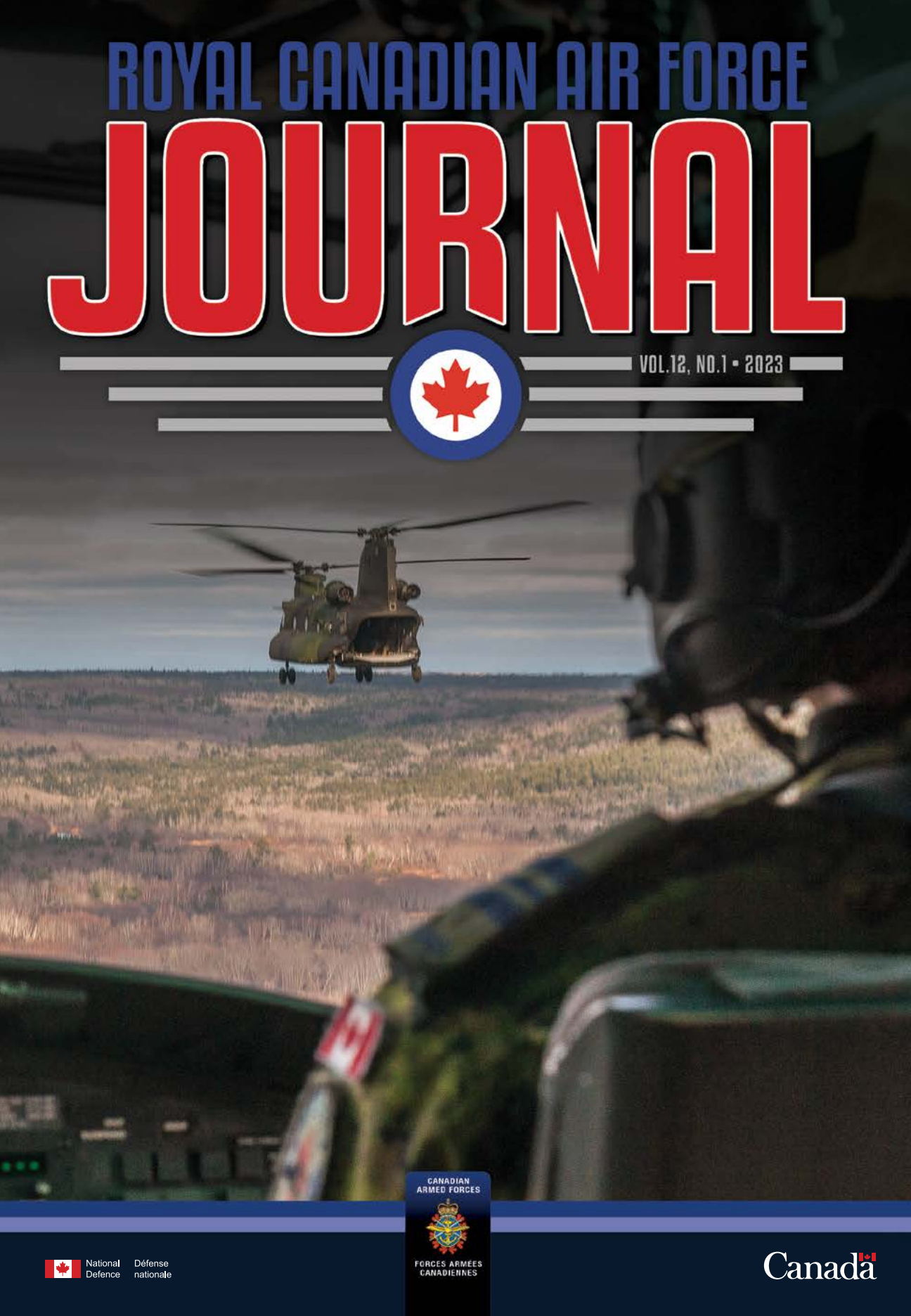
ROYAL CANADIAN AIR FORCE JOURNAL

VOL.12, NO.1 • 2023



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Published by Royal Canadian Air Force Aerospace Warfare Centre
ISSN 1927-7601

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ROYAL CANADIAN AIR FORCE
JOURNAL

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.
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- 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.

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EDITOR'S **MESSAGE**

As the new Editor-in-Chief of the *Royal Canadian Air Force Journal*, I welcome you all to our newest issue.

