ROYAL CANADIAN AIR FORCE JOURNAL

WINTER 2020 • VOL.9, NO.1

CANADIAN ARMED FORCES
FORCES ARMÉES CANADIENNES

National Defence   Défense nationale

Canada

The *ROYAL CANADIAN AIR FORCE JOURNAL* is an official publication of the Commander Royal Canadian Air Force (RCAF) and is published quarterly. It is a forum for discussing concepts, issues and ideas that are both crucial and central to air and space power. The *Journal* is dedicated to disseminating the ideas and opinions of not only RCAF personnel, but also those civilians who have an interest in issues of air and space power. Articles may cover the scope of air-force doctrine, training, leadership, lessons learned and air-force operations: past, present or future. Submissions on related subjects such as ethics, technology and air-force history are also invited. This journal is therefore dedicated to the expression of mature professional thought on the art and science of air warfare and is central to the intellectual health of the RCAF. It serves as a vehicle for the continuing education and professional development of all ranks and personnel in the RCAF as well as members from other environments, employees of government agencies and academia concerned with air-force affairs.

EDITORIAL TEAM

EDITORIAL STAFF

Editor-in-Chief: Colonel Shayne Elder, MSC, AM
Senior Editor: Lieutenant-Colonel Doug Moulton, CD, MBA
Managing Editor: Major Derrek Williamson, CD, PLog

Published by Canadian Forces Aerospace Warfare Centre
ISSN 1927-7601

ASSISTANT EDITORS Adri Boodoosingh, Leah Fallis and Vickie Thobo-Carlsen

GRAPHIC DESIGN Cara Hunter

ONLINE EDITION Christine Rodych

PRODUCTION MANAGER Denis Langlois

For digital version please visit:
http://www.rcaf-arc.forces.gc.ca/en/cf-aerospace-warfare-centre/index.page
http://w08-ttn-vmweb01/CFAWC/en/elibrary/journal/current-issue.asp

NOTE TO READERS

As a bilingual publication, readers should take note that where quotations are translated from their original language, we will use the term [Translation] at the end of the quote to indicate that readers can find the original text in the other language version of the *Journal*. Unless otherwise noted, photographs appearing in the Journal are attributable to the Department of National Defence and the public domain.

ROYAL CANADIAN AIR FORCE JOURNAL

AIR SPACE POWER IN FORMATION

AGILE • INTEGRATED • REACH • POWER

SUBMISSION REQUIREMENTS

The *ROYAL CANADIAN AIR FORCE JOURNAL (RCAFJ)* welcomes the submission of articles, book reviews and shorter pieces (which will be published in the Letters to the Editor, Points of Interest, Pushing the Envelope and Point/Counterpoint sections) that cover the scope of Air Force doctrine, training, leadership, lessons learned and Air Force operations: past, present or future. Submissions on related subjects such as ethics, technology and Air Force history are also invited.

JOURNAL SECTIONS

ITEM	WORD LIMIT*	DETAILS
LETTERS TO THE EDITOR	50–250	Commentary on any portion of a previous *RCAFJ*.
ARTICLES	3000–5000	Written in academic style.
BOOK REVIEWS	500–1000	Written in academic style and must include: • the book's complete title (including subtitle); • the complete names of all authors as presented on the title page; • the book's publisher, including where and when it was published; • the book's ISBN and number of pages; and • a high-resolution .jpg file (at least 300 dpi and 5 by 7 inches) of the book's cover.
POINTS OF INTEREST	250–1000	Information on any topic (including operations, exercises and anniversaries) that is of interest to the broader aerospace audience.
PUSHING THE ENVELOPE	250–2000	Forum for commentary, opinions and rebuttal on *RCAFJ* articles and/or issues that are of interest to the broader aerospace audience.
POINT/COUNTERPOINT	1500–2000	Forum to permit a specific issue of interest to the RCAF to be examined from two contrasting points of view.

* Exclusive of endnotes

AUTHORS ARE ASKED TO NOTE THE FOLLOWING GUIDELINES:

- Submissions may be made in either official language.
- Authors must include a brief (one paragraph) biographical sketch which includes current appointment/position, telephone number and email address. Please include all professional and academic designations as well as military decorations.
- Selected articles that have been peer reviewed have a to the left of the title.
- The Senior Editor will notify contributors on the status of their submission. It may not be possible to publish all submissions.
- All text submissions must be digital, in Microsoft Word or rich text format. Files must not be password protected and must not contain macros. Files may be submitted by mail or email at the addresses provided below.
- All supporting tables, images and figures that accompany the text should be sent in separate files in the original file format (i.e., not imbedded in the text). Original vector files are preferred; high-resolution (not less than 300 dpi) .psd or .jpg files may be submitted.
- Authors are required to provide "alternate text" with detailed descriptions for all figures. The alternate text is to be labelled as such and placed below the caption.
- Copyright permissions are required for all material that is not Department of National Defence or author originated. It is the author's responsibility to obtain and submit the necessary written permissions which must include the author's/artist's name as well as the publisher's name and location. Any material not meeting these requirements may be omitted from the article.
- The Senior Editor may select images or have graphics created to accompany submissions.
- Authors should use *Oxford English* spelling. When required, reference notes should be endnotes rather than footnotes and formatted in Chicago style. For assistance refer to *The Chicago Manual of Style, 17th Edition* or RCAF AWC Production Section at RAWCProd@forces.gc.ca
- Acronyms and abbreviations should be used sparingly:
  - If they are required in the text, the term is to be written out in full the first time it is used and then followed by the abbreviated form in parentheses.
  - A list of all abbreviations (and their terms) used in the text will be included at the end of each submission.
- The Senior Editor reserves the right to edit submissions for style, grammar and length but will not make editorial changes that will affect the integrity of the argument without consulting the author.

FOR FURTHER INFORMATION OR TO MAKE A SUBMISSION PLEASE CONTACT THE SENIOR EDITOR AT:

RCAF Aerospace Warfare Centre
8 Wing / CFB Trenton
Box 1000 Stn Forces
Astra, Ontario K0K 3W0

Attn: LCol Doug Moulton RAWCRCAFJournal@forces.gc.ca

CALL FOR SUBMISSIONS

For the Winter issue: **30 October**

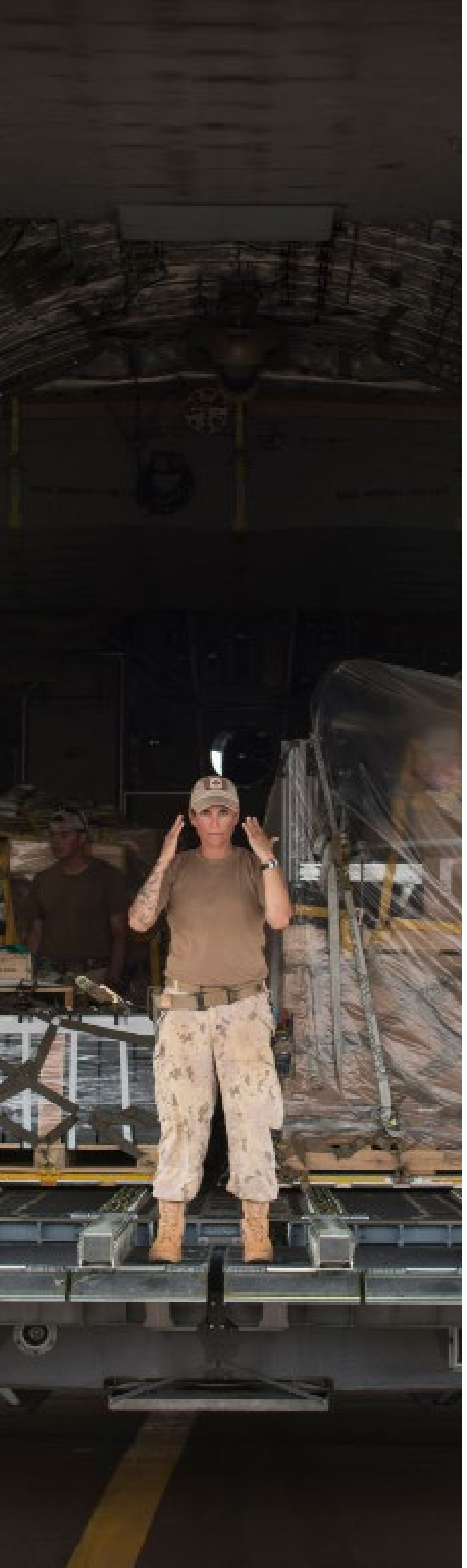
For the Spring issue: **30 January**

For the Summer issue: **30 April**

For the Fall issue: **30 July**

DISCLAIMER

Opinions expressed in the *RCAFJ* remain those of the author and do not represent Departmental or Canadian Armed Forces policy. Doctrine, training and other material published in the *RCAFJ* does not represent authority for action on that particular topic. All published material remains copyright of the Department of National Defence and may not be used without written permission.



CONTENTS
WINTER 2020
VOLUME 9 • NUMBER 1

EDITOR'S **MESSAGE**

This winter 2020 issue of the *Royal Canadian Air Force Journal* provides an assortment of articles, discussing topics such as fifth-generation tactical transport and the raising of the RCAF's multistatic IQ. Together, these articles represent some of the future challenges associated with the RCAF's ongoing development as we strive to meet our defence requirements.

The first article, "Use It or Lose It: The Demise of the Air Combat Force" examines the demise of the Royal New Zealand Air Force's (RNZAF's) air combat force. The similarities of the RNZAF and RCAF are eerily familiar and provide food for thought on Canada's way forward.

The second article, "A Fifth-Generation Tactical Air Transport Platform, Part 1," provides insight into the opportunity that the RCAF has to increase the capability of our CC130J fleet. Major Anderson (Retired) delves into the opportunities that exist with the Block 8.1 Program (RCAF 105), which is slated to deliver the next major capability improvement in the 2026–27 time frame. The possibilities available should not be missed.

In our third article, Mr. Stoddard discusses the implications of Modular VME Acoustic Signal Processors (MVASPs), which were fully realized during the Block III upgrade to the CP140. MVASPs are now helping the RCAF push the antisubmarine warfare envelope with their significantly enhanced passive and active sonar capabilities over the legacy CP140 acoustic sensor suite.

In the first "Pushing the Envelope" segment, Major Koussay discusses the meaning of continuous improvement and how it could be better applied within the RCAF. Finally, in our second segment, Lieutenant-Colonel Paul examines the deployed aircraft maintenance activities undertaken as part of Operation IMPACT for the CC150 Polaris aircraft, with a goal of drawing insightful conclusions by describing the lessons learned.

As always, enjoy the read, and I look forward to hearing your thoughts.

Sic Itur Ad Astra

Lieutenant-Colonel Doug Moulton, CD, MBA
Senior Editor

USE IT OR LOSE IT

THE DEMISE OF THE AIR COMBAT FORCE

BY LIEUTENANT-COLONEL ROBERT NASH, CD, BSc, MA, MIntSy (RETIRED)

> *The A-4 Skyhawks which New Zealand has possessed for nearly 30 years have never been used by the RNZAF in a combat role, and almost certainly never will be.*
>
> — Inquiry into Defence Beyond 2000[1]

In 1968, the National Government of Prime Minister Keith Holyoake agreed to purchase 14 American-built A-4 Skyhawk multi-role combat aircraft to replace the Royal New Zealand Air Force's (RNZAF's) ageing fleet of British-built Canberra bombers.[2] In 2001, the Labour Government of Prime Minister Helen Clark withdrew the Skyhawk from service without replacement. These decisions reflected continuity and change in foreign and defence policy. Prior to the Vietnam War, successive National and Labour governments adhered to the realist approach to international security that served New Zealand so well during the Second World War. After Vietnam, in response to rising public sentiment against the Cold War strategy of mutual assured destruction and declining economic fortunes, successive Labour governments imposed an idealist perspective on foreign and defence policy. Specifically, they challenged the validity of an alliance system based on nuclear deterrence.[3] The acquisition, employment and withdrawal from service of the Skyhawk reflected New Zealand's approach to international security, and to foreign and defence policy, before and after the Vietnam War.

New Zealand is a small country in the South Pacific, surrounded by ocean and far from the trouble spots of the world. The national interests of New Zealand include maintaining a secure and prosperous New Zealand, security and stability in the South Pacific and East Asia, and a peaceful, rules-based international order.[4] While geographical isolation protects New Zealand from direct military threats, New Zealand depends on freedom of navigation over the world's oceans for its prosperity. A realist approach to international security recognizes that military force is the principal guarantor of national interests in a dangerous world. Further, lacking the national power necessary to protect its own interests,[5] New Zealand's prosperity and security are best served through formalized cooperation with strong allies.[6] New Zealand's defence policy from the end of the Second World War through to the withdrawal from Vietnam in 1972 included a bipartisan commitment of air power to meet its obligations to its allies.

Following the Second World War, New Zealand embraced the idealist principle of collective defence of Empire and Commonwealth.[7] As the wartime alliance between America, Britain and the Soviet Union evolved into an ideological rivalry between capitalism and communism, the threat to vital lines of communication and trade between Britain and New Zealand could not be ignored.[8] New Zealand's security relationships with Australia and Britain depended on the commitment of credible military force to the defence of common interests. The deployment of combat aircraft to Cyprus in 1952 as well as to Malaya in 1955[9] and 1964[10] demonstrated a meaningful contribution by New Zealand to collective defence against the growing threat of communist encroachment in the Middle East and Southeast Asia.[11] The defence relationship between New Zealand and Australia remained constant following the signing of the Canberra Pact in 1944; however, declining British power following the fall of Singapore in 1942 compelled New Zealand to align itself increasingly with America. The tripartite Australia, New Zealand, United States Security Treaty (ANZUS) was signed in 1951 by Wellington, Canberra and Washington.[12] The security relationship with America was broadened and strengthened by the creation of the Southeast Asia Treaty Organization (SEATO) in 1954, which allied the ANZUS partners to Britain, France, Pakistan, the Philippines and Thailand in response to communist encroachment in Southeast Asia.[13] New Zealand's "entangling" alliance commitments contained the seeds of the decision to disband the Air Combat Force.

