott Taylor, "ON TARGET: Time to Re-Think Entire Structure of Canada's Military," EspiritdeCorps, June 5, 2023, https://www.espritdecorps.ca/on-target-4/time-to-re-think-entire-structure-of-canadas-military.

[7] Minister of National Defence, *Defence Renewal Charter* (Ottawa: Department of National Defense, 2013), 10, http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/about/defence-renewal-charter.pdf.

[8] National Defence, "Fixed-Wing Search and Rescue Procurement Project," Government of Canada, December 13, 2018, https://www.canada.ca/en/department-national-defence/services/procurement/fixed-wing-search-and-rescue-procurement-project.html.

[9] National Defence, "Fighter Jets," Government of Canada, March 13, 2013, https://www.canada.ca/en/department-national-defence/services/procurement/fighter-jets.html.

charter, stretching existing resources and an RCAF that is still struggling even more so today.[10] With models suggesting that it will be years before newly recruited members will be both trained and effective in their roles, these problems will require continuous active management.[11] As such, it is argued that efforts need to be shifted towards addressing improvements to the operational output of the RCAF utilizing the resources available today.[12]

3. The research conducted focused on finding optimization solutions to address the air power concepts of fragility and support dependency. Optimization was chosen due to the ability to increase the efficiency and effectiveness of an organization by utilizing various strategies, algorithms and technologies.[13] Important to this approach is the ability to generate solutions through the utilization of existing resources. In addition, it was concluded that there is a common theme between fragility and support dependency and the relationship to RCAF operations through the principles of sustainment.[14] An example is that of foresight and the requirement to ensure that appropriate stock levels of resources are available to support operations.[15] Though profits are not a consideration for the CAF and as noted by Cohen, the organization needs to be seen as effectively and appropriately managing taxpayer dollars.[16] As such, there is a finite amount of resources available that need to be utilized to achieve the required outcomes. The scope of this paper was limited to existing research and makes arguments for optimizing the aircraft maintenance program, resources and operations.

DISCUSSION

4. In their study of warfare theorists, Michael Handel concludes that while war is more of an art than it is a science, it does not mean that it cannot be studied.[17] As such, optimization looks to apply mathematical models to existing problems in order to determine the best course of action. As an example, RCAF operations necessitate the scheduling of aircraft for upcoming taskings and missions.[18] Nikolas Papadakos describes this problem set as being computationally interactable.[19] In other words, the problem can be broken down into a structure, variables defined, formulas applied and mathematically solved. It is in this way that some of the problems currently facing the RCAF and CAF at large can be addressed and, more importantly, optimized.

---

[10] Chris Thatcher, "RCAF's LGen Eric Kenny on the Challenging Transition to Gain Operational Advantage," *Skies Mag* (blog), November 14, 2023, https://skiesmag.com/features/rcaf-eric-kenny-challenging-transition-gain-operational-advantage/.

[11] Bériault, "Retention in the Canadian," 55.

[12] R. Cohen, "US Air Force Fleet's Mission-Capable Rates Are Stagnating. Here's the Plan to Change That," Air Force Times, February 14, 2022, https://www.airforcetimes.com/news/your-air-force/2022/02/14/us-air-force-fleets-mission-capable-rates-are-stagnating-heres-the-plan-to-change-that/.

[13] Lucas Downey, "Optimization: Overview and Examples in Technical Analysis," Investopedia, May 25, 2022, https://www.investopedia.com/terms/o/optimization.asp.

[14] National Defence, *Royal Canadian Air Force Doctrine: Force Sustainment* (Ottawa: Department of National Defense, 2017), 7, https://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-384-2017-eng.pdf.

[15] National Defence, *RCAF Doctrine: Force Sustainment*, 8.

[16] Cohen, "US Air Force Fleet's."

[17] Michael I. Handel, *Masters of War : Classical Strategic Thought* (London: Routledge, 2001), 21, https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=144940&site=ehost-live&scope=site.

[18] National Defence, *RCAF Doctrine: Force Sustainment*, 23.

[19] N. Papadakos, "Integrated Airline Scheduling," January 2009, 176, https://www-sciencedirect-com.cfc.idm.oclc.org/science/article/abs/pii/S0305054807001499?via%3Dihub.