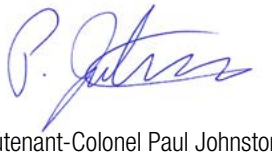
Firstly, I have to thank my predecessor and long-time friend Bill March for his tireless work on the *Journal*; hopefully, I will be able to continue such efforts and build upon his solid foundations. In coming issues we plan to move in several directions, both reinvigorating peer-reviewed articles on air-power topics and emphasizing the *Journal*'s role as the organ for professional debate within the Royal Canadian Air Force (RCAF).

Towards that end, sharp-eyed readers will note some changes to our masthead; we are introducing an oversight board, with senior-level representation from the Air Staff and all three of the RCAF's divisions. We look forward to themed issues about the way the RCAF is wrestling with the wider Canadian Armed Forces (CAF) challenges of professional conduct, recruiting, retention, reconstitution and the RCAF's strategy and vision, more specifically.

For this issue (and I have to acknowledge that most of the heavy lifting was done by Bill before he handed over) we have, from Bill March himself and Dr. Richard Goette, a timely look at how the RCAF wrestled with some previous rounds of transformation, which demonstrated lessons for today's challenges. As well, there is a detailed look at some of the technicalities of air navigation in this increasingly computerized world by Paul Anderson of the project-management realm in Ottawa. As a Point of Interest, Major James Tutte (Retired) offers something in a similar vein, examining what technology can do for ab initio flight training. We also have our first ever column from RCAF History and Heritage, something that will become a regular feature from now on. Finally, we have a review of one of the most recent scholarly works on air power published in Canada, Richard Goette's *Sovereignty and Command in Canada–US Continental Air Defence, 1940–57*.

Enjoy, share, debate.

Sic Itur Ad Astra



Lieutenant-Colonel Paul Johnston, CD, PhD

Transforming Canada's Post–Cold War Air Force

By Dr. Richard Goette, Associate Professor, Canadian Forces College, and Major William March (Retired),CD, M.A. Historian

INTRODUCTION

There is a certain amount of lethargy in the ability of large institutions to change, or transform, to any meaningful degree. If the institution in question is part of an even larger establishment, such as the Royal Canadian Air Force (RCAF)[1] within the Department of National Defence (DND) and the Canadian Armed Forces (CAF), one can even argue that the inherent lethargy is increased significantly. Often, the need to transform is driven by an external factor (or factors) that constitutes a "significant emotional event" and forces the institution to adapt. In wartime, such an event may take the form of defeat, but in peacetime, transformation within a military service will likely be driven by a change in political focus, budget or both. For the RCAF (which only regained the "Royal" appellation in August 2011), its multiple-decade transformational journey began when the fall of the Berlin Wall and subsequent end of the Cold War were coupled with severe budget restraints during the first five years of the 1990s.

Often, the need to transform is driven by an external factor (or factors) that constitutes a "significant emotional event" and forces the institution to adapt.

Although "victory" in the Cold War appeared to shift Canada's political focus away from NATO, in practical terms, the alliance remained an important aspect of the nation's international engagement, as demonstrated by Canadian involvement in the Balkans, Kosovo, Afghanistan, Libya and, more recently, Eastern Europe and Iraq. For the Canadian air force, as with other NATO air forces, budget pressure was the dominant transformational factor throughout the 1990s and into the first part of the twenty-first century. During this period, military aviation in Canada experienced a 20-percent reduction in resources, a 40-percent reduction in personnel and a 60-percent reduction in equipment (i.e., aircraft). Furthermore, this period coincided with an unprecedented level of overseas commitments, resulting in high operational and personnel tempos coupled with the need to embrace "jointness." Although transformation for the Canadian air force has been based on a variety of aspects—such as capabilities, organization, doctrine and how one thinks about using military power—the central characteristic has been fiscal. Under these pressures, transformation became more a matter of crisis management than a well-structured process.

CANADA'S AIR FORCE – SOME CONTEXT

Canada does not have a large air force; in 2020, it consisted of approximately 12,074 Regular Force, 1,969 Primary Reserve and 1,518 civilian personnel as well as a fleet of about 380 aircraft, including leased and contracted airframes.[2] Some have called it a medium-sized air force, and others call it a small air force. However, the best description is something in between: a "smedium" air force.[3] For a smedium service, Canada's air force has had a broad range of domestic and international commitments, ranging from search and rescue (SAR) to participation in the international coalition against the Islamic State in Iraq and Syria (ISIS).