In 1966, the Johnson Administration approached America's ANZUS and SEATO allies seeking additional military commitments that would boost the legitimacy of the country's increasing involvement in the Vietnam War.[14] Conscious of the need to be seen to support its ally,[15] the Holyoake Government augmented its commitment of ground forces in Vietnam by deploying aircrew from the Air Combat Force to perform forward air control duties with the United States Air Force (USAF) from 1968 to 1972.[16] While America was grateful for the contributions of its allies, and decorated several Kiwis,[17] the explicit demonstration of New Zealand's commitment to its alliance commitments contributed to growing unease in the Labour Party over the benefits and risks of America's strategy of nuclear deterrence.[18] This unease was fanned into full-fledged protest by French nuclear weapons tests in French Polynesia starting in 1966.[19] Anti-war and anti-nuclear weapons protests contributed to a dramatic change in New Zealand's approach to foreign policy and the fortunes of the Air Combat Force.[20]

THE SKYHAWK PURCHASE SIGNALLED WELLINGTON'S COMMITMENT TO A BALANCED DEFENCE FORCE EQUIPPED TO HONOUR ITS ALLIANCE RESPONSIBILITIES. HOWEVER, TO THE DETRIMENT OF THE AIR COMBAT FORCE, THE SKYHAWK WAS NEVER DEPLOYED IN COMBAT.

New Zealand's air power commitments to and experience in Southeast Asia in the 1960s highlighted the increasing obsolescence of the RNZAF.[21] Starting in 1961, Wellington embarked on the wholesale replacement of its ageing British aircraft with American-built maritime patrol, transport as well as combat aircraft and introduced American-built helicopters.[22] The Air Combat Force acquired the A-4K Skyhawk attack aircraft to replace the Canberra bombers in 1970.[23] The Skyhawk acquisition was contentious, given the Holyoake Government's inclination to give priority to Army requirements over those of the Air Force and Navy. It took the considerable energy and persuasive talent of the Chief of the Air Staff, Air Vice-Marshal Ian Morrison, to convince the Holyoake Government that New Zealand required balanced land, maritime and air power, and that, without combat aircraft, the RNZAF would be an air force in name only.[24] The argument was made all the more difficult by the absence of a direct threat to New Zealand upon which to justify the purchase.[25] Absent a credible air defence role, the primary purpose of the Skyhawk-equipped Air Combat Force was to provide close air support to the New Zealand Army.[26] The Skyhawk purchase signalled Wellington's commitment to a balanced defence force equipped to honour its alliance responsibilities. However, to the detriment of the Air Combat Force, the Skyhawk was never deployed in combat. By the end of the century it would be supplanted by the newly acquired Iroquois helicopter as the air capability most relevant to Army operations.

Starting in 1972, the bipartisan approach based on realist principles that characterized the New Zealand approach to international security was swept aside by the Labour Government of Prime Minister Norman Kirk. Under Kirk, Labour led New Zealand onto a defence-policy track that emphasized the idealist principles of disarmament and collective security based on international institutions.[27] President Nixon's visit to China in 1972 and the Strategic Arms Limitation Talks between Washington and Moscow during the period 1969 to 1972, encouraged a single-minded pursuit of nuclear disarmament in New Zealand that undermined America's deterrent strategy and strained the defence relationship.[28] In 1975, the United Nations endorsed a nuclear-weapons-free zone in the South Pacific sponsored by New Zealand.[29] Labour's ultimate goal—a ban on nuclear weapons in New Zealand—would have to withstand a resurgence of Cold War tension in the late 1970s and a brief reprieve for the Air Combat Force.

The withdrawal of New Zealand personnel from Vietnam in 1972, and of American combat forces in 1973, encouraged a sense that the military threat in Southeast Asia was receding. The Vietnam War phase of the Cold War concluded with the fall of Saigon in 1975; the SEATO alliance was dissolved in 1977.[30] The receding nuclear and regional threat marked an initial victory for Labour's idealist agenda, but it was not to last. In 1979, the Soviet Union acquired access to naval basing facilities in Vietnam. This allowed surface vessels, submarines and long-range maritime patrol aircraft to range far and wide in the western Pacific and Indian oceans, creating a "new and hostile presence in the region."[31] Fears of a new communist encroachment in the region were buttressed by the deployment of intermediate-range nuclear weapons in Europe by America and the Soviet Union in the 1980s. These developments reinforced the importance of ANZUS and the Five Power Defence Arrangements (FPDA) in defence policy.[32] The FPDA had been created in 1971 as a consultative arrangement involving Australia, Britain and New Zealand in the defence of Malaysia and Singapore.[33] The renewed threat of communist encroachment in Southeast Asia encouraged the modernization of the Skyhawk fleet[34] and the purchase of additional aircraft made surplus by Australia.[35] It also justified participation of the Air Combat Forces in air exercises with its ANZUS and FPDA partners.[36] This "happy time" for the Air Combat Force was short-lived. The election of a Labour Government in 1984, led by Prime Minister David Lange, marked the beginning of a major disruption of the ANZUS partnership with America and another step towards the demise of the Air Force's air combat capability.

Shortly after Labour came to power in 1984, it banned nuclear weapons in New Zealand.[37] When the United States (US) tested the ban in 1985, the United States Ship *Buchanan* was denied a port visit to Wellington because the United States Navy refused to confirm or deny that she carried nuclear weapons, as was its policy.[38] The repercussions of New Zealand's declared anti-nuclear weapons policy for defence cooperation were profound: Washington stopped all interaction between its armed forces and the New Zealand Defence Force in 1986.[39] Encouraged in their idealism, the Labour Government seized the opportunity to take foreign and defence policy in radical new directions that diminished further the value of traditional military alliances. With the ANZUS Treaty suspended, collective defence of New Zealand rested on the Canberra pact with Australia.[40] The 1987 Defence Policy emphasized collective defence under the United Nations at the expense of Cold War "entanglements," defence cooperation with Australia and independent operations in the South Pacific.[41] While the modernizing Air Combat Force retained a role in defence against maritime threats, the perceived value of its contribution to national interests faced increasing scrutiny.

THE REPERCUSSIONS OF NEW ZEALAND'S DECLARED ANTI-NUCLEAR WEAPONS POLICY FOR DEFENCE COOPERATION WERE PROFOUND.

When Prime Minister Jim Bolger's National Government came to power in 1990, it faced the immediate task of deciding New Zealand's contribution to the United Nations-sanctioned, US-led response to the invasion of Kuwait by Iraq. The decision to not deploy the New Zealand Skyhawk[42] missed the best opportunity since Vietnam to commit combat forces in the cause of collective security and undermined fatally the future of the Air Combat Force. A further blow was delivered when the defence review in 1991 coincided with the collapse of the Soviet Union and the end of the Cold War. The review identified the need to repair defence relations with New Zealand's traditional allies based on a "fiscally sustainable … credible minimum defence force."[43] However, by refusing to reverse the ban on nuclear weapons, which was highly popular in New Zealand, the best that could be achieved was a policy of "self-reliance in partnership."[44] The focus of Air Combat Force operations on support to ground forces and maritime defence remained unchanged from 1987,[45] as did the commitment to FPDA-sponsored exercises.[46] The only new commitment was the 1991 agreement to base the Skyhawk at Nowra in Australia in support of the Royal Australian Navy; an Enhanced Nowra Agreement, negotiated in 1996, extended this training commitment out to 2001.[47] Exercises and training provided slim justification for replacing an expensive military capability during tough economic circumstances.

The emphasis in the 1991 Defence Policy statement on fiscal sustainability reflected a theme that permeated defence planning in New Zealand during the second half of the 20th century. The limitations of economic power to support military capabilities cast a persistent shadow over the Skyhawk-equipped Air Combat Force. The 1960s were good years economically for New Zealand, based on the country's privileged access to markets in Britain.[48] Nevertheless, New Zealand governments were forever conscious of the small size of the national economy and the impact that procurement of military hardware—aircraft, ships, combat vehicles—from foreign sources would have on the balance of payments and foreign exchange holdings.[49] At the same time, they were equally committed to defending trade and to meeting their collective security obligations.[50] Even as the 1970s brought unprecedented economic challenges, New Zealand governments continued to prioritize the maintenance of effective air combat capabilities.[51] Funding available for defence was limited by the collapse of the wool price in 1967, currency devaluation in 1968, the loss of preferential access to the British market in 1973, the oil price shock in 1973–74, slow economic deregulation and diversification throughout the 1970s and 1980s as well as the stock market crash in 1987.[52] Gross domestic product per capita and living standards declined relative to other Organization for Economic Cooperation and Development countries throughout the 1970s and 1980s, and did not stabilize until the late 1990s.[53] These economic challenges prompted increasing scrutiny on defence spending, especially as the costs of highly valued social programmes placed an ever-increasing demand on the public purse. Combat aircraft, in particular, were unpopular with the Treasury: they were "costly, inessential and offering no economic return."[54] That both Labour and National governments prioritized the purchase of the Skyhawk fleet in 1968 and its upgrade and reinforcement in the 1980s reflected, more than anything, the importance placed on the aircraft's contribution to national security objectives through collective security.

The constant tension between the equipment requirements of the Army, the Air Force and the Navy has also been a persistent theme of defence planning. New Zealand purchased the UH-1H Iroquois medium-utility helicopter in 1965 to provide tactical airlift support to the Army before the Skyhawk purchase was approved.[55] In Vietnam, New Zealand deployed aircrew from the Air Combat Force in support of USAF and from the fledgling Helicopter Force to reinforce 9 Squadron of the Royal Australian Air Force (RAAF). While this marked the end of an era for the Air Combat Force, it marked the beginning of one for the fledgling Helicopter Force. The next deployment of helicopter pilots was to the Sinai in 1982–1984, also in company with 9 Squadron RAAF, to support the American-led Multinational Force and Observers.[56] The value of tactical helicopter support to the Army was demonstrated clearly during operations in Bougainville and Timor in

1997 as well as 1999–2001 respectively.[57] By 2000, with a foreign policy that emphasized support to United Nations peacekeeping operations firmly in place, the relevance of close air support to the Army had been eclipsed by the proven benefits of tactical airlift.[58]

Allied experience during the Gulf War in 1991 and NATO-led operations in the Balkans in 1995 prompted Prime Minister Bolger's government to note in the 1997 defence review that the Skyhawk fleet needed upgrading or replacement to provide a viable contribution to coalition operations.[59] However, the White Paper prioritized the immediate need to re-equip the Army for peacekeeping operations and to upgrade the maritime surveillance capabilities of the Air Force.[60] The need to upgrade or replace the Iroquois helicopter was also noted.[61] The conflict between the funding requirements of the Army, Navy and Air Force and internally between the components of the Air Force was clear. In tough economic times, Helen Clark's Labour Government faced hard decisions when it came to power in 1999.

The 2001 *Review of the Options for an Air Combat Capability Force* concluded that, in their current state, the Skyhawks would make only a marginal contribution to multinational operations and were unlikely to contribute meaningfully to security in the South Pacific.[62] It assessed further that, while disbanding the Air Combat Force carried some risk, it would free up scarce financial resources that could be redirected to higher-priority requirements.[63] These views reinforced the conclusions of the 1999 *Inquiry into Defence Beyond 2000* report, which questioned strongly the rationale for retaining the Air Combat Force and suggested that its disbandment was a viable option for Clark's newly elected government.[64] In May 2001, the Clark Government announced that the Air Combat Force would be disbanded by the end of the year. It was argued that this would free up resources that could be better applied to more important defence capabilities.[65]

In conclusion, the disbandment of the Air Combat Force was a devastating blow to the proud heritage of the RNZAF. It was clearly the victim of radical changes in the international security environment during the second half of the 20th century. Under constant financial pressure, New Zealand governments were increasingly challenged to justify the expenditure of scarce resources on a balanced suite of combat capabilities. While the Air Combat Force provided a useful tool by which to demonstrate a commitment to allies prior to the war in Vietnam, following that war it became an increasingly expensive liability of limited utility in the pursuit of prosperity and security. The purchase of the Skyhawk in 1968 was justified by the realist approach to international security that had been pursued to that point. Similarly, the decision to withdraw it from service without replacement in 2001 reflected the equally valid idealist approach that had been pursued since its introduction into service in 1970. Following the war in Vietnam, an aggressively idealist approach to international security gradually pushed the use of military force "beyond the pale." The disbandment of the Air Combat Force was not a popular decision, but in the prevailing conditions of 2001, it was a valid one. It is not clear,

THE DISBANDMENT OF THE AIR COMBAT FORCE WAS A DEVASTATING BLOW TO THE PROUD HERITAGE OF THE RNZAF. IT WAS CLEARLY THE VICTIM OF RADICAL CHANGES IN THE INTERNATIONAL SECURITY ENVIRONMENT DURING THE SECOND HALF OF THE 20TH CENTURY.

today, that New Zealand will ever regret that decision. What *is* clear is how profoundly changes in political ideology and national power, notably economic resources, can drive change to the military force structure of a small state like New Zealand.

Robert Nash served in the Royal Canadian Air Force and the RNZAF for more than 36 years as an aerospace engineering officer and, since 1988, as an intelligence officer. In service to Canada, Robert provided intelligence support to air, joint and multinational operations and exercises involving Canadian, NORAD and NATO forces. Robert served as an intelligence staff officer and teaching fellow as a member of the RNZAF; he provided intelligence support to New Zealand operations, participated in exercises involving the forces of the FPDA and served as the RNZAF's National Program Manager for the Air and Space Interoperabilty Council. Robert has a Master's degree in International Security, a Master of Arts degree in War Studies and a Bachelor's degree in Mathematics and Science. He has lectured on contemporary military operations at the undergraduate level and remains a writing advisor to Massey University's National Centre for Teaching and Learning. Robert is currently employed as a defence contractor with the Royal Canadian Air Force in Winnipeg, Manitoba, and the Canadian Forces College in Toronto, and as a sessional instructor at the University of Manitoba.