5. With the goal of optimization in mind, Figure 1 below represents a proposal of how the problem space can be bounded. The development of this strategy for full spectrum optimization follows the guiding principles of the RCAF in the conduct of operations and maintenance.[20] Though three levels are depicted for simplicity, there are additional levels that one could draw to further expand and bound the problem space. Complicating the problem even further are the dependencies and interrelations between each area. As a simple example, the ability to execute maintenance requires a combination of people, materiel, and infrastructure which may or may not be available which further impacts the ability to execute a mission.[21] Complicating this even further and despite our best efforts, humans simply don't possess the capacity to assess and solve these problems at complex levels.[22] The following subsections describe a sample of some of the benefits and challenges of optimization across maintenance, resources, and operations as an argument for why the RCAF should further investigate such a strategy.

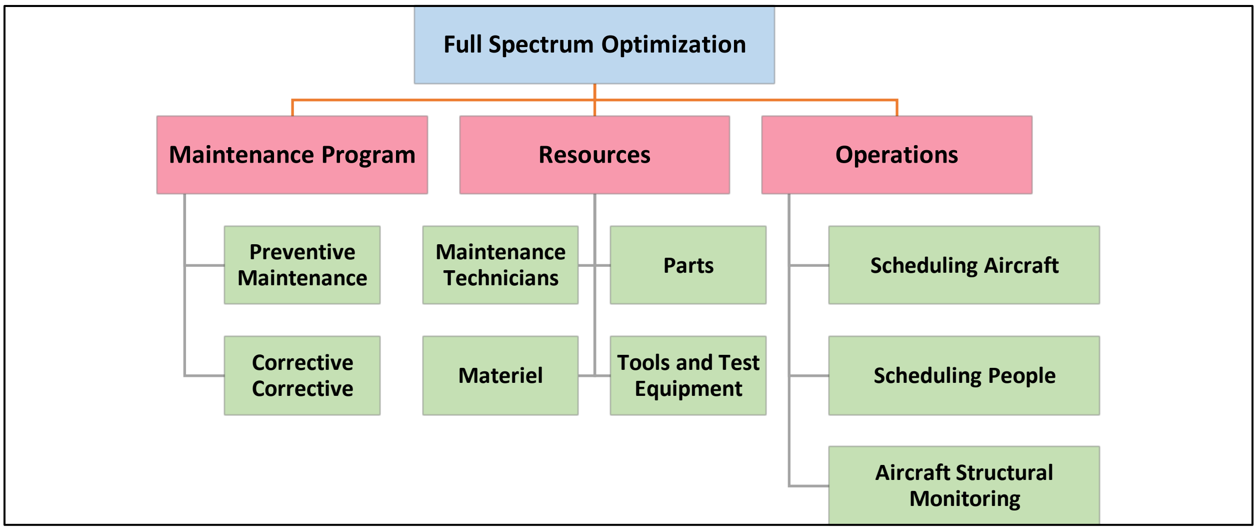

Figure 1: RCAF Optimization Strategies
Source: Author Created.

Maintenance Program Optimization

6. The aviation maintenance program is one of three areas that should be investigated for optimization. This is simply due to the fragility of aircraft and the level of effort that is required to maintain them in a safe and operational state.[23] Skybrary describes the maintenance program as being comprised of both preventive maintenance as well as corrective maintenance which could include reactive and predictive maintenance.[24] Corrective maintenance, as the name implies are the activities performed on an aircraft to return it to a serviceable state after it has been determined to not be flight worthy. In an ideal situation, an organization would be able to

[20] National Defence, *RCAF Doctrine: Force Sustainment*, 23.
[21] National Defence, *RCAF Doctrine: Force Sustainment*, 10.
[22] Thomas L. Griffiths, "Understanding Human Intelligence through Human Limitations," *Trends in Cognitive Sciences* 24, no. 11 (November 1, 2020): 873, https://doi.org/10.1016/j.tics.2020.09.001.
[23] National Defence, *RCAF Doctrine*, 14.
[24] Skybrary, "Aircraft Maintenance," Skybrary, n.d., https://skybrary.aero/articles/aircraft-maintenance.

predict when a component is about to fail and schedule it for maintenance prior to this point. This has been shown to save upwards of 40% over preventive or reactive maintenance practices.[25] With advancements in sensors and data collection capabilities on aircraft, it is now more feasible than ever to predict when a component will fail.[26] Aviation organizations are now investing in this predictive maintenance strategy due to potential savings.[27] From a commercial perspective where the cost of an aircraft being out of service is approximately $150,000 per hour, there are potential benefits to prematurely changing out a near life expired part.[28]