As with most military services, the RCAF's organizational construct evolved in accordance with governmental direction, actual (or perceived) mandates, its relationship with the other environments and the overarching defence department, not to mention budgetary constraints. None of these factors are unique to the RCAF, as they resonate with most military institutions. This article will primarily focus on how Canada's air force was transformed in the quarter century following the conclusion of the Cold War (1990–2015) and will, therefore, be put into the context

A Canadian Armed Forces soldier guards his arcs of fire on board a CH146 Griffon helicopter during an air mobility mission in Northern Iraq as part of Operation IMPACT on November 4, 2016.

of Canadian defence policy during that period. However, it is important to appreciate a rather unique set of circumstances confronting the air force for most of those 25 or so years: it was not a separate service, but the "air element" of a unified Canadian military force. The exact extent of unification can be debated; nevertheless, it placed constraints on senior air force officers and transformation, as they had to "play the game" and conform, at least outwardly, to the unified construct.[4]

After the unification of the Canadian Forces (CF) in 1968 almost destroyed Canada's air force, a group of former RCAF officers—led by Lieutenant-General (LGen) William (Bill) Carr—carefully "stickhandled" an initiative that consolidated Canadian air power under one CF Air Command (AIRCOM) in 1975. Significantly, AIRCOM consisted of all the CF's air assets. AIRCOM thus carried out not only all the functions of the former RCAF, but also those of the aviation forces of the former Canadian Army and Royal Canadian Navy.[5]

Since 1975, AIRCOM / the Canadian air force (the latter name increasingly came into use by the mid-1990s) has owned, commanded and operated all military air power assets in Canada.[6] This realized the dreams of air power prophets/theorists such as Giulio Douhet and Billy Mitchell. Mitchell believed in the indivisibility of air power, which meant that a nation's military air power should be centralized and concentrated under professional aviators at the top of a professional air force that owns and commands all air assets. Moreover, the breadth of AIRCOM's operational air power functions and, hence, its operational capability were substantially greater than those of the predecessor RCAF. As former Commander AIRCOM (1989–91) LGen Fred Sutherland (Retired) noted, "the Canadian air force is universal—it supports the army, navy, does search and rescue, etc."[7] Although such institutional indivisibility of air power resulted in particular benefits (e.g., enhanced potential for increased joint operations and capabilities), it has also brought forth significant challenges for Canada's air force.

Search and rescue technicians from 442 Transport and Rescue Squadron discuss their plan of action on the ground as a Cormorant helicopter comes in to land on top of a mountain near Hope, British Columbia, on February 27, 2014, during an annual search and rescue exercise.

The most significant challenge has been balancing Canadian air power functions and responsibilities, given the smedium size of Canada's air force. Could the RCAF operate effectively as an air power institution, considering its comparatively smaller size (i.e., number of personnel, aircraft and other equipment); its wide breadth of air power functions and responsibilities in a country of such geographical vastness as Canada; and its continental and overseas commitments? This was an issue of almost unique concern for the RCAF, which has long had substantial expeditionary and domestic responsibilities. In particular, when the army and navy are not on expeditionary operations, they are not as active as the RCAF, which has huge domestic air power responsibilities, especially the air-mobility community. In an environment of fiscal restraint, meeting Canada's vast air power roles and responsibilities has been a challenge that the RCAF faces daily.

Unification, as well as the absorption of naval and land air assets, exacerbated certain institutional challenges, such as what constitutes an air force identity. Prior to unification, the ever-present tendency to over-identify with one's air community was tempered by a pervasive understanding that individuals were, first and foremost, part of the RCAF; this idea was supported by pan–air force training and education. However, unification destroyed this sense of belonging to an air power entity greater than a specific air community by substituting the CF for the RCAF. The formation of AIRCOM in 1975 was an attempt to recreate a pan–air force culture, but it has been less than successful, as there has been a growing connection and identification of personnel with their specific air force community. Indeed, Canada's air force truly consists of several communities or subcultures. There are essentially two distinct, overarching cultures: The first is focused on certain air power functions or airframe types (e.g., fighters, maritime air, tactical helicopter, air mobility, SAR), all primarily concerned with "operations" at the tactical level (i.e., operational communities). The second is subdivided into communities based on the type of occupation that one does for the air force, dealing mainly with the day-to-day "housekeeping" of the organization (i.e., occupational communities).[8] The main focus of this article will be the first cultural grouping.