ABBREVIATIONS

ANZUS	Australia, New Zealand, United States Security Treaty
FPDA	Five Power Defence Arrangements
RAAF	Royal Australian Air Force
RNZAF	Royal New Zealand Air Force
SEATO	Southeast Asia Treaty Organization
USAF	United States Air Force

NOTES

1. New Zealand Foreign Affairs, Defence, and Trade Committee, *Inquiry into Defence Beyond 2000: Report of the Foreign Affairs, Defence and Trade Committee* (Wellington: New Zealand House of Representatives, 1999), 94.

2. Don Simms and Nick Lee-Frampton, *Skyhawks: The History of the RNZAF Skyhawk* (Christchurch, NZ: WillsonScott, 2011), 30.

3. David McCraw, "New Zealand's Defence Policy: From Realism to Idealism?," *Defense & Security Analysis* 24, no. 1 (March 2008): 19.

4. New Zealand Defence Force, New Zealand Defence Doctrine Publication (NZDDP-D), *Foundations of New Zealand Military Doctrine*, Fourth Edition (Wellington, NZ: New Zealand Defence Force, 2008), 2-3.

5. New Zealand Defence Force, NZDDP-D, 2-5.

6. David J. McCraw, "The Zenith of Realism in New Zealand's Foreign Policy," *Australian Journal of Politics and History* 21, no. 3 (2002): 353–68.

7. Jim Rolfe, "New Zealand's Security: Alliances and Other Military Relationships," Working Paper (October, 1997), 9.

8. Jim Rolfe, "New Zealand Defence Policy During the Cold War," in *Lenin's Legacy Down Under: New Zealand's Cold War*, ed. Alexander Trapeznik and Aaron Fox (Dunedin, NZ: University of Otago Press, 2004), 42.

9. Margaret McClure, *Fighting Spirit: 75 years of the RNZAF* (Auckland, NZ: Random House New Zealand, 2012), 150–55.

10. McClure, *Fighting Spirit*, 171–74.

11. New Zealand, "Review of Defence Policy 1961" (Wellington: Government of New Zealand, 1961), 4.

12. Rolfe, "New Zealand Defence Policy," 46.

13. Rolfe, "New Zealand's Security," 11.

14. Stanley Robert Larsen and James Lawton Jr. Collins, *Allied Participation in Vietnam* (Washington, DC: Department of the Army, 1975), 88.

15. New Zealand, "Review of Defence Policy 1966" (Wellington: Government of New Zealand, 1966), 3–8.

16. McClure, *Fighting Spirit*, 180–82.

17. McClure, *Fighting Spirit*, 184.

18. Rolfe, "New Zealand's Security," 19.

19. "Nuclear-free New Zealand: Nuclear Testing in the Pacific" New Zealand History (New Zealand Ministry for Culture and Heritage Te Manatu Taonga, n.d.), accessed June 5, 2019, http://www.nzhistory.net.nz/politics/nuclear-free-new-zealand/testing-in-the-pacific.

20. Roberto Rabel, "New Zealand and the Vietnam War: Politics and Diplomacy," *Australian Historical Studies* 128 (2005).

21. Larsen and Collins, *Allied Participation in Vietnam*, 103–113.

22. McClure, *Fighting Spirit*, 197–198.

23. Greener, *Timing is Everything: The Politics and Processes of New Zealand Defence Acquisition Decision Making* (Canberra: Australia National University, 2009), 90.

24. McClure, *Fighting Spirit*, 198–99.

25. Don Simms and Nicke Lee-Frampton, *Skyhawks: The History of the RNZAF Skyhawk* (Christchurch: WillsonScott, 2011), 28.

26. Simms and Lee-Frampton, *Skyhawks*, 25.

27. McCraw, "New Zealand's Defence Policy: From Realism to Idealism?," 22; and David J. McCraw, "New Zealand's Foreign Policy under National and Labour on Governments: Variations on the 'Small State' Theme?," *Pacific Affairs* 67, no. 1 (1994): 7–25, accessed June 5, 2019, http://www.jstor.org/stable/2760117?-origin=JSTOR-pdf (requires an account to proceed to article).

28. United States, "Strategic Arms Limitations Talks (SALT 1)" United States Department of State, n.d., http://www.state.gov/www/global/arms/treaties/salt1.html (link discontinued).

29. McCraw, "New Zealand's Defence Policy," 22.

30. John K. Franklin, "The Hollow Pact: Pacific Security and the Southeast Asia Treaty Organisation" (Midwestern State University, 1996), 2.

31. New Zealand, "Defence Review 1983" (Wellington: Government of New Zealand, 1983), 9–12.

32. New Zealand, "Defence Review 1983," 15–18.

33. "Five Power Defence Arrangements (FPDA)," GlobalSecurity.org (2011), accessed June 5, 2019, http://www.globalsecurity.org/military/world/int/fpda.htm.

34. New Zealand, "Defence Review 1983," 32.

35. Simms and Lee-Frampton, Skyhawks, 124–25.

36. New Zealand, "Defence Review 1983," 32.

37. Kevin P. Clements, "New Zealand's Role in Promoting a Nuclear-free Pacific," Journal of Peace Research 25, no. 4 (1988): 395–410.

38. Clements, "New Zealand's Role," 395.

39. Clements, "New Zealand's Role," 395.

40. New Zealand, Defence of New Zealand: Review of Defence Policy (Wellington: Government of New Zealand, 1987), 14.

41. New Zealand, Defence of New Zealand, 12.

42. Simms and Lee-Frampton, Skyhawks, 185–86.

43. New Zealand, The Defence of New Zealand: A Policy Paper (Wellington: Government of New Zealand, 1991), 8.

44. New Zealand, The Defence of New Zealand, 52–54.

45. New Zealand, The Defence of New Zealand, 72.

46. New Zealand, The Defence of New Zealand, 84.

47. Simms and Lee-Frampton, Skyhawks, 189–212.

48. Robert G. Patman, "Introduction," in New Zealand and Britain: A Special Relationship in Transition, ed. Robert G. Patman (Palmerston North, NZ: The Dunmore Press, 1977), 9–18, 10–13.

49. New Zealand, 1978 Defence Review (Wellington: Government of New Zealand, 1978), 8–9.

50. New Zealand, The Defence of New Zealand, 22.

51. Simms and Lee-Frampton, Skyhawks, 141–59.

52. "The Reserve Bank and New Zealand's Economic History" (Wellington: Reserve Bank of New Zealand, 2007), 20–22, accessed June 5, 2019, http://www.rbnz.govt.nz/publications/3072832.html.

53. "The Reserve Bank," 22.

54. McClure, Fighting Spirit, 198.

55. McClure, Fighting Spirit, 197.

56. McClure, Fighting Spirit, 213–215.

57. McClure, Fighting Spirit, 251–54.

58. New Zealand, "The Government's Defence Policy Framework" (Wellington: Government of New Zealand, 2000), 4.

59. New Zealand, The Shape of New Zealand's Defence: A White Paper (Wellington: Government of New Zealand, 1997), 49–50.

60. New Zealand, The Shape of New Zealand's Defence, 8.

61. New Zealand, The Shape of New Zealand's Defence, 51.

62. New Zealand, "Review of the Options for an Air Combat Capability" (Wellington: Government of New Zealand, 2001), 5.

63. New Zealand, "Review of the Options," 5.

64. New Zealand Foreign Affairs, Defence, and Trade Committee, Inquiry into Defence Beyond 2000, 99.

65. New Zealand, "A Modern, Sustainable Defence Force Matched to New Zealand's Needs: Government Defence Statement" (Wellington: Government of New Zealand, 2001), 10.

A FIFTH-GENERATION TACTICAL AIR TRANSPORT PLATFORM, PART I

By Major Paul Anderson, CD, BASc (Retired)

Editor's note: Part 2 of this article will appear in the Spring 2020 issue of the Royal Canadian Air Force Journal.

EXECUTIVE SUMMARY

The current CC130J development plan requires modification in order to meet the objectives stated in *Strong, Secure, Engaged: Canada's Defence Policy* (*SSE*). The *Defence Investment Plan 2018* has the CC130J Block 8.1 Program (RCAF 105) slated to deliver the next major capability improvement in the 2026–27 timeframe, costed out between $250–499 million.

This article will propose this project be used to position the Super Hercules to deliver the effects needed by supported commands (our "customer") beyond the original, pre-*SSE* project scope. A fifth-generation (5G) tactical air transport platform can be developed, providing the necessary backbone and infrastructure to integrate future Royal Canadian Air Force (RCAF) and customer mission equipment. This will carry the CC130J beyond the traditional B-GA-404-000/FP-001, *Canadian Forces Aerospace Move Doctrine* and into a fully integrated, joint mission platform with rapid roll-on roll-off (ro-ro) capabilities. This tactical air transport platform will support the Government of Canada (GC) vision with a true multirole aircraft.

The aircraft will be highly integrated into command, control, communications, intelligence, surveillance and reconnaissance (C3ISR) networks, whether as a sole asset in a theatre or as part of a larger joint effort connected via tactical data link (TDL). Customers on-board the aircraft will no longer wait to receive their orders and intelligence; real-time, high-bandwidth secure Internet will be available throughout the flight to the objective. On-board sensors and equipment will both support the Air Force mission to arrive at the objective and provide intelligence to the customer en route.

Effects will not end when the customer departs the CC130J. A fully integrated platform could be designed to act as a communications relay station or an aerial-delivered ground refuelling station, to perform intelligence, surveillance and reconnaissance (ISR) overwatch, or to deliver kinetic effects in direct support of troops in contact.

Such an aircraft will require an improved defensive electronic warfare (EW) system / self-protection suite. Canada no longer needs to subordinate its authority to foreign developers. An EW bus controller offers Canadian EW specialists the ability to tailor threat responses based on Canadian priorities. EW threat-reaction training and system abilities will be significantly enhanced.

The Canadian Armed Forces' (CAF's) original acquisition plan for the CC130J was based on a pressing combat requirement. Lessons learned from lengthy developmental delays reinforce the concept that technology will continue to force adaptation. External influences, from civil-airspace regulations to military secure-radio requirements, will continue to stress the current highly integrated design. The RCAF 105 Project can provide multiple incremental opportunities to incorporate new capabilities, whether they be regulatory requirements or operational effects.

The GC has a clear vision in SSE. A fully integrated, multi-mission aircraft meets the requirements—the current plan does not. Without delay and without exceeding the budget, RCAF 105 can deliver the 5G tactical air transport platform that the RCAF, CAF and the GC need to meet the defence challenges through 2035 and beyond.

This article will use SSE as a rationale to modify the current CC130J sustainment-and-development vision. The GC's *Defence Investment Plan 2018* has a CC130J Block 8.1 project slated for fielding in 2026–27.[1] This modification would meet current project requirements and technically position the Super Hercules to meet Canada's defence requirements into 2035 and beyond.

WHAT IS THE SUPER HERCULES IN 2018?

The CC130J fleet is made up of 17 versatile, medium-range tactical transport aircraft. These aircraft are used domestically to transport personnel and equipment, resupply Arctic stations, evacuate civilians in floods and fires as well as airdrop troops and supplies in training. The CC130J is used internationally both as a small strategic airlifter intertheater and as a tactical airlifter intratheatre as well as to deliver troops and supplies via both airland and airdrop in peaceful and hotly contested countries.

The CC130J is a highly integrated aircraft. The mission computers sit at the heart of a complex network of 13 data buses and several dozen aviation, systems and display computers, all acting together to provide a consolidated system of systems within the platform.[2] This arrangement has great advantages, simplifying an ever-increasing amount of data for real-time pilot consumption and offering full automation in some respects. It also provides a challenge to modify the aircraft, as one modification often impacts several associated computer systems' data flows.

Due to the multirole nature of the aircraft, it is subject to many external influences in order to stay relevant and operational. Without even considering the military functionality, first and foremost, the Super Hercules is subject to technical-airworthiness considerations. It operates within domestic and international airspace, requiring compliance to civilian airspace regulations. Often operating as part of a coalition, it must maintain commonality in mission capability and execution with allied nations. As these external variables change, the CC130J requirements can be modified before considering the effects provided.

THIS GLOBAL RESTRUCTURING OF CIVIL AIRSPACE FORCED A SIGNIFICANT CHANGE IN THE ARCHITECTURE OF MOST AIRCRAFT DESIGNED PRIOR TO 2000.

There are many external influences: military-customer requirements, military-airspace requirements, military-policy requirements, Air Force requirements, GC direction, obsolescence in functionality, and availability. Understanding the effects of these influences and developing the CC130J within this scope becomes significantly more challenging as the platform becomes more and more integrated, both from within and in the larger military context.

Much of what the CC130J does puts it into civilian airspace. The International Civil Aviation Organization (ICAO) is in the midst of a momentous transition in airspace and pilot-controller communications. Conventional navigation, using ground-based radio beacons and conventional surveillance, is being displaced with precision-based navigation and automatic dependent surveillance – broadcast (ADS-B) monitoring. Digital and satellite-based systems are replacing analog ground-based support systems. Military transport aircraft operate primarily within civil airspace, compelling fleets into major retrofits to meet these civil-airspace requirements.

Communications/Navigation/Surveillance – air traffic management (CNS/ATM) was the primary element rapidly driving the Block 6.0 CC130J flight management system (FMS) into obsolescence. The old system was capable of navigating within five nautical miles of true course 95% of the time. New requirements demand much higher precision and on-board monitoring of the error.[3] This global restructuring of civil airspace forced a significant change in the architecture of most aircraft designed prior to 2000. The FMS is highly integrated into the avionics architecture and calculates both civil and military functions for the CC130. This affected the tactical airdrop and airland functionalities significantly.

The expected outcome in the original acquisition of the RCAF Block 7.0 aircraft was not met in a timely nor entirely successful fashion. The Airlift Capability Project – Tactical (ACP-T) “Statement of Operational Requirement” (2006) did not forecast the actual length of time to receive the Block 7.0 aircraft, nor did it foresee the contractual failures within. As an internationally funded development, scoped before Canada joined the joint user group (JUG), Block 7.0 was designed without Canadian input. There are significant issues that must be addressed to meet the intent of the 2006 United States Air Force (USAF) Block 7.0 contract.