7. It is this latter strategy that was investigated and further refined by Mike Isbill of Lockheed Martin in conjunction with the Royal Air Force (RAF) and analytic company SAS.[29] Of the over 300 parts that make up a C130J Hercules aircraft, the project implemented tracked the usage of just 50 parts over a six-month period on 20 aircraft. The resultant study concluded an estimated 2000 person-hours of maintenance saved, an increase of 2.6% in aircraft availability. The benefits of such a project in just one area of aviation maintenance demonstrate the potential, power and possibility of optimization. Beyond just the Canadian fleet of C130J aircraft, such predictive maintenance strategies could also be employed on other fleets such as the C17 Globemaster, CH147 Chinook or CH148 Cyclone and across to the other Services.

Resource Optimization

8. The optimization of resources is another area that provides additional benefits that can improve efficiency and effectiveness. While not a complete list, some of the more important resources are that of people, parts, material, tools and test equipment.[30] This is to say that the ideal situation for any given task is to ensure that the appropriate number of qualified and authorized personnel are present at the time when the aircraft, parts and tools have also been made available to complete maintenance. Depending on the situation within an organization, there are times when any of the previously identified resources could limit maintenance execution. Beyond limiting the ability to generate a serviceable aircraft, this has also been shown to decrease the airworthiness or safety of the aircraft.[31]

9. The optimization of parts and logistics is an area that shows promise as an argument for additional research. The optimization of parts should consider factors such as the number necessary, local stock quantities, the maintenance program as well as the logistics costs of

---

[25] UpKeep, “Maintenance Statistics: Predictive & Preventive, Labor & Costs,” UpKeep, 2021, https://www.upkeep.com/learning/maintenance-statistics/.

[26] M. Isbill, “Artificial Intelligence and IoT Analytics,” SAS, February 17, 2020, https://www.sas.com/en_us/customers/lockheed-martin.html.

[27] R. Cohen, “USAF Tripling Data Driving Maintenance Efforts in 2020,” Air and Space Forces Magazine, May 26, 2020, https://www.airforcemag.com/usaf-tripling-data-driven-maintenance-efforts-in-2020/.

[28] M. Ciavarella, “An AOG Can Cost Up To $150K/Hr,” Airspace Technologies, January 19, 2018, https://www.airspacetechnologies.com/blog/an-aog-can-cost-up-to-150k-hr-how-to-combat-this-cost-2018.

[29] Isbill, “Artificial Intelligence and IoT.”

[30] Skybrary, “The Human Factors ‘Dirty Dozen,’” Skybrary, n.d., https://www.skybrary.aero/index.php/The_Human_Factors_%22Dirty_Dozen%22.

[31] Skybrary, “The Human Factors.”

moving parts between warehouses and when.[32] Purchasing a one of part when an aircraft is broken and expediting its shipment to that location may be more expensive than a long-term forecasting of parts.[33] Furthermore, the locations of where the various warehouses are located, will impact not only transportation costs but the time to obtain a part for a specific task. It is this scenario that Richter and Walther researched and proposed a solution for aerospace logistics optimization based upon a study between Porsche Automotive Group and an European airline.[34] The study reviewed an innovative forecasting model utilizing predictive analysis and artificial intelligence, supply chain management practices, and ordering methodologies, all under an umbrella strategy called "a plan for every part."[35] Compared to the established practices within the airline, the optimized solution was able to achieve an over 200% increase in predictive orders, over 30% decrease in aircraft downtime and upwards of 20% increase in aircraft availability, as well as numerous other benefits.[36]

Operations Optimization

10. The last pillar of the optimization model investigates the subcategories unique to that of operations and the aircraft within a Squadron. An analysis could include factors such as the pilots and other aircrew, their training and qualifications, currency requirements and scheduling details. When arranged, this paints a picture of what personnel are available on what days to fly missions as well as what personnel on what days need to fly a tasking in order to stay current. Further expanding within operations are the missions being tasked to a Squadron to be carried out. Not every mission can be carried out on a single day and often needs additional personnel or days to complete. Expanded further are the differences in flying conducted as part of each mission and how it affects the residual life of an aircraft. The remaining life on Canada's fleet of F18 aircraft necessitated the purchase of aircraft from the Royal Australian Air Force (RAAF) in order for Canada to maintain its operational mandates.[37]