The operational communities have made Canada's air force very multidimensional, but they have also brought forth a certain amount of fragmentation. Critics argue that, when established, AIRCOM simply consisted of multiple air forces based on their operational focuses. Some have argued that the different operational communities within the air force resulted in "inefficient stovepipes"[9] with their own unique ethos and point of view. With this stovepiping, the different air force communities have had little understanding of and appreciation for each other; they have been too focused on themselves and their "customer base" at the expense of the air force's development as an institution. It could be argued that having the maritime air power and tactical-aviation assets—that would be under the navy or army in other countries—under the air force in Canada had led to those groups being neglected in terms of funding and development. Others state that the navy and army should have owned these elements so the air force can focus more money and resources on "traditional" air power roles, such as transport, air superiority and strategic attack. The dilemma for these communities, in terms of where they should be, has been who will neglect them more: the air force or the army/navy?[10]

The operational communities have made Canada's air force very multidimensional, but they have also brought forth a certain amount of fragmentation.

According to air force Major Steve James (Retired), stovepiping resulted in a "federated air force" of competing "rival communities." In particular, he identified four specific rival operational communities, each of which has "divergent mandates[,] differing corporate aspirations and resource priorities": the fighter community, the maritime air community (maritime patrol and ship-based maritime helicopters), the rotary-wing tactical-aviation community and the air-mobility community (air transport and SAR). Moreover, by concentrating all the country's military air assets under the Canadian air force, this professional air power institution "has been found wanting in creating a unifying identity and vision across its various parts." James laments the failure of air force leadership to create "a singleness of purpose and unity across its disparate communities" over the years, arguing that they have "persistently fallen short of bringing together the disparate subordinate parts into a unified whole [… and] failed to create a singleness of purpose of vision."[11]

Canadian air power academic Scot Robertson echoes James' conclusions, arguing that, despite the full range of roles that the RCAF performed in the Second World War, Canada's air force, during the subsequent Cold War years, "was never fully integrated, and this failure to develop a full appreciation of the broad range of air power roles has had a baleful influence upon the development of a Canadian context of the air weapon. In short, the strategic culture of the air power community in Canada was limited."[12] This inherent organizational weakness, although recognized as a major issue by successive officers commanding AIRCOM, made it much more difficult for the Canadian air force to weather the transformational shocks of the 1990s.

THE 1990s: A TRANSITIONAL DECADE

With the end of the Cold War in the early 1990s and the collapse of the Soviet Union, it seemed at first that the West had won. However, the "new world order" of the post–Cold War period was one of uncertainty for Canada's air force and the world in general. With the Soviet Union gone, there was a power vacuum in much of the world, leading to violence, death and destruction on an unprecedented scale. Peace support operations skyrocketed, and Canada was in the thick of it, which led to an increase in the CF's operational tempo.[13] At the same time, however,

the government began to make massive cutbacks in defence, seeking to capitalize on another peace dividend. The irony was that—at a time when there was greater demand for the use of the military, including the air force, due to the Canadian government's "can-do" attitude—the CF was also experiencing a degradation of capabilities due to massive cutbacks in defence spending in the post–Cold War era.[14] While Canadian peace support operations increased, the nation's commitment to NATO declined. With the Soviet threat gone, Canada's longstanding NATO deployments to Europe came to an end. Canada began a gradual withdrawal of its NATO forces out of Europe and back home to Canada, including the air force's NATO Air Group. In 1993, Canadian air operations in Europe ceased, and the Canadian bases in Baden and Lahr, Germany, closed in 1994 and 1995, respectively.[15] The 1990s in Canada became known as the "Decade of Darkness"[16] for Canada's military, and the budget cuts hit Canada's air force particularly hard.

At the start of the decade, AIRCOM consisted of 19,114 regular military personnel supported by 1,472 reservists and 5,741 civilians. It operated approximately 680 aircraft,[17] organized into functional groups that were structured to support specific clientele or missions.[18] Although Canadian air power played a key role in the first Gulf War and was actively engaged in operations at home and abroad, budget pressures meant that hard decisions were required, as the Canadian air force struggled to maintain its operational focus and capabilities as well as its culture and sense of identity.