THE C-130J JUG

The United States Government (USG) has appointed the USAF Air Mobility Command (AMC) as the lead agency in the development of the C-130J.[4] When Canada joined the JUG, the Royal Air Force (RAF), Italian Air Force, Royal Danish Air Force and Royal Australian Air Force (RAAF) were developing the Block 7.0 aircraft.[5] Requirements had been established and the contract was underway before the Project Management Office (PMO) ACP-T joined the group. Prior to Canada's arrival, the JUG had begun to move away from its original two-year block upgrade concept to adopt a three-year block upgrade plan, with Block 7, Block 8 and Block 9 forecast for delivery before 2020.

Block 8 had been conceived by the JUG as the first of two planned follow-on upgrades to the Block 7.0 upgrade.[6] Due to cost overruns, Block 9 was cancelled and Block 8.1 took to the stage, incorporating the minimum common design requirements from Block 9. Due to design implementation issues, a timeline overlap between the Block 7.0 delivery and Block 8.1 occurred. Block 8.1 carried on before all the issues had been derived from Block 7.0, and it inherited many of the deficiencies.[7]

For instance, the original JUG Block 7.0 requirements failed to include true airspace functionality. The result is that neither Block 7.0 nor Block 8.1 are capable of providing approach information nor correct take-off and landing data (TOLD) for Canada's High Arctic airports. This forces the crew into mitigation measures for TOLD or else they risk severe consequences. This requirement's "oversight" means the aircraft have a smaller set of degraded-capability approaches when conducting Arctic sovereignty and resupply missions than in similarly serviced airfields in southern domestic airspace.

This one deficiency can highlight a key limitation of JUG-directed design: the "common" requirements are a baseline set of requirements. Although Canada absolutely requires the ability to operate in true north airspace, Italy has no requirement thus and neither does the RAAF. USAF supported Canada primarily because fixing true north opened up a venue to increase database memory, but had no pressing need for the fix. Clearly, common civilian and military requirements do not encompass all of Canada's needs for a tactical air transport aircraft.

The JUG is addressing deficiencies found in the Block 8.1 project. Canada is participating in that effort as well as working to address the Block 7.0 deficiencies through the Block 7.1 and Block 7.1.1 programs. There are international, national, joint and RCAF projects that can all have influence on the CC130J upgrade process.

External military projects, such as the CAF Secure-Radio Modernization Project, the Canadian Cryptographic Modernization Project and the Multi-Fleet Air Traffic Management Avionics Project (MFATMA), have a requirement to replace equipment deeply integrated into the CC130J.[8] The equipment under consideration is integrated into the avionics architecture of the aircraft and will require incorporation into the FMS. Changes such as this require a significant investment in supplier time to achieve full integration into the avionics system. The integration effort has not been considered in either project scope. Integration will likely become either the RCAF 105 Project's (Block 8.1) or weapon system manager's (WSM's) responsibility, since Lockheed Martin (LM) has not yet been approached nor contracted by any of these projects.

The current Defence Capabilities Blueprint indicates the next update to the CC130J is the RCAF 105 Project, scheduled for a 2026–27 final delivery.[9] This project is part of *SSE*, yet the scope of the project precedes both it and the delivery of the RCAF Block 7.0 aircraft.

RCAF 105 is currently called the CC130J Block 8.1 Project. This article will argue that a USAF Block 8.1 aircraft is only a baseline to meeting both *SSE* and RCAF Vectors. As a foundation, the Block 8.1 configuration has merit; the 2013 goal was primarily to meet civil-airspace requirements. But, when considering effects, the USAF Block 8.1 design lacks specific capabilities that can transform the CC130J into a platform able to deliver the effects the RCAF requires between 2026 and 2047:[10] a 5G tactical air transport platform.

CANADA WAS GIVEN PRIORITY ON THE SUPER HERCULES PRODUCTION LINE; 17 AIRCRAFT ORIGINALLY DESTINED FOR THE USAF AMC BECAME RCAF SUPER HERCS INSTEAD.

There is a better future for the CC130J. Civil CNS/ATM and airworthiness considerations can be met and adapted to as future requirements develop. The pace of technological change is accelerating military-capabilities development. The original JUG vision was to sponsor block upgrades on a two-year basis. It is time to re-establish the concept of frequent updates to the aircraft.

Future projects can be incorporated into a well-designed, robust platform using agile systems engineering.[11] Canada's Block 7.1 and Block 7.1.1 projects are testaments to the rapid pace with which LM and Canada can achieve results, both through the In-Service Support (ISS) program and through direct military sales. Both of these projects will be delivered and tested faster than a USG project can even be brought to the quote stage by the contractor.

BACKGROUND

Canada initially procured the CC130J during the Afghanistan mission. Forecasts showed that the CC130E/H fleet would be incapable of sustaining troops in the field. The ACP-T replaced the tactical Hercules fleet with the Super Hercules. Normal acquisition timelines would have a severe operational impact. Canada was given priority on the Super Hercules production line; 17 aircraft originally destined for the USAF AMC became RCAF Super Hercs instead.

This meant that the USAF AMC baseline became the RCAF baseline. The initial forecast was that Canada would receive two Block 6.0 aircraft and fifteen Block 7.0 aircraft during the delivery phase, with the original two getting refitted soon after. Previously discussed delays to the Block 7.0 program pushed Canada to accept seventeen Block 6.0 aircraft rather than receive the expected Block 7.0 configuration.[12]

The key capability differences between the aircraft ordered and the aircraft delivered involved civil CNS/ATM requirements and the Link 16 TDL system. The Block 6.0 FMS cannot meet the requirements of the ICAO future performance-based-navigation airspace structure. Also, Block 6.0 had no TDL system. Block 6.0 is approaching obsolescence both in the civil-airspace structure and on military operations.[13]

ACP-T delivered and the RCAF continued operations. Before initial operational capability was declared, Canada deployed the CC130J in both Afghanistan and Libya simultaneously. The operational imperative to replace the ageing CC130E/H tactical aircraft had been successfully accomplished.

The civil CNS/ATM requirement drove the need to replace the Honeywell FMS with a General Electric (GE) FMS in Block 7.0. The GE FMS was touted to be fully developed for the tactical-transport role, but in reality, came from a mixed pedigree.[14] The FMS was originally fielded on the Boeing 737-300- through 900ER-series aircraft. It was a Federal Aviation Administration (FAA) required navigation performance (RNP)–certified vertical navigation (VNAV) FMS. The original software code was designed solely for civil airline operations.

In 2000, USAF was developing the C-130 Avionics Modernization Program (AMP). Approximately 525 C-130E/H aircraft needed new avionics to meet 2020 FAA and global airspace requirements.[15] The GE FMS (then under the Smith name) was selected for the project. The USG influenced LM to select the GE FMS for the Block 7.0 upgrade. This would facilitate a simple transition from AMP C-130H to C-130J for USAF aircrew. The AMP project continued to wither on the vine (and continues to do so to this day); however, the C-130J inherited and employs the GE FMS in Block 7 and up.

As the Block 7.0 development continued, critical design issues were discovered. The issues were addressed and the designs revised and submitted for approval. These cost overruns ran into the hundreds of millions of dollars and delayed the Block 7.0 program well into the planned Block 8.1 program. In late 2014, just a few months before Canada was to accept the first Block 7.0 aircraft, USAF announced it was no longer going to embody the Block 7.0 configuration; it would proceed directly to Block 8.1. With the ACP-T project closure imminent and the Block 8.1 aircraft years away from the field, Canada had little choice but to become the first nation to upgrade its fleet of Block 6.0 aircraft.

USAF's decision left the RAF, RCAF and Italian Air Force to complete Block 7.0 testing.[16] The change in FMS also necessitated a change in mission planning. Canada took the lead, with ACP-T engaging Jacobs Engineering after an evaluation of available systems.[17] A new interface had to be developed between the new aircraft FMS and the USG Portable Flight Planning System, similar to the one used in Block 6.0.

During the acquisition phase, the Aerospace Engineering Test Establishment (AETE) placed a new multi-engine test pilot with a master's degree in software engineering on the program. This test pilot identified a host of deficiencies within the Block 7.0 program: everything from errors in the engineering RNP containment analysis to software-system safety-analysis inaccuracies. The FMS was demonstrated to have some large, unaddressed deficiencies; however, mitigation measures existed. Fleet embodiment continued while the PMO ACP-T engaged LM for solutions.

AETE efforts inspired Director Technical Airworthiness & Engineering Support (DTAES) and the PMO ACP-T to take a second look at the Block 7.0 aircraft. While acceptable on many accounts, it had serious flaws that needed immediate mitigation and longer-term rectification. The Block 8.1 program was not going to address them, so the RCAF engaged LM on a Block 7.1 program. An RCAF flight-safety incident involving inaccurate navigation guidance into San Diego airport in September 2016 demanded a more detailed understanding of the design deficiencies. This was documented in a paper presented to the JUG steering committee and LM engineers.[18]

The Block 7.1 program addressed many deficiencies outlined within the AETE CC130J Block 7.0 preliminary report.[19] With the project closure imminent, an extension was granted to allow the PMO ACP-T to address key deficiencies with known solutions. The PMO and LM contracted a program that addressed 86 deficiencies, added 4 enhancements and introduced ADS-B surveillance capability. This is a critical 2020 global airspace element, and was ported back from Block 8.1.

With ADS-B Out came the transponder military Mode 5 capability, another Block 8.1 capability that was drawn into Block 7.1. Block 7.1 was accepted by the RCAF in December 2017.

An RCAF flight encountered loss of command and control (C2) of the Block 7.0 FMS while supporting the British Columbia (BC) forest fires in 2017. This caused LM to conduct a design review. LM approached Canada with a proposed Block 7.1.1 program to correct software-design logic flaws associated with critical-navigation and communication-system failures.

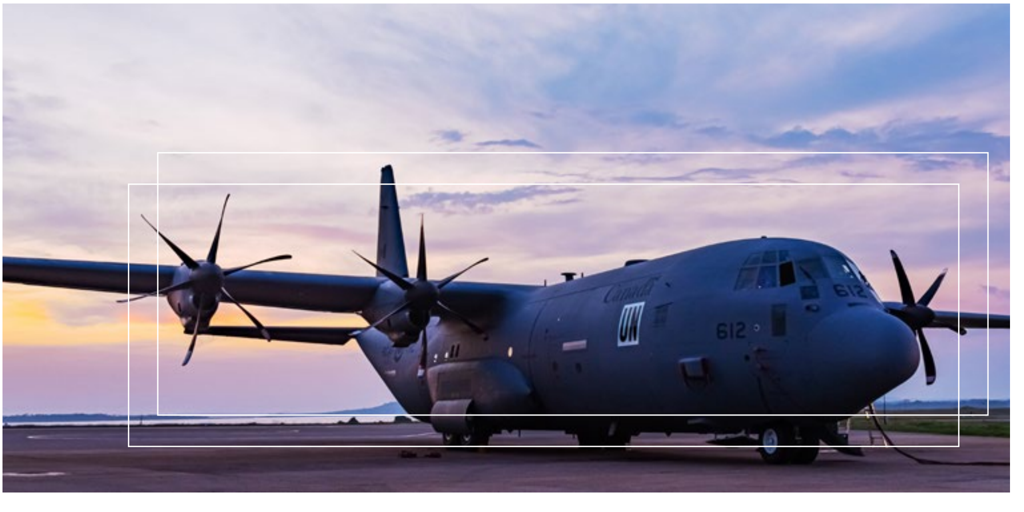
When completed, Block 7.1.1 will improve the robustness of the FMS to handle software exceptions. With the mission-computer software under necessary modification, the PMO ACP-T worked to have other deficiencies included in this build. Block 7.1.1 was expected to be delivered in October 2018 and, after test and evaluation, fielded in early 2019.

In the meantime, 436 Squadron is continuing to fulfil its mission internationally in Iraq and Mali with Block 7.1 aircraft.

HOW CAN CANADA FIX DEFICIENCIES AND ADD ENHANCEMENTS?

Deficiencies in software design were, are and will remain to be a part of the avionics. The complexity of the system and the changing external influences will continue to drive continuous software maintenance and improvements.

Many deficiencies are not yet addressed in any military build, but solutions have been developed. Parallel to the Block 8.1 program, LM has been building a civilian Super Hercules, which is designated the LM-100J. Certification efforts are nearing completion, but the software has remained "open" during much of Canada's test period. During the Block 7.0, Block 7.1 and Block 7.1.1 programs, LM and Canada have developed an honest and frank communication system. Deficiencies and improvements are discussed and acted upon accordingly. The rapid and direct communication of Canadian Block 7.0 and 7.1 deficiencies allowed Lockheed to address them within this "open" civilian LM-100J build. The fixes created have been made available to Canada within the Block 7.1 and 7.1.1 program, sometimes at a cost, sometimes for free.



True north operations remain degraded, however. The operational impact is mitigated while conventional navigation aids (NAVAIDs) remain available in the north. AETE has also devised an approved method to fly area navigation (RNAV) approaches in true north airspace.[20] Conventional NAVAID approaches cannot be pulled from the FMS, but they can still be flown. These steps represent mitigations to a clear deficiency requiring a long-term solution—make the aircraft operate in the true north frame of reference the same as it operates in the magnetic frame of reference.

RNP for RNP 5, RNP 2, RNP 1 and RNP approach were intended for the Block 7.0 aircraft. Although RNP certification remains unapproved by DTAES,[21] the RCAF has some time before this will have a significant operational impact. RNP airspace was only just taking a foothold in CNS/ATM in 2018. RNAV remains the prevalent en route, terminal and approach construct outside of conventional NAVAIDs.[22] There are a few years before RNP airspace and approach design will become restrictive to the RNAV-certified fleet. As performance-based-navigation airspace becomes the global norm, RNP will overtake RNAV as the new navigation standard. Canada must continue pursuit of RNP certification for the CC130J.