11. The story of this purchase is unique to the discussion on optimization because of its similarities with that of the United States Navy (USN). As early as 2012, the USN engaged with ProModel, a US-based company specializing in process modelling and simulation, to develop an optimization program to assist in managing aircraft structural lives.[38] The purpose of this program was to manage the lives to extend the overall life of the fleet to a point where the USN would start to receive the F35 as a replacement for the F18 fleet. Noting that not every mission imposes the same structural fatigue on an airframe, selecting the best-fit aircraft for an intended

---

[32] K. Richter and J. Walther, *Supply Chain Integration Challenges in Commercial Aerospace: A Comprehensive Perspective on the Aviation Value Chain* (Cham: Springer, 2016), 12, https://link-springer-com.cfc.idm.oclc.org/book/10.1007/978-3-319-46155-7.

[33] Henry Canaday, "Risky Business," *Aviation Week & Space Technology* 177, no. 2 (2015): MRO6–MRO6, https://archive.aviationweek.com/issue/20150203#.

[34] Richter and Walther, *Supply Chain Integration*, 105.

[35] Richter and Walther, *Supply Chain Integration*, 106.

[36] Richter and Walther, *Supply Chain Integration*, 116.

[37] David Pugliese, "Deal to Buy Used Australian Fighter Jets Finalized, with Canadian Forces Set to Be Flying Them by Summer," National Post, January 3, 2019, https://nationalpost.com/news/canada/deal-to-buy-used-australian-fighter-jets-finalized-with-canadian-forces-set-to-be-flying-them-by-summer.

[38] Rob Wedertz, "Changing the Vision of Naval Aviation," ProModel, May 2, 2016, https://blog.promodel.com/2016/05/02/changing-the-vision-of-naval-aviation/.

use could accomplish this goal. The system would effectively manage the life based upon the given taskings of each day within a Squadron, defining a schedule of when aircraft should be rotated between training, local, overseas and aircraft carrier-based Squadrons. As Canada was likely beyond a point where such a system would have helped our F18 fleet, it may not be too late for current fleets where the management of structural lives is vital, like with the C130J fleet.

Why Additional Research Is Needed

12. In summary of the brief statements on optimization and benefits to the RCAF, research has shown that there are benefits to be gained. Of the scope of full spectrum optimization, as depicted in Figure 1, the previous sections only covered a few areas of what an overarching strategy could be. Implementation of these various strategies within the RCAF, while feasible, may show varying degrees of results for several reasons and is not without some challenges. Firstly, it has already been established that the RCAF and CAF at large are having issues due to personnel limitations. Any additional research would likely come at the cost of what the organization is trying to achieve today through a reprioritization of efforts. Complicating this further is the lack of personnel trained in these strategies. The CAF does not have on hand a section of personnel whose goal it is to complete this type of work. Even further, the CAF's budget has been cut back over the previous six months, which leads to questions on funding training, contracting to another organization, and even eventual implementation.[39] Lastly, and arguably most importantly, the previously identified research does not speak to the unique makeup of the RCAF or CAF. As such, the question remains as to the business case for implementation. Nonetheless, this opens the possibility for an expanded research paper that more broadly defines benefits such that a better business case and prioritization of efforts and money can be undertaken. As Porsche, in their study, was able to demonstrate upwards of a 20% increase in aircraft availability, what would this translate into for the CAF? Considering all the various fleets within the RCAF, ships and equipment needing service within the RCN and vehicles needing maintenance within the CA, a 20% increase is not something to be overlooked. It is for this reason that additional research on this topic is needed to support additional efforts.

CONCLUSION

13. In summary, this service paper aimed to describe some of the benefits of the implementation of optimization strategies to increase the RCAF's operational efficiency and effectiveness. The scope of the research focused on a model of full spectrum optimization that took into account aspects of the maintenance program, resources, and operations. With a limited scope of research, solutions across these models identified potential savings in cost as well as increases in aircraft serviceability and availability, resulting in an increase in mission execution. However, the limitation of the identified solutions is their applicability to the RCAF. More directly, the research focused on external military and civilian organizations. The results would need to be replicated within the RCAF and CAF at large to determine any benefit. It is for this reason that with such an incredible opportunity available to address the problems facing the RCAF and CAF today, the CAF should invest in additional research.