In 1993, AIRCOM initiated several changes, largely to accommodate the significant reductions in personnel and equipment brought about by declining defence budgets. Certainly, the desire

Senior non-commissioned officers and officers from the "Desert Cats" ground crew pause for a photo in Qatar in 1991, during Operation FRICTION, Canada's contribution to the first Gulf War. The squadrons that made up the Canadian Desert Cats force were 416 "Lynx" Squadron from Cold Lake, Alberta, and 439 "Tiger" Squadron from Baden-Soellingen in Germany. PHOTO: ISC91-5322, by Sergeant Ed Dixon

for better organization as well as command and control (C2) was one motivation, but the main one was crisis management due to fiscal restraints imposed from above. The air force adopted the "wing" organizational structure, creating 17 numbered wings and superimposing them over the existing organization of CF bases. The primary rationale was to enhance the operational role of air force base commanders, in addition to their other administrative and support roles, based on the idea of "one wing, one boss." The wings were also formed in an attempt to increase the sense of belonging to the air force rather than to a unified CF. Still, the measure may not have been very successful, as it created a level of formation in addition to the Air Group structure with little, if any, operational benefit.[19]

The next four years saw a whirlwind of change for the CF as a whole and the air force in particular. Although the employment of military forces both at home and in support of United Nations (UN) missions had never been higher, public support for the CF had never been lower. A series of high-profile scandals, the most horrendous of which was the murder of an unarmed Somali teenager by Canadian peacekeepers, increased the pressure for meaningful change within DND.[20] Government direction, public pressure, budgetary constraints and geopolitical restructuring combined to create a perfect transformational storm for the air force to weather.

In Ottawa, a Management, Command and Control Re-engineering Team (MCCRT) was established to provide top-down guidance to the three CF elements; reduce and restructure the various levels of headquarters (HQ); and ensure that the new "joint" C2 philosophy, first seen during the Gulf War, was fully implemented. In the language of the day, the team's purpose was to "focus resources on operational capability by reducing resources assigned to headquarters and achieving dramatic performance improvements by re-engineering processes."[21] Transformational activities would concentrate on a comprehensive review of the entire defence organization, various management and C2 processes, the management of information, the culture, and the mechanisms for the management of change. First and foremost was the need to reduce financial, personnel and infrastructure resources allocated to HQ functions by 45 percent, as directed by the government, plus an additional 5 percent imposed by higher command.[22]

One of the major pillars upon which Flight Plan 97 rested was the firm belief that the air force, in whatever final form it would take, would still be an important element of Canadian defence.

AIRCOM was already in the midst of a series of adjustments brought about by a first round of budget reductions and an operational shortcoming. Revealed by the Gulf War, this shortcoming was meant to be corrected by the acquisition of a precision guided munition (PGM) capability for the CF188 Hornet. Project Genesis sought to reduce the fighter force by approximately 25 percent and reinvest some of the savings into modernizing and equipping the remaining aircraft with PGMs. Follow-on government direction—which was primarily in the form of additional personnel as well as financial cuts and was guided by the MCCRT—resulted in the expansion of Project Genesis. It grew to include the retirement of aircraft fleets and capabilities, the amalgamation and rationalization of maintenance trades, and the adoption of alternate-service-delivery provisions for a host of training and support requirements. The "jewel in the crown" of alternate service delivery was the establishment of a partnership with a civilian contractor to provide large portions of pilot training under the umbrella of a NATO flying training centre, located in Portage La Prairie, Manitoba. Eventually, these initiatives would be grouped together under the title of "Flight Plan 97."[23]

Recognizing that the rapid pace of forced transformation was both overwhelming and demoralizing to personnel, senior air officers incorporated a cultural element within Flight Plan 97. In a little over a year, more than 18,000 AIRCOM members underwent training to help them adapt to the new reality. Throwaway phrases, like "learning to do more with less" and "leaner and meaner," were put into a broader institutional context that allowed individuals to better cope with what seemed to be a downward spiral of continuous change.[24] Certainly, one of the major pillars upon which Flight Plan 97 rested was the firm belief that the air force, in whatever final form it would take, would still be an important element of Canadian defence.

Royal Canadian Air Force CF188 Hornets are refuelled by a KC-135 Stratotanker assigned to the 340th Expeditionary Air Refueling Squadron on October 30, 2014, over Iraq during the first combat mission in the area of operations, supporting Operation INHERENT RESOLVE.