Both true north and RNP have received attention at the C-130J JUG. They are being considered with new requirements in the JUG USAF-contracted capability management unit (CMU) 1c contract. CMUs are smaller upgrade efforts, generally consisting of software updates. CMU 1c is scheduled to become available in mid-2020.[23] As of now, Canada has no contractual vehicle to incorporate CMU 1c.

RCAF EXPERIENCE WITH THE BLOCK 7.0/7.1/7.1.1 AIRCRAFT HAS PLACED CANADA IN THE LEAD-NATION ROLE. BESIDES HAVING A POINT OF PRIDE, CANADA SHOULD TAKE ADVANTAGE OF THIS POSITION, DEFINING REQUIREMENTS AND EVALUATING FIXES IN THE FUTURE.

DTAES has recently released a technical note[24] that influenced three risk-alert notifications by the CC130J WSM. While two of the three concerns are addressed within the Block 7.1.1 build, there are a number of outstanding concerns about the computed air release point (CARP) functionality.[25] Additionally, as AETE continues testing, additional deficiencies are bound to arise.

During research into the GE FMS, it was found that the Boeing implementation has had 14 software builds since its inception.[26] Common recurring issues include CNS/ATM improvements and better handling of software exceptions. This indicates that the experience of over 5,000 B-737 aircraft must be fairly similar to the experience of the 17 CC130J aircraft. In the age of fully integrated flight-management computers, continuous software improvements are a recurring theme. The need for a contract vehicle to address deficiencies continuously is evident.

RCAF experience with the Block 7.0/7.1/7.1.1 aircraft has placed Canada in the lead-nation role. Besides having a point of pride, Canada should take advantage of this position, defining requirements and evaluating fixes in the future. Additionally, the positive working relationship between LM and Canada can be measured in the time it takes to field a software build. The USG processes[27] are lengthy and cumbersome by design (The legacy AMP still remains at the starting blocks nearly 20 years after inception!).

USAF CERTIFICATION ISSUE

The USG does not certify its aircraft to civilian standards. DTAES and most partner-nation-certification authorities hold aviation software to the Radio Technical Commission for Aeronautics DO-178 standards.[28] The USG contracts to a Military Handbook (MIL-HDBK)-516 standard. The design-standard differences are significant. While DO-178B is an acceptable means of compliance for portions of MIL-HDBK-516, it is not the only means, and Lockheed had used other means for Block 7.0 and 8.1 as they were USAF contracts. This has led to a great deal of forensic evaluation of the Block 7.0 and Block 8.1 designs for DO-178B compliance. Partner nations spent several million dollars and several years having an American designated engineering representative evaluate the software code and the design process at both GE and LM to determine compliance to a DTAES-approved standard.

A PLAN FOR THE FUTURE: PRESENT TO 2025

Canada now sits in a unique position as the first-to-field with integrated in-service support from LM. We have an excellent working relationship with the company. On more than one occasion, LM has approached Canada to develop new capabilities.

LM presently experiences a challenge during software design and testing. Each software build undergoes over one billion assurance steps during final qualification testing (FQT). There are 39 variants of C-130J for USAF to test individually. In addition to the United States's (US's) variants, within the JUG, each national unique build is another FQT. LM's workforce is challenged to deliver products in a timely, cyclical fashion due to the sheer number of FQT builds the company must individually test. The common software approach (CSA) was offered to Canada and partner nations as a means to reduce LM staffing concerns while improving responsiveness to the customer. It will allow LM to combine FQT, reducing staffing and improving responsiveness to the customer.

LM has proposed to use the LM-100J improvements to the RCAF Block 7.1.1 software as the baseline for the CSA. The LM-100J software build is a civilian Super Hercules. The design of the LM-100J is 95% identical to the C-130J, equal to or greater than Block 7.1. It was set to be certified by the FAA before February 2019 with software designed to DO-178.[29] The FAA is recognized by DTAES as a competent authority, and DO-178B is a DTAES-recognized standard. As mentioned previously, the software code within the LM-100J includes a great number of fixes to deficiencies found by Canada. With the certification standard and the software fixes, the CSA software build will be the best move for Canada in the long term.

LM has proposed one DO-178–certified software build for Canada—the LM-100J—and other nations interested in this certification standard. Military-specific functionality will be embedded within the CSA code, but not activated for LM-100J customers. Individual nations still have the opportunity to modify and enhance the software in unique segments of code that would be activated for them—it would remain inactive and encrypted within other customers' software builds. All code would be built to DO-178 standards. This is the de facto LM standard for the Super Hercules now, since they have to meet this civilian standard.

USAF and foreign-military-sales clients of USAF will likely remain with MIL-HDBK-516 as their avionics standard. This divergence of standard will have no operational impact, as the military functional commonality will remain. Code developed under USAF contracts will still be built in a factory using DO-178B design standards as well as MIL-HDBK-516 standards. It will provide the best of both worlds. For Canada, a CSA will provide the correct software certification for DTAES and meet civil-airspace requirements.

The CSA approach does not spell the end of the JUG. It could spawn a forum similar to the military JUG, comprised of participants interested in the civil-airspace compliance challenges moving forward. The JUG could remain as the allied nation forum to develop common military capabilities.

There are two improvement programs underway within the C-130J JUG at this time. CMU 1b is an upgrade to the terrain awareness and warning system (TAWS). TAWS uses a pre-loaded digital map of the world, which is tied into the navigation system, to provide awareness and warning to the pilot if the sensed aircraft's position is unreasonably low or on collision with virtual terrain ahead. There is a civilian component to TAWS, governed by DO-161A, and a higher-resolution tactical mode. Since the earliest C-130J, the tactical mode suffered from gaps in coverage and limitations in latitude, both of which are addressed in CMU 1b.[30] CMU 1b was forecast to become available in mid-2019.

CMU 1c is an upgrade to the Block 8.1 software baseline (which includes Block 7.1). It is currently under negotiation between the lead nation, the USG and LM.[31] CMU 1c will address

a. RCAF San Diego incident map shift anomaly;

b. FMS fails tactical air navigation during negative distance condition;

c. FMS support for holds, TOLD and destination landing zones in true;

d. erroneous radio position; and

e. data transfer and diagnostics systems – upload/download intermittent problems with communication, navigation, identification (CNI) system processor (SP) 2;

Some of these anomalies remain within the RCAF Block 7.1.1 software and will require long-term fixes.[32]

Additional CMU 1c items under consideration are:

a. a deficiency found on an RAAF Block 6.0 aircraft that Block 8.1 software inherits; and

b. BIU Backup Mode 1553 conflict with mission computer still running.

The following are RCAF-noted deficiencies:[33]

a. Block 7.0 – Undetected 1553 CNI bus contention;

b. Block 7.0 – CNI-SP is not utilizing 1553 bus redundancy to obtain sensor data from mission computers;

c. Block 7.0 – CNI-SP recovery should be attempted while second CNI-SP is operational;

d. Block 7.0 – RNP alerting is deficient;

e. Block 7.0 – CNI-SP fail advisory, caution and warning system (ACAWS) due to communications loss with mission computers is confusing;

f. Block 7.0 – In the event of dual FMS, shut down present position data unavailable on head-down display (HDD) formats;

g. Block 7.0 – Magnetic heading goes invalid when both CNI-SPs fail; and

h. Block 7.0 – RNP-related total system error is not presented on either head-up display (HUD) or HDD.

Finally, three transponder problems and some mission computer changes are as follows:

a. Block 8.1 – Identification friend or foe (IFF) identification (ident) does not restart timer;

b. Block 7.0 – IFF contractor repair of (the above IFF ident issue) inadvertently causes microphone ident problem;

c. Block 7.0 – IFF Mode 5 response light not on during ident request when in standby mode;

d. pilot reference set panel fault and underlying bit failure permanently set;

e. Coordinated Aircraft Positioning System (CAPS) / Station Keeping Equipment – CAPS commanded airspeed is incorrectly limited; and

f. maximum-effort landing approach speed change.

It is important to note that this contract is not yet agreed upon by USAF, the JUG and LM. Several of the additional deficiencies have been addressed in the RCAF Block 7.1 and Block 7.1.1 software builds, as the fixes were ready and deemed to have a significant operational or safety impact. The key items remaining unaddressed are the first five (some map shift behaviours, tactical air navigation, true north and SP2 loading).

Pursuing the CSA approach would give Canada an on-ramp to fielding the CMU 1c software fixes into the CC130J in the timeliest manner. Should CMU 1c become available in mid-2020, the CSA-based build plus CMU 1c could become the foundation for a CC130J Block 7.2 build.

There is no active project to fund this build. Two options are available. The RCAF 105 is an *SSE* project valued at between $250 and $499 million. It is currently called the CC130J Block 8.1 Upgrade Program and is scheduled for delivery in 2026–27. This program could be accelerated and mandated to provide phased upgrades to the aircraft rather than one large upgrade.

The ISS contract could be another vehicle used to pursue updates to the existing platform build with WSM oversight. Software updates could be considered "service packages" and treated like current initiatives.[34] The RCAF 105 Project could remain as a platform upgrade scheduled for 2026–27.

BLOCK 7.2

A mid-2020 Block 7.2 software build would bring many DTAES certification issues to a close, address true north and RNP compliance as well as provide an early opportunity to address the most recent Record of Airworthiness Risk Management concerning the CARP.[35] It has the potential to be a kickoff event establishing regular software updates.

One of the key challenges faced when planning software updates is the decision on where to place the financial resources. Although the system is highly integrated, individual components such as the FMS, the mission computer, the bus interface unit and the HUD each has its own software build within. The testing and certification regimen can make modifications involving all components at once prohibitively expensive. Regular updates could be financially feasible by establishing a battle rhythm where LM expects Canada to offer a statement of work on a regular basis, and Canada can place special focus on one or two key components each time.

BLOCK 7.3

1 Canadian Air Division submitted a statement of capability deficiency (SOCD) on the CC130J defensive electronic-warfare system / self-protection suite (DEWS/SPS).[36] It is endorsed and the Commander (Comd) RCAF has indicated it is high priority. Modifying the DEWS/SPS in such an integrated suite of software involves significant development effort both on the part of LM and Canada. Lockheed must open the mission computer software and modify/test the code changes. Canada must make acquisition and design decisions based on the DEWS/SPS requirements, and determine the level of integration desired. This will not meet a 2020 timeline; however, 2022 may be an appropriate time to have another software build. Perhaps a Block 7.3 in which to incorporate this update and address further deficiencies within the mission computer should be considered.

The Link 16 system, although new to the CC130J in Block 7.0, is a mature TDL system used to present the allied common air picture. This NATO standard system is scheduled for an upgrade in security. This will render the current Multifunctional Information Distribution System (MIDS) obsolete. The Secure-Radio Modernization Project offers a couple of options to upgrade the hardware and software. Most JUG nations, Canada included, have expressed a strong desire to replace the MIDS with the Joint Tactical Radio System (JTRS). JTRS offers the fullest series of security and communications enhancements over the existing MIDS. Whether JTRS or another system is chosen, the CC130J mission computer software and the special mission-display-processor software will require new design and modification. This may drive a Block 7.3 build.

OTHER ASSISTANT DEPUTY MINISTER (MATERIEL) PROJECTS

The MFATMA project is tasked to update several fleets' avionics for CNS/ATM purposes. There are outstanding requirements not addressed in the Block 7.0/7.1/7.1.1 and Block 8.1 designs.[37] MFATMA initial delivery is scheduled for 2023–24.[38] The level of system integration affected will likely require opening of the software code to push these new capabilities into the aircraft. This could generate the demand for a 2024 software build focused on the FMS.

Similarly, the Cryptographic Radio Modernization Project is expected to replace the ARC-222 very high frequency (VHF) and ARC-164 ultrahigh frequency (UHF) radios, along with their KY-58 cryptographic modules. The ARC-210 Generation VI satellite-communications radio (with embedded cryptography) is expected to replace some, if not all, of the VHF and UHF radios. The communication/navigation buses on the aircraft are controlled by the FMS. It is highly probable the FMS software will be affected by this change. Based on the project timeline, Block 7.4 (2024) could provide the opportunity to incorporate this project onto the CC130J.

Of course, whenever software is opened for modification, it affords both opportunity and challenge. The opportunity comes in the form of addressing additional deficiencies, or the inclusion of some new software capabilities. The challenge lies with the knock-on effect; as aircraft software changes, so must simulator software and other training-aid software.

One of the largest challenges faced within the CC130J virtual environment is a direct result of the CAE [formerly Canadian Aviation Electronics] architectural implementation. Much of the equipment in the virtual environment is not real hardware; some of the software is re-hosted or re-coded to emulate the aircraft behaviour. In the case of Block 7.0, CAE modelled a portion of the emulated equipment by observing and collecting data directly from the aircraft behaviour. By necessity, this approach to simulation creates a significant time lag after aircraft modification.

A key example is civil aviation company CAE's representation of the FMS computers.[39] Rather than possessing two real FMS and using physical 1553 and ethernet buses to connect them, the CAE design for the RCAF has a single computer that re-hosts both FMS and emulates the bus behaviour. During the Block 7.0 upgrade, the re-hosted FMS would develop software exceptions at a rate far exceeding the equipment on the aircraft. CAE had to bring in GE subject matter experts to solve the puzzle, adding code to the existing aircraft code and several months' delay before aircrew could adequately train on the category D simulators.

The time difference between fielding a first aircraft software build and fielding the virtual aircraft software has been coined "simulator (sim) lag."

Sim lag represents one of the biggest challenges to the operational community when fielding new software builds.[40] During the Block 7.0 upgrade, pilot production suffered a 10-month interruption, severely impacting force generation both at 426 Squadron and the operational unit, 436 Squadron.[41] Reducing sim lag would ease the burden of modifying training programs to teach both ab initio and seasoned aircrew.

Perhaps the best method to reduce sim lag is to contract CAE to upgrade the virtual environment to become "aircraft without wings."[42] Stimulation of real equipment rather than simulation could eliminate most sim lag. When a new software build for the aircraft is released onto an air vehicle software (AVS) card, the weapon-system trainer could be issued a new AVS card and upgraded at the same time. Zero lag may be unobtainable, but any reduction of sim lag will have a positive impact on aircrew training. Technology will continue to force rapid adaptation through frequent software builds; the simulation architecture cannot hinder continued aircrew and ground crew training during these disruptive periods.