[39] Murrary Brewster, "Federal Government Looking to Cut $1 Billion from National Defence Budget," CBC, September 29, 2023, https://www.cbc.ca/news/politics/department-national-defence-budget-billion-1.6981974.

RECOMMENDATIONS

14. In review of the potential benefits to the overall efficiency and effectiveness of the RCAF, a number of recommendations are put forward for consideration:

a. Considering the limited research scope and purpose of this service paper, the results have demonstrated theoretical benefits for the RCAF. It is recommended that further research into these strategies be conducted for implementation within the RCAF and the other Services that would culminate with a business case analysis;

b. Various In-Service Support (ISS) contractors, like that of Lockheed Martin (LM), have already shown some benefits via these strategies. Noting the contract between LM and Canada[40], it is recommended to initiate an Additional Work Request (AWR) under the CC130J ISS contract to expand upon the research by Mike Isbill and applicability within the CC130J fleet;

c. Pending the results of the research, it is recommended to discuss an expanded implementation strategy to also include the Services within various Allied partners. This mechanism also serves to decrease any costs associated with research, development, and implementation. As an example, a revised and optimized preventive maintenance program for the F35 that includes Canada, Australia, the United Kingdom, and the United States; and

d. Finally, it is recommended that a new Section be established within ADM(Mat) that will lead these efforts under a Joint umbrella looking at all services. The size and scope of this team will depend upon the results of the research and agreements between the various Services.

[40] National Defence, "CC-130J Hercules Tactical Airlift Procurement Project," Government of Canada, December 13, 2018, https://www.canada.ca/en/department-national-defence/services/procurement/cc-130j-hercules.html.

BIBLIOGRAPHY

Bériault, Kim. "Retention in the Canadian Armed Forces: A Complex Problem That Requires Active and Continued Management." Minister of National Defense, 2021. https://www.cfc.forces.gc.ca/259/290/23/286/Beriault.pdf.

Brewster, Murray. "Federal Government Looking to Cut $1 Billion from National Defence Budget." CBC, September 29, 2023. https://www.cbc.ca/news/politics/department-national-defence-budget-billion-1.6981974.

Brewster, Murray, and Richard Raycraft. "Military Personnel Shortage Will Get Worse before It Gets Better, Top Soldier Says." CBC, October 6, 2022. https://www.cbc.ca/news/politics/eyre-shortage-directive-1.6608107.

Canaday, Henry. "Risky Business." *Aviation Week & Space Technology* 177, no. 2 (2015): MRO6–MRO6. https://archive.aviationweek.com/issue/20150203#.

Carter, Chris. "KPMG - A Value Management Approach to Business Transformation." Value Analysis, November 17, 2014. https://www.valueanalysis.ca/publications.php?file_id=432.

Ciavarella, M. "An AOG Can Cost Up To $150K/Hr." Airspace Technologies, January 19, 2018. https://www.airspacetechnologies.com/blog/an-aog-can-cost-up-to-150k-hr-how-to-combat-this-cost-2018.

Cohen, R. "US Air Force Fleet's Mission-Capable Rates Are Stagnating. Here's the Plan to Change That." Air Force Times, February 14, 2022. https://www.airforcetimes.com/news/your-air-force/2022/02/14/us-air-force-fleets-mission-capable-rates-are-stagnating-heres-the-plan-to-change-that/.

———. "USAF Tripling Data Driving Maintenance Efforts in 2020." Air and Space Forces Magazine, May 26, 2020. https://www.airforcemag.com/usaf-tripling-data-driven-maintenance-efforts-in-2020/.

Downey, Lucas. "Optimization: Overview and Examples in Technical Analysis." Investopedia, May 25, 2022. https://www.investopedia.com/terms/o/optimization.asp.

Griffiths, Thomas L. "Understanding Human Intelligence through Human Limitations." *Trends in Cognitive Sciences* 24, no. 11 (November 1, 2020): 873–83. https://doi.org/10.1016/j.tics.2020.09.001.

Handel, Michael I. *Masters of War : Classical Strategic Thought*. London: Routledge, 2001. https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=144940&site=ehost-live&scope=site.

Isbill, M. "Artificial Intelligence and IoT Analytics." SAS, February 17, 2020. https://www.sas.com/en_us/customers/lockheed-martin.html.