In 1997, the aptly named Air Force Command and Control Re-engineering Team provided recommendations on how the air force would achieve the goal of eliminating one layer of HQs. Both AIRCOM HQ and the Air Groups were dissolved, and all air assets were consolidated under a redesigned HQ that adopted 1 Canadian Air Division (1 Cdn Air Div) as its official title. Furthermore, in 1996, the Canadian NORAD Region HQ (located at 22 Wing North Bay, Ontario) was transferred to Winnipeg and amalgamated within 1 Cdn Air Div. Deemed an "operational-level" HQ, 1 Cdn Air Div was prepared to work in a joint CF environment. In addition, a new "strategic-level" staff organization was created to support a re-established Chief of the Air Staff (CAS). This staff system harkened back to the days of the RCAF and, serving as CAS, became a new "hat" for the Commander AIRCOM. Under the revamped air force organization, strategic-level direction and command of AIRCOM were vested in the CAS in Ottawa, while operational and tactical control of AIRCOM forces were delegated to the Commander 1 Cdn Air Div in Winnipeg. Some question whether this really was the case, especially with regard to 1 Cdn Air Div, as there was an overlap in some of the responsibilities. Moreover, many of the changes were not brought to fruition in a coherent and effective way, but rather have been ad hoc and reactionary to various fiscal pressures. Again, these changes were more a matter of crisis management or were in response to the government's fiscal policies compared to being a well-structured process.[25]

There was also a huge effect on Canadian air force operations, which put massive stress on air force equipment and people. During the 1990s, the CF was reduced by 20 percent; the air force suffered the most, as its personnel and aircraft were reduced by 48 percent in this time period. There were also massive reductions in the number of airframes available for operations, leading to decreased capabilities right when demands for those airframes increased. The Canadian air force's newfound focus on expeditionary operations resulted in doubled taskings, especially many "crisis" peace support operations in the "new world disorder." At the same time, the number of its personnel deployed on operations increased threefold, and these personnel were deploying for longer periods of time compared to the Cold War. There were also increased domestic-crisis commitments, such as a response to a major ice storm in Ontario and Quebec in 1998 as well as flooding in Manitoba. As a result, AIRCOM found itself increasingly hard-pressed to keep up with the tempo of operations and a reduced primary combat-power capability, and its personnel were adversely affected by the extremely high personnel tempo.[26]

Yet all was not doom and gloom. Efforts to incorporate a PGM capability within Canada's fighter force allowed the Canadian government to play a valued role in the 1999 Kosovo air campaign, an option that was unavailable just a few years before.[27] There was also a renewed emphasis on the Canadian air force developing its own doctrine to guide the service as it transformed and to provide a solid foundation for ongoing budgetary and organizational battles in Ottawa. Two capstone doctrine publications were planned: *Out of the Sun: Aerospace Doctrine for the Canadian Forces* was published in 1997, but the accompanying *Out of the Hangar: Aerospace Support Doctrine for the Canadian Forces* never advanced beyond the draft stage.[28] Still, these documents signalled an attempt by senior air officers to provide a doctrinal basis for ongoing transformational activities.

Security at home therefore began with security abroad, and this was a catalyst for CF Transformation.

POST 9/11: AFGHANISTAN AND CF TRANSFORMATION

Even while the CF was adjusting to organizational and operational changes brought about during the previous decade, the dawn of a new century brought with it unexpected challenges. Further transformation of the CF (hereafter referred to as "CF Transformation") resulted from changes occurring in the Canadian military—and militaries globally—which were sparked by the terrorist attacks on September 11, 2001 (9/11). Canada stood tall with its neighbour to the south; as Minister of Foreign Affairs John Manley remarked, "If we weren't committed to our best friend and ally, just what would we be committed to?"[29] This terrorist attack resulted in a strategic reconsideration of how to protect North America from asymmetric threats. Enhanced bilateral security and defence cooperation with the United States formed a logical step that Canada took, and this resulted in an expanded maritime role for NORAD.[30] There was also the realization that greater emphasis must be placed on eliminating threats at their sources before they can strike directly at Canadians and Americans. In this new environment, security at home therefore began with security abroad, and this was a catalyst for CF Transformation.[31]

Following 9/11, Canada immediately invested billions in domestic security and legislated new security measures. Canada also sent special operations forces units to fight alongside the Americans and other allies in Afghanistan and, later, increased its contribution to that conflict. Conspicuously, however, and at the insistence of Prime Minister Jean Chrétien, Canada did not support the United States' invasion of Iraq in 2003. Nonetheless, what most Canadians all too often forget is that

some CF personnel on exchange with the US military did take part in the Iraq War. Moreover, CF maritime forces in the southern part of the Persian Gulf and the Gulf of Oman took over some United States Navy responsibilities related to the war in Afghanistan—including command over a multinational task group—which freed up American ships to support the US invasion