The tactical flight-training device is highly-emulated. It has multiple touch screens rather than actual overhead panels. It could be replaced with a non-motion weapon-system trainer and use an AVS card as well. With three devices, upgrades could be tested on any one device without serious degradation of the pilot-production stream. Director Air Simulation and Training could engage CAE for other suggestions to reduce simulator lag within the maintenance-training-device equipment as well.

A certainty is that the pace of technology is not slowing down. The CC130J design needs to remain agile, with oversight by a team willing to evaluate and embrace new technologies as they emerge, whether from an air power perspective or in support of the customer.[43] The Chief of Force Development identified science and technology as the broadest emerging trend shaping the future security environment.[44]

This observation can drive one to despair, given the several years' development period between identifying the problem and operational deployment. Fortunately, a solution is available, if an agile platform is developed—one capable of rapid adaptation to pressing requirements. A platform such as this would have robust communications, both within and external to the aircraft. It would be multirole and capable of tactical air transport, precision aerial delivery, mass airdrop, kinetic effects and ISR. It would be fully integrated into an operating environment anywhere in the world. In short, it would be a 5G tactical air transport platform ready to serve Canada into 2035 and beyond.

Paul Anderson joined the Canadian Forces in 1988 after completing an engineering science degree at the University of Toronto. From 1992 to 2018, he served 7,500 hours on the CC130 Hercules at 429 Transport Squadron, the USAF 41st Airlift Squadron and 436 Transport Squadron, operating in Somalia, Sudan, Rwanda, Yugoslavia, Congo, Iraq, Afghanistan and Libya. In 2014, his focus moved to test and evaluation, working with AETE to bring the CC130J Block 7.0 and Block 7.1 upgrades to the fleet. He now works for Assistant Deputy Minister (Materiel), Director Aerospace Equipment Program Management (Transport) as a civilian engineer on the CC130J.

ABBREVIATIONS

5G	fifth generation
ACP-T	Airlift Capability Project – Tactical
ADS-B	automatic dependent surveillance – broadcast
AETE	Aerospace Engineering Test Establishment
AMC	Air Mobility Command
AMP	Avionics Modernization Program
AOC	aeronautical operational control
APV	approach procedure with vertical guidance
AR	authorization required
ATM	air traffic management
ATS	air traffic services
C2	command and control
C3ISR	command, control, communications, intelligence, surveillance and reconnaissance
CAF	Canadian Armed Forces
CANSOFCOM	Canadian Special Operations Forces Command
CARP	computed air release point
CMU	capability management unit
CNI	communication, navigation, identification
CNS	Communications/Navigation/Surveillance
comd	commander
CPDLC	controller-pilot data link communications
CSA	common software approach
DEWS	defensive electronic-warfare system
DND	Department of National Defence
DTAES	Director Technical Airworthiness & Engineering Support
DZ	drop zone
EGPWS	enhanced ground proximity warning system
EW	electronic warfare
FAA	Federal Aviation Administration
FMS	flight management system
FQT	final qualification testing
GC	Government of Canada
GE	General Electric

GNSS	global navigation satellite system
HDD	head-down display
HUD	head-up display
ICAO	International Civil Aviation Organization
IFF	identification friend or foe
ISR	intelligence, surveillance and reconnaissance
ISS	In-Service Support
JUG	joint user group
JUSWG	Joint User Systems Working Group
kVA	kilovolt-ampere
LM	Lockheed Martin
LPV	localizer performance with vertical guidance
LRU	line replaceable units
MFATMA	Multi-Fleet Air Traffic Management Avionics Project
MIL-HDBK	Military Handbook
OT&E	operational test and evaluation
PMO	Project Management Office
RAAF	Royal Australian Air Force
RAF	Royal Air Force
RNAV	area navigation
RNP	required navigation performance
ro-ro	roll-on roll-off
SBAS	satellite-based augmentation system
sim	simulator
SMDP	Special Mission Data Processor
SOCD	statement of operational capability deficiency
SOF	special operations forces
SPS	self-protection suite
SSE	*Strong, Secure, Engaged: Canada's Defence Policy*
TAWS	terrain awareness and warning system
TDL	tactical data link
TOLD	take-off and landing data
USG	United States Government
VNAV	vertical navigation
WSM	weapon system manager

NOTES

1. Canada, Department of National Defence (DND), *Defence Investment Plan 2018: Ensuring the Canadian Armed Forces is well-equipped and well-supported*, 2018, https://www.canada.ca/en/department-national-defence/corporate/reports-publications/defence-investment-plan-2018.html.

2. There are left and right avionics, panel, display and communications/navigational buses; unsecure and secure special-mission-processor buses; an EW bus; a cargo-handling bus; and an inter-processor communications bus. All but the latter bus are capable of supporting 32 LRUs.

3. On-board performance monitoring and alerting are fundamental components of RNP flight.

4. AMC leads the Air Force Special Operations Command, Air Force Reserve Command, Air National Guard, Air Education Training Command, Air Combat Command, US Navy and US Coast Guard in defining requirements for the USG.

5. The Royal Norwegian Air Force joined approximately the same time as Canada.

6. As of 2008, the JUG was still considering three-year block upgrades, with Block 7 installed in 2011–13, Block 8 in 2014–16, Block 9 in 2017–19, Block 10 to be installed in 2020–22 and Block 11 in 2023–25. See https://c-130j-jug.com/org.php?libpath=JUG+Library%2FHistory. (website access requires a username and password)

7. Canada commenced Block 7.0 testing and provided key data to influence some changes into the third software build of Block 8.1. Canada, DND, "Preliminary Report of Results - AETE 2014-025, CC130J Block 7.0 Modification, Summary of Customer Demonstration Testing" (July 2015), led the JUG to appreciate many of the RNP and other operational deficiencies in the LM design.

8. The Secure Radio Modernization Project's scope will modernize the Link-16 terminal on the CC130J. Crew resource management appears to have significant influence on the external VHF, UHF and military-satellite-communications design of all RCAF aircraft. The MFATMA project is an effort to modernize RCAF fleets to civil airspace standards with CPDLC, AOC and ATS as well as new cockpit voice recorders and underwater acoustic beacons.

9. The Block 8.1 project is included in *Defence Investment Plan 2018*.

10. The expected end of useful life for the CC130J is 2047.

11. Conventional systems-engineering models have used a waterfall methodology. The PMO ACP-T has engaged LM in a more agile approach to systems engineering, engaging LM throughout the development process. This has successfully fielded Block 7.1 and brought Block 7.1.1 to the final stages in very short order. Instead of seven-year developments, Canada and LM are bringing changes in less than two years.

12. Block 7.0 took nearly seven years to develop rather than the expected three-year development cycle. The first Block 7.0 aircraft fielded was an RAF C-130J in late 2014. Canada received its first Block 7.0 aircraft in early 2015.

13. Vice Chief of the Defence Staff guidance calls for all tactical elements to be J-series compatible by 2022.

14. "GE Aviation Delivers 10,000th Advanced Flight Management Computer for Boeing 737," AviationPros, June 17, 2015, https://www.aviationpros.com/press_release/12084514/ge-aviation-delivers-10000th-advanced-flight-management-computer-for-boeing-737.

15. For more on the AMP project history, see "C-130 Hercules Avionics Modernization Program," Global Sercurity.org, February 12, 2017, https://www.globalsecurity.org/military/systems/aircraft/c-130-amp.htm.

16. The RAAF, Royal Norwegian Air Force and Royal Danish Air Force had no contractual commitment to Block 7.0 implementation and chose to follow the USAF plan.

17. The RAF had a unique system incompatible with allied mission planning systems. The USAF Joint Mission Planning System software was not yet available as a C-130J mission planning tool. The Portable Flight Planning System was the only viable option but required an entirely new interface to communicate with the GE FMS.

18. Many of the flaws relate to design differences between the GE White Paper on the FMS, dated 2007, and the actual LM design. For a more detailed explanation, read Major Paul Anderson and Captain David LeBlanc, "C-130J Block 7.0/7.1/8.1 Required Navigation Performance Discussion Paper: An Investigation into RNP

Certification Issues Stemming from the San Diego Flight Safety Incident," (June 8, 2017). The San Diego incident continues to affect both Block 7.1 and Block 8.1 aircraft (see Canada, DND, "Technical Note DTAES 63-18-03, CC130J B7.1 Avionic Systems," File Number: 2182D-1027-820 Vol 1, (n.d., AEPM RDIMS #1833078).

19. Canada, DND, "Preliminary Report of Results - AETE 2014-025."

20. AETE and the 1 Canadian Air Division Instrument Check Pilot have agreed on a means to have a technical representative modify true north missed approaches to remove the encoded leg types that the FMS cannot handle. They are replaced with acceptable leg types and the approaches should be retrievable from the FMS by line crew.

21. Refer to Block 7.1 Specific Purpose Flight Permit, limitation #3. Performance monitoring and alerting are the key differentiators between RNP and RNAV airspace. The monitoring and alerting scheme in the Block 7.0/7.1 and 8.1 aircraft is deficient.

22. RNP has on-board performance monitoring and alerting, whereas RNAV area navigation does not.

23. Although USG contracts are notoriously slow and prone to late delivery. As of October 4, 2018, indications were that the USAF contract for CMU 1c may not be completed until the third quarter of 2021.

24. Canada, DND, Technical Note DTAES 63-18-03.

25. Specifically: "CARP01 from route 1 corrupts CARP01 in route 2 including Altitude wind, Altitude temp and altimeter setting; Entering and exiting a CARP in route 1 caused the altitude and surface winds of the CARPs in route 2 to flip 180 degrees when unnoticed this could lead to an off DZ drop; CARP racetrack corruption leading to corrupting CARP and landing zone; Corrupt computed drop altitude (minimum drop height, minimum required clearance altitude disregarded, DZ elevation, point-of-impact elevation); Corrupt Crew entered drop altitude (SNP to SNP, VNAV cruise); Crew data entry for CARP drop altitude entered below minimum safe altitude (but greater than International Standard Atmosphere (ISA) minimum drop altitude) was accepted without warning (ISA min vs. ISA + temperature error correction); Incorrect high-altitude release point calculations; Misleading CARP bomb fall line (ASL) tic mark countdown to Red-light; "Check Altitude" Unexpected change to HUD VNAV cruise altitude target when within 350 feet of REF SET altitude; Combination CARP OFF DZ Messages Do Not Re-assert After Subsequent CARP initialization modification; and combination CARP OFF DZ Messages Erroneously Cleared During Route Update. Refer to CC130J WSM Direction Risk Alert Notification (RAN) CC130J - Erroneous CARP Computation Provided Update 1." Email from Captain David LeBlanc to 436 Squadron Aircraft Maintenance Control and Records Office, September 15, 2018 at 1039 EST.

26. See "Flight Management Computer," The Boeing 737 Technical Site, last modified April 18, 2019, http://www.b737.org.uk/fmc.htm.

27. The current C-130J JUG software-maintenance process takes five years from inception to completion. The USAF AMP history involves an even longer development timeline.

28. The most current version DO-178C, but DO-178B was in effect during the development of B7.0 and is the design standard of record.

29. LM filed a type design update for the L-382J on January 21, 2014. According to FAA regulations, LM commenced a five-year clock for certification standards at that date. See Stephanie Sonnenfeld Stinn, "C-130 Hercules News: Lockheed Martin Files for FAA Type Design Update – LM-100J:," C-130.net, February 4, 2014, http://www.c-130.net/c-130-news-article98.html.

30. The Royal Norwegian Air Force suffered a fatal mishap when its crew descended on a civilian approach using the Tactical TAWS. The aircraft was in a coverage gap, and the TAWS failed to warn the crew of an impending collision with terrain. See "Database" Aviation Safety Network, 2012, https://aviation-safety.net/database/record.php?id=20120315-1.

31. The draft USG contract is available on the JUG website, https://c-130j-jug.com/fetchfileX2018%2F0419+JUSWG+Telecom%2FPresentations%2FCMU+1C+DRAFT+SOW+17+Apr+2018.docx. (Website access requires a username and password.)

32. These were not components of the Block 7.1.1 program offered to Canada. Reports on these faults may be found in AETE reports on Block 7.0 and Block 7.1, as well as in the LM Root Cause Analysis of the San Diego International Airport event. The first four deficiencies resulted in DTAES recommending technical restrictions to the aircraft.

33. See Canada, DND, "Canadian Armed Forces Aerospace Engineering Test Establishment AETE Report 2014-025 CC130J Block Upgrade 7.0 Engineering Test and Evaluation," June 10, 2016. It is valuable to note Canada provided most of the deficiencies being addressed within the CMU 1c USAF contract. Steering the direction of the proposed fixes is a key advantage in being the lead nation to test and field the equipment.

34. A new Aviation Life Support Equipment rack, Interactive Electronic Technical Manuals, and the Electronic Flight Bag Integration project are all examples of WSM-led initiatives being developed and/or fielded under the ISS contract.

35. See Canada, DND, "Technical Note DTAES 63-18-03, CC130J B7.1, Avionic Systems," File Number: 2182D-1027-820 Vol 1, n.d., AEPM RDIMS #1833078.

36. The SOCD is classified. Directorate Aerospace Requirements has a copy. It currently sits at number 7 on the RCAF priority list.

37. For instance, the traffic alert and collision avoidance system 7.1 (also called ACASII) and a deployable underwater acoustic beacon are mandated within MFATMA but have no means to integrate within the CC130J.

38. See Canada, DND, *Defence Capabilities Blueprint*, May 29, 2019, http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?ie=1353.

39. The FMS contains two SPs. The terms "flight management computer" and "system processor" are interchangeable.

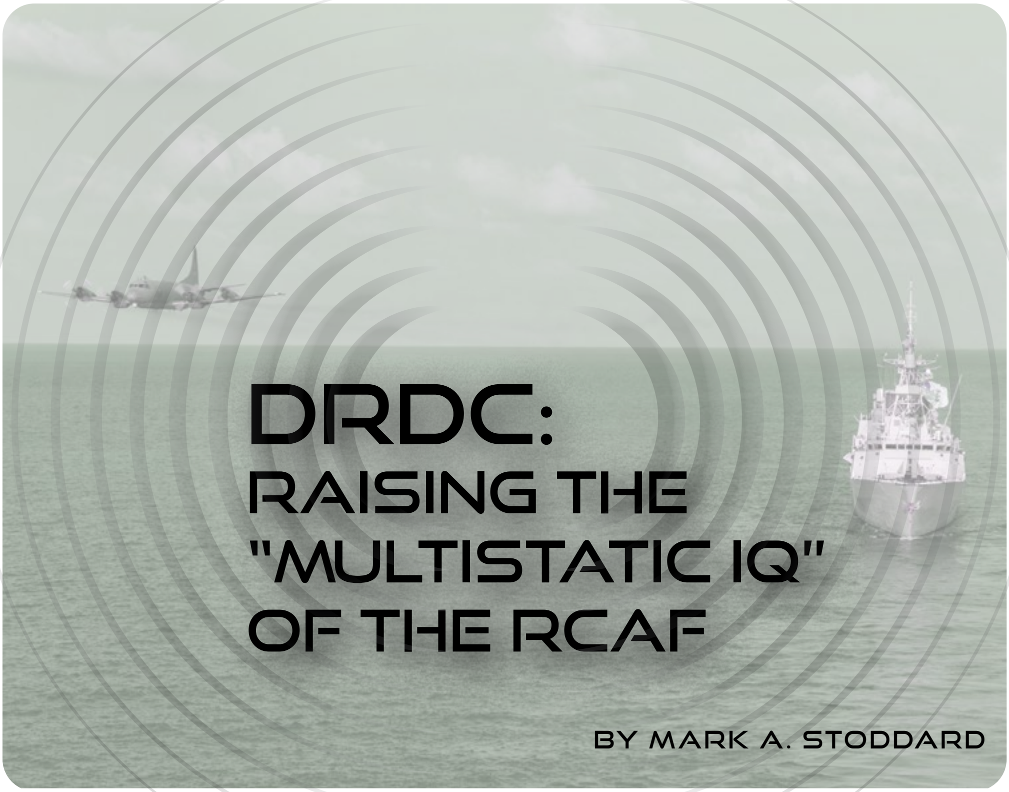
40. Pilot production ceased when the weapon systems trainers were under modification. Pilot production is critical to continued success with the fleet. The number of aircraft commanders qualified on the CC130J fell nearly 33% during the Block 7.0 upgrade.

41. 426 Squadron Operations Officer Major Mark Kelso (Retired) reported the last Block 6.0 crew graduated in May, and the first six-month Block 7.0 course commenced in October. The delay in pilot production was directly due to the problems CAE had in emulating the new GE FMS.

42. CAE Tampa, the USAF C-130J Weapons System Trainers, and Lockheed's LM-100J trainer all use real LRUs.

43. "Aerospace power *will* belong to those actors who embrace new technologies and processes. Aerospace supremacy, therefore, will belong to those who have imagination and the will to use it." [emphasis in original] Andrew B. Godefroy, ed., *Projecting Power: Canada's Air Force 2035* (Trenton, ON: DND, 2009), vi.

44. Canada, DND, A-FD-005-001/AF-001, *The Future Security Environment 2008–2030 Part I: Current and Emerging Trends* (Winnipeg: Chief of Force Development, 2010).



DRDC: RAISING THE "MULTISTATIC IQ" OF THE RCAF

BY MARK A. STODDARD

Building on years of research and development work, Defence Research and Development Canada (DRDC) is currently riding a wave of renewed interest in airborne multistatic sonar within the Royal Canadian Air Force (RCAF). DRDC has played a pivotal role in developing multistatic sonar technologies in support of the Aurora Incremental Modernization Project (AIMP). This work produced many of the early technical specifications used to guide the development of the world-leading airborne acoustic signal processor, Modular VME Acoustic Signal Processor (MVASP), created by General Dynamics Mission Systems – Canada (GDMS-C). Fully realized during the AIMP's Block III upgrade to the CP140, MVASPs are now helping the RCAF push the antisubmarine warfare (ASW) envelope with their passive and active sonar capabilities, significantly enhanced over the legacy CP140 acoustic sensor suite.

Multistatic sonar has long been heralded as the air power–enabler to regaining the tactical advantage lost to modern, ultra-quiet fourth generation submarines. Tracing back to the 1950s, multistatic sonar aims to increase the probability for detection of a sub-surface target; it does so by searching for a target echo using a source and receiver that are not collocated, as with traditional monostatic sonar. The most significant advantage of multistatic sonar over monostatic active sonar is that the locations of the receivers may be covert, limiting the adversary's ability to reduce their detectability through evasive manoeuvring. DRDC pioneered much of this work during the mid-1990s to the early 2000s with various test bed technologies, culminating in the transfer of these key technologies to GDMS-C, who further developed, commercialized and fielded their airborne acoustic signal processor, MVASP.

Illustration of the CP140M airborne multistatic concept. (Courtesy of General Dynamics Mission Systems–Canada)

Shortly following the introduction of the Block III upgrade to the CP140, the RCAF conducted a full-scale multistatic evaluation during Exercise RIM OF THE PACIFIC (RIMPAC) in 2014. The multistatic evaluation at RIMPAC 2014 was led by the 14 Wing Maritime Proving and Evaluation Unit (MPEU), with dedicated support from the DRDC Atlantic Research Centre. The evaluation consisted of three multistatic flights against cooperative United States Navy submarine assets, producing an invaluable data set to evaluate and progress the CP140's multistatic sonar capability. Testing at RIMPAC 2014 proved that MVASP was indeed a multistatic-capable processor, but also that much work remains to further refine multistatic tactics, techniques and procedures (TTP) and training to fully operationalize the capability. The observations and lessons learned from RIMPAC 2014 continue to vector multistatic research within DRDC, in support of both the RCAF and the Royal Canadian Navy (RCN).

The RIMPAC 2014 Integrated RCAF / DRDC Multistatic Evaluation Team.

More recently, coalition ASW operations have provided the RCAF with exposure to the operational employment of allied multistatics capabilities, some of whom have successfully demonstrated the effectiveness of this approach in real-world operations. Having now observed the advantages provided by multistatic sonar employment, it is imperative that the RCAF maritime-air community builds on the past and present work of DRDC and our allies in order to rapidly advance the CP140 multistatic capability, thereby ensuring that we stay abreast in ASW effectiveness. The reality of the current situation is that the Block III upgrade to the CP140 delivered a multistatic-capable acoustic processing system, but in the absence of validated multistatic TTP, the true extent of the CP140's multistatic capability remains just out of reach.

As always, with every challenge lies opportunity. The DRDC Atlantic Research Centre has renewed its efforts in multistatic sonar as a vehicle to help the RCAF operationalize this capability within the CP140. Starting in 2016, DRDC initiated a focussed research effort within the DRDC Air-Integrated Radio Frequency Project to help progress the CP140 multistatic capability. The research effort has three main vectors:

1. development of a multistatic sonar operational techniques and procedures training pack;
2. development of a CP140 multistatic capability test and evaluation plan; and
3. post-analysis support for in-water multistatic sonar testing.

Collectively, these research efforts are intended to help progress the development of TTP for multistatic sonar, and to ensure essential data is collected and analyzed from in-water testing to support TTP validation. GDMS-C has been contracted to assist DRDC in these efforts, leveraging their knowledge of the Block III acoustic sensor suite, as the original manufacturer, as well as their recent experiences delivering airborne multistatic capabilities to both the South Korean and Japanese defence forces.

Significant progress has been made on all three objectives over the past year, thanks to the close working relationship enjoyed amongst DRDC and 404, 415 and 434 Squadrons. Highlights included a one-week CP140M multistatic capability familiarization event, hosted by Canadian Forces Base Greenwood's 404 Squadron in late January 2018, and two successful, cooperative multistatic flights during the summer of 2018 with Her Majesty's Canadian Ship (HMCS) WINDSOR. The multistatic capability familiarization event included operator participation from 404, 405, 407 and 415 Squadrons, alongside participants from DRDC and GDMS-C. The goal of this event was to raise the "multistatic IQ" of all participants by providing comprehensive classroom instruction on

Two RCAF acoustic sensor operators filling seats 1 and 2 in the CP140 operational mission simulator during a 404 Squadron simulated exercise.

multistatic theory, coupled with practical guidance on how to successfully employ the multistatic capabilities of the CP140 acoustic sensor suite. The event also served as an opportunity to validate a multistatic sonar test plan under development using the cutting-edge crew trainer / mission simulators residing with 404 Squadron. This validation activity was a key enabler to the success enjoyed during two recent multistatic test events, discussed later.

Operator feedback on DRDC's efforts to date has been overwhelmingly positive and best summarized by Warrant Officer Matt Whyte of the Long-Range Patrol Standardization and Evaluation Team (LRPSET), who noted the following:

> [As] the senior acoustic operator for the Aurora fleet, I view the work that DRDC does as crucial in progressing the CP140 capability and operator knowledge. I take the information they generate, [and] circulate it among the operators who then employ it operationally around the world. Anything in my power to strengthen the bonds between DRDC and RCAF is a priority for me.

Multistatics in the RCAF has taken a giant leap forward in 2018, successfully lifting up and off from bottom dead centre. Two successful multistatic tests were conducted with HMCS WINDSOR, the first in-water testing since RIMPAC 2014. The execution of these tests required close coordination between DRDC, the RCAF, the RCN and industry partner GDMS-C to achieve success. The complexity of the test plan, target coordination, environmental authorization and data analysis required the experience and expertise of many individuals and organizations, resulting in closer linkages between DRDC and many of the RCAF and RCN operations and support organizations on the critical path to executing in-water testing.

415 Squadron / DRDC / GDMS-C Multistatic Integrated Project Team (June 2018)

More importantly, at the direction of the Long-Range Patrol Capability Advisory Group, 2018 saw the creation of the RCAF Multistatic Active (MSA) Working Group, first convened at 14 Wing Greenwood in January 2019. The aim of the MSA Working Group is to provide the necessary project governance to bring MSA sonar to initial operational capability (IOC) by 2021.

The first MSA Working Group assembled over forty participants, with representation from each of the long-range patrol squadrons and other organizations: Long-Range Patrol Operational Test and Evaluation Flight, LRPSET, Director Aerospace Requirements, Project Management Office, Weapons Systems Manager, Canadian Forces Maritime Warfare Centre, Trinity, DRDC, 434 Squadron, Maritime Helicopter Test and Evaluation Force, our valued United States Navy allies in the Naval Air Systems Command and VX-1, and industry partners GDMS-C and Ultra Electronics Maritime Systems. The team was successful in identifying a number of challenges and opportunities facing capability development of this wide-area search tool, inspiring VX-1 to begin planning a collaborative multistatic test event with a United States Navy P-8 and RCAF CP140 for the summer of 2019.

Building on the successful collaborations of the past, the RCAF and DRDC are partnered and poised to unlock the full ASW potential of the Block III upgrade to the CP140. With the equipment already installed, the growing multistatic IQ within the CP140 community, and a desire at all levels in the RCAF and DRDC to cut our multistatic teeth, CP140 operators like Whyte are surfing the wave of innovation. This wave will carry the CP140 into the future, setting the course for the innovation and development of mission systems for future Canadian multimission aircraft.

Mr. Mark Stoddard is a defence scientist working for DRDC. For the past 10 years, his research efforts have focussed on the development of underwater warfare systems and capabilities for the RCN and RCAF to support undersea surveillance, ASW and acoustic intelligence operations. In 2018, Mr. Stoddard received a Chief of the Defence Staff Commendation for his important contributions to the maritime defence of Canada. Mr. Stoddard is currently the leader of the Operational Analysis and System Integration Support (OASIS) Group at the DRDC Atlantic Research Centre in Halifax, Nova Scotia. In addition to his daily work in the lab, he is also in the final stages of completing a PhD in Industrial Engineering at Dalhousie University, focussing on Arctic maritime risk assessment.

ABBREVIATIONS

ASW	antisubmarine warfare
DRDC	Defence Research and Development Canada
GDMS-C	General Dynamics Mission Systems – Canada
HMCS	Her Majesty's Canadian Ship
LRPSET	Long-Range Patrol Standardization and Evaluation Team
MSA	multistatic active
MVASP	Modular VME Acoustic Signal Processor
RCAF	Royal Canadian Air Force
RCN	Royal Canadian Navy
RIMPAC	Exercise RIM OF THE PACIFIC
TTP	tactics, techniques and procedures

PUSHING THE ENVELOPE

Continuous Improvement Institutionalized

By Major Ismael Koussay

How could the Royal Canadian Air Force (RCAF) improve its continuous-improvement programme in the workplace? Contrary to what one may think, this is not an insurmountable task. Let me tell you why.

I like to think of continuous improvement as a state of mind steeped in an unwavering desire to reduce inefficiencies in every action that one undertakes as a normal part of everyday practices. The result of this individual state of mind should benefit the organization and the community at large.

To that effect, this state of mind needs to be nurtured and supported in order to instill a creative environment. Thus, for a culture of continuous improvement to flourish in an organization such as the RCAF, certain conditions need to exist. First, have a simple, common process to collect the ideas put forth for improvement. Second, in a timely manner, have a dedicated entity to validate the potential benefit of the improvement. Lastly, establish an organic structure mandated to coordinate the implementation of the identified improvement. Et voila!

One would recognize that the RCAF has already established multiple continuous-improvement programmes with varying degrees of success, such as the RCAF Lessons Learned Programme, RCAF Quality Standards for Aerospace Engineering and Maintenance and, to a certain extent, the RCAF Flight Safety Program. The latest of the bunch, the RCAF Fellowship Programme, led by the RCAF Aerospace Warfare Centre, is another great initiative geared towards instilling both critical and strategic thinking into RCAF leaders.

However, one would also recognize that enacting changes can be a lengthy process, as it often boils down to resources (i.e., personnel and materiel). Therefore, initiatives aimed at institutionalizing the RCAF's overall ability to not only embrace but also swiftly implement continuous-improvement initiatives, from both within and outside the organization, are paramount to creating a vibrant and sustainable culture of innovation in the workplace.

As mentioned above, resources are often the limiting factors towards the implementation of continuous-improvement initiatives. However, I am not aware of an organization in the RCAF specifically mandated to seek out already-developed technology solutions or best practices from civilian industries or other military partners with the objective of implementing them in the RCAF.

Here is an example that I have encountered in my professional experience that I believe illustrates well the point that I am trying to make. On one hand, the current aircraft tool system used in the RCAF has not evolved for the past several decades and is still based on a tag system to indicate who has drawn that wrench or screwdriver from the tool board. On the other hand, companies such as Boeing have already developed automated tool-distribution and tracking systems that enhance tool control every step of the way.

Under the current personnel year neutral environment, transferring these technology solutions already in use for many years in industry to the RCAF would greatly benefit the RCAF and the Canadian Armed Forces as a whole. Furthermore, the transfer of these off-the-shelf technology solutions would very likely modernize the production tools of the RCAF at a similar pace to that of the civilian aerospace industry without a significant financial commitment up front—nor a high technology risk—as long as we carefully limit the application of the technology within its original design with no "Canadianized" modifications.

If the concept is supported by the RCAF's leadership, I envision that the organization mandated to transfer civilian technology solutions and best practices will fall under the command and control of Director General Aerospace Equipment Program Management (DGAEPM) and would be an extension of the current Quality Engineering Test Establishment (QETE). It would be composed of multi-trades teams of operators and support trades to validate the benefits and risks associated with the solutions being transferred. In addition, this new organization would liaise with the appropriate RCAF agency for the in-service support of the new technology solutions being acquired. Finally, an organic team of contract officers would also be part of this organization, with the ability to tap into other federal government support organizations, such as the National Research Council. Needless to say, this concept of transferring off-the-shelf technology and best-practices solutions from civilian industry would allow the RCAF to continuously modernize its processes and production tools in a cost-effective way.

While one aspect of the mandate consists of seeking solutions from the outside world, this new organization would also be allocated sufficient resources to implement best practices identified by RCAF members within their respective communities. In turn, these members should be recognized through various means to include—but not be limited to—financial incentives, awards and the like to promote a culture of innovation and continuous improvement in the workplace.

While there is a noticeable level of effort required up front to establish this new organization, it is clear in my mind that the RCAF will very shortly reap the benefits of that investment and commitment to continuous improvement.

Maj Koussay joined the Canadian Armed Forces in September 2004. He has held positions as Flight Safety Officer / Quality Manager; Aerospace Telecommunications and Engineering Support Squadron Technical Services Officer; CC177 Deputy Engineering Officer at Wright-Patterson Air Force Base in Dayton, Ohio; Deputy Chief of Staff / A7 Lessons Learned Officer with the Air Task Force – Iraq; and Aircraft Maintenance Evaluation at 1 Canadian Air Division in Winnipeg. He is a graduate of the Université Pierre et Marie Curie, Paris, France, with a master's degree in Mechanical Engineering. In July 2019, Maj Koussay was posted to Canadian Forces Base Winnipeg, Detachment Dundurn, as the Detachment Commander.

PUSHING THE ENVELOPE

DEPLOYED CONTRACTED AIRCRAFT MAINTENANCE

BY LIEUTENANT-COLONEL CLAUDE PAUL

This piece discusses the deployed aircraft maintenance activities undertaken as part of Operation (Op) IMPACT for the CC150 Polaris aircraft. It does not attempt to justify their existence, nor the current resources employed to provide maintenance activities; rather, it describes the successes and possible pitfalls of this support model while aiming to draw insightful conclusions by describing the lessons learned.

REALITY

The CC150 detachment was located in Camp Vincent, Kuwait, and it consisted of 21 members as part of Air Task Force Iraq. This detachment was charged with flying air-to-air refuelling missions using one of two Polaris aircraft, both configured for this purpose and belonging to 437 Squadron. The detachment's contribution to the mission, supplying fuel to Canadian and coalition fighter aircraft that conducted strike and patrol sorties, was a tangible enabler of the fundamental tenets of air power, such as reach, flexibility and persistence. Working behind the scenes was a formidable 11-person maintenance team—composed entirely of contractors who were charged with maximizing the aircraft's serviceability—which performed superbly from the outset.

SUCCESSES AND CHALLENGES

Given that the aircraft's design was intended for civilian purposes, maintenance has been performed by first- and third-line civilians from the aircraft's inception. The deployment of civilian contractors was therefore a natural progression of this maintenance posture, as well as being the only option. Despite some divergence between the arrangements uncovered during the fact-finding reconnaissance and those that were finally imposed on the contractors, this deployment was an undeniably viable and successful model. However, this arrangement may have created an uncomfortable precedent, given that, when considering the primacy of operations, it continues to produce and enable serviceable aircraft.

While trite, it is generally accepted that the success was due to a team effort. It is also almost inarguable to attribute a degree of success to the financial incentives received by the contractor at the personal level rather than the corporate one; while money remains a motivation, behind it lies a deep-rooted pride in enabling Royal Canadian Air Force (RCAF) operations.

This support posture was not without challenges. An aborted takeoff incident in 2017 engendered a multitude of logistical and repair hurdles, and it exposed the fleet's vulnerability due to a lack of spares for major assemblies. Another recent and similarly aborted takeoff (albeit on a lesser scale) also illustrated the quandary of operating such a small fleet. Moreover, the clearing of host-nation customs (a requirement that cannot be relegated to contractors), as well as the dependency on infrequent service flights to transport parts, often left the maintenance team at the mercy of the logistics lines of communication. These were not uncommon circumstances, but under a performance-based framework, waivers and special arrangements were vital to avoid unduly punishing the contractors for circumstances beyond their control.

PREVIOUS CAMPAIGN

Op IMPACT differed from the previous campaign in which the CC150 was deployed, mostly in terms of duration and force-protection level. During Op MOBILE, Canada's contribution to the United Nations–imposed arms embargo and no-fly zone on Libya, the CC150 was deployed as part of Task Force Libeccio, active from March to September 2011. Contractors were deployed to Trapani to support this expeditionary capability; however, the threat level was deemed low and thus afforded the contractors greater latitude and autonomy in making arrangements. Moreover, this conflict was also relatively short and did not strain contractual resources. In contrast, Op IMPACT required that contractors be protected and sheltered, thereby vicariously rendering Canada liable for their safety. Yet even this protection was limited in scope, and while it was welcomed by the contractor, it was not a continuum; there were gaps in its coverage. Alternatively, and to greater benefit, arrangements may exist in which contractors, being non-combatants, would appropriately remain at arm's length and therefore at less risk of retaliation.

LESSONS FOR THE RCAF

A reasonable and perhaps critical sounding board for this maintenance posture remains in B-GA-402-003/FP-001, Royal Canadian Air Force Doctrine: Force Sustainment, which lists the principles of sustainment as foresight, economy, flexibility, simplicity, cooperation, self-sufficiency, visibility, responsiveness and survivability.[1] A cursory analysis of Op IMPACT against these criteria reveals a general alignment with several principles, but also exposes flaws when measured against the principles of foresight (for being outside the contractor's span of control), self-sufficiency (for the contractor's inability to self-protect) and survivability (for a lack of redundancy and robustness).

The principle of flexibility merits further commentary, given its prominence in debates surrounding blue-suit maintenance. Although some documents define flexibility as an ability to allocate resources towards other tasks when necessary—such as the ability to employ military people towards other activities in the pursuit of a mission—this definition could be construed more as versatility than as flexibility. In contrast, others define flexibility as the "ability to rapidly evolve the changing roles of a weapon system without the encumbrances of contractual commitments,"[2] which also serves the proponents of military maintenance. Contextualized for the CC150, flexibility is better characterized in terms of expansibility and compressibility to meet changes in scale, operational demand, operating location and depth of maintenance. From that perspective, the maintenance provided by the CC150 Integrated Systems Support Centre may be deemed very flexible, as it offers the ability to support multiple lines of taskings, as well as multiple levels of maintenance, at multiple lines of maintenance. However, the current support posture falls short on several measures: its dependence on civilian maintainers to accompany the aircraft, thereby limiting its exposure to risk; the possible curtailment of where the aircraft could be deployed (in the context of hostile, combat, or austere areas); and its limits on being sustainable from that location (aside from other noteworthy risk-assessment factors such as self-protection equipment). Finally, flexibility may be hindered "when going to war with civilians."[3]

The operational planning process entails consideration for destination, demand, distance, duration and risk when planning the support requirements for a military operation.[4] To what extent, then, does the employment of civilian aircraft maintainers reduce a commander's set of options? Here is an assessment of each of the five criteria:

1. **Destination.** The aircraft is possibly a more central determinant than its supporting workforce. It is fortuitous that the CC150 can be deployed and supported by a team of civilians, given that the long-range and operating performance of the aircraft never justified its permanent basing in a tactical scenario, and that its lack of self-protection precludes its employment in a combat environment. Were the threat level high, the contractors would become both a limiting factor and a liability.[5]

2. **Demand.** One of the advantages of employing contractors lies in their responsiveness, and in their freedom from requirements to adhere to the rigorous processes required of military personnel (e.g., the Departure Assistance Group, pre-deployment training, etc.). One key downside, however, is an unprecedented reliance on contractors to generate and provide this deployed capability,[6] along with concerns for contractor accountability and, to a certain degree, loyalty. Although a remote possibility, the RCAF could be left without a critical maintenance capacity in the event of a contractor's sudden change of allegiance, a misalignment of interests or a bankruptcy. The fact that a previous CC150 Integrated Systems Support Centre has already declared bankruptcy, leaving the RCAF stranded and scrambling to re-establish an alternate contract, still serves as a cautionary tale for many in the weapons-system-management community.

3. **Distance.** In this particular operation, the presence of commercial alternatives for transportation and the acquisition of parts, as well as that of infrastructure, had a larger impact on determining how far from their home base aircraft could operate. Parts were often shipped by commercial means, and hangars were rented from Kuwait Airways on various occasions to sustain operations.

4. **Duration.** The extended role assigned to the fleet by virtue of the Strategic Air-to-Air Refuelling Project opened the door to unknown operating conditions,[7] but the system of volunteers from L3Harris MAS has enabled the sustenance of the expeditionary regime for longer than anyone anticipated as being feasible. As for distance, the existence of commercial alternatives greatly influenced the potential duration of an expeditionary stance.

5. **Risk.** Largely manifested as threat level, which in itself forces a certain force-protection level, this factor strongly influences the commander's options. However, a strategic asset—such as refuelling aircraft—demands strategic protection, and in the absence of suitable protection, the chance for risk is lowered. Regardless of whether civilian or military personnel provide maintenance, the aircraft needs to be based in a low-risk environment.

CONCLUSION

Since its inception, the maintenance of the CC150 has been entrusted to civilian maintenance organizations, thus freeing precious military resources for other core activities. This contractual arrangement is not unusual; rather, it reflects a posture common to several other aircraft fleets, in which qualified civilian organizations provide maintenance services at best value for money, particularly when the aircraft is based on a civilian configuration, and when industry-wide standards and facilities are available. There are currently no plans to abandon this maintenance concept nor any compelling reasons to do so; the serviceability rate and the safety track record for the CC150 have served the Canadian Armed Forces and the Canadian population exceptionally well so far.

Despite the many arguments for preserving blue-suit maintenance, the particular case of the CC150 deployed maintenance team merits closer scrutiny; many interesting observations and lessons can be drawn from this support posture. There were inevitable challenges to surmount for this concept to be realized, but there is also a harsh reality to this success story in the precedent that it may have created, given that producing serviceable aircraft and enabling operations ultimately drives our entire business, independent of who performs the support activities. It does not present a threat to blue-suit maintenance; on the contrary, it enhances its appeal as a model to emulate for specific fleets so as to ensure the vitality of our air maintenance trades. The fact that aircraft maintenance technicians are a precious and scarce resource was well known even before the Auditor General's report confirmed it. While there are various initiatives to replenish our aircraft maintenance capacity, the model espoused by the CC150 is worthy of consideration for future platforms.

Lieutenant-Colonel Claude Paul is an aerospace engineer with experience in the electronic-warfare domain with numerous aircraft fleets; he holds a BEng (Elec) from the Royal Military College of Canada and an MBA with specialization in Global Aviation Management. At the time of writing this article, he was the weapon-system manager for the CC115, CC138, CC144 and CC150, which entailed oversight of the CC150 Integrated Systems Support Centre. He is currently assigned outside Canada.

NOTES

1. Canada, Department of National Defence (DND), B-GA-402-003/FP-001, *Royal Canadian Air Force Doctrine: Force Sustainment* (July 2017), 7–9, http://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-384-2017-eng.pdf.

2. Air Mobility Project Management Office, "Service Paper – Fixed Wing Search and Rescue (FWSAR) Integrated Service Support Concept" (2004).

3. Lieutenant-Colonel T. M. Endicott, "Use of Contractors on Canada's Deployed Operations – To What Extent?" (Toronto: Canadian Forces College, 2005), 16, https://www.cfc.forces.gc.ca/259/260/268/endicott.pdf.

4. Canada, DND, B-GA-402-003/FP-001, *Royal Canadian Air Force Doctrine: Force Sustainment*, 67.

5. Major M. D. Fitz-Gerald, "Contracted Maintenance Support and Canada: Problem or Panacea?" (Toronto: Canadian Forces College, 2011), 71, https://www.cfc.forces.gc.ca/259/290/297/286/fitzgerald.pdf.

6. Lieutenant-Colonel T. M. Endicott, "Use of Contractors on Canada's Deployed Operations – To What Extent?"

7. "Legally, contractors cannot be compelled to go into harm's way, even under contract, unless there is a formal declaration of war." Major J. R. Jensen, "Civilian Contractors on Deployed Operations: An Enabler for the Canadian Forces" (Toronto: Canadian Forces College, 2006), 19, https://www.cfc.forces.gc.ca/259/290/292/287/jensen.pdf.