Minister of National Defence. *Defence Renewal Charter*. Ottawa: Department of National Defense, 2013. http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/about/defence-renewal-charter.pdf.

National Defence. "Canada Purchasing up to 16 P-8A Poseidon Multi Mission Aircraft for the Royal Canadian Air Force." Government of Canada, November 30, 2023. https://www.canada.ca/en/department-national-defence/news/2023/11/canada-purchasing-up-to-16-p-8a-poseidon-multi-mission-aircraft-for-the-royal-canadian-air-force.html.

———. "CC-130J Hercules Tactical Airlift Procurement Project." Government of Canada, December 13, 2018. https://www.canada.ca/en/department-national-defence/services/procurement/cc-130j-hercules.html.

———. "Fighter Jets." Government of Canada, March 13, 2013. https://www.canada.ca/en/department-national-defence/services/procurement/fighter-jets.html.

———. "Fixed-Wing Search and Rescue Procurement Project." Government of Canada, December 13, 2018. https://www.canada.ca/en/department-national-defence/services/procurement/fixed-wing-search-and-rescue-procurement-project.html.

———. *Royal Canadian Air Force Doctrine*. Ottawa: Department of National Defense, 2016. https://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-368-2016-eng.pdf.

———. *Royal Canadian Air Force Doctrine: Expeditionary Operations*. Ottawa: Department of National Defense, 2020. https://publications.gc.ca/collections/collection_2022/mdn-dnd/D2-393-3-2020-eng.pdf.

———. *Royal Canadian Air Force Doctrine: Force Sustainment*. Ottawa: Department of National Defense, 2017. https://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-384-2017-eng.pdf.

Papadakos, N. "Integrated Airline Scheduling," January 2009. https://www-sciencedirect-com.cfc.idm.oclc.org/science/article/abs/pii/S0305054807001499?via%3Dihub.

Pugliese, David. "Deal to Buy Used Australian Fighter Jets Finalized, with Canadian Forces Set to Be Flying Them by Summer." National Post, January 3, 2019. https://nationalpost.com/news/canada/deal-to-buy-used-australian-fighter-jets-finalized-with-canadian-forces-set-to-be-flying-them-by-summer.

Richter, K., and J. Walther. *Supply Chain Integration Challenges in Commercial Aerospace: A Comprehensive Perspective on the Aviation Value Chain*. Cham: Springer, 2016. https://link-springer-com.cfc.idm.oclc.org/book/10.1007/978-3-319-46155-7.

Sahay, A. *Leveraging Information Technology for Optimal Aircraft Maintenance, Repair and Overhaul*. Cambridge: Woodhead Publishing, 2012.

Skybrary. “Aircraft Maintenance.” Skybrary, n.d. https://skybrary.aero/articles/aircraft-maintenance.

———. “The Human Factors ‘Dirty Dozen.’” Skybrary, n.d. https://www.skybrary.aero/index.php/The_Human_Factors_%22Dirty_Dozen%22.

Taylor, Scott. “On Target: Time to Re-Think Entire Structure of Canada’s Military.” EspiritdeCorps, June 5, 2023. https://www.espritdecorps.ca/on-target-4/time-to-re-think-entire-structure-of-canadas-military.

Thatcher, Chris. “RCAF’s LGen Eric Kenny on the Challenging Transition to Gain Operational Advantage.” *Skies Mag* (blog), November 14, 2023. https://skiesmag.com/features/rcaf-eric-kenny-challenging-transition-gain-operational-advantage/.

UpKeep. “Maintenance Statistics: Predictive & Preventive, Labor & Costs.” UpKeep, 2021. https://www.upkeep.com/learning/maintenance-statistics/.

Verhoeff, M., W. Verhagen, and R. Curran. “Maximizing Operational Readiness in Military Aviation by Optimizing Flight and Maintenance Planning,” 2015. https://www.sciencedirect.com/science/article/pii/S2352146515002355?via%3Dihub.

Waraich, Major A S. “CAF Policy Considerations Related to the Recruitment and Retention of Millennials.” Minister of National Defense, May 12, 2014. https://www.cfc.forces.gc.ca/259/290/301/305/waraich.pdf.

Wedertz, Rob. “Changing the Vision of Naval Aviation.” ProModel, May 2, 2016. https://blog.promodel.com/2016/05/02/changing-the-vision-of-naval-aviation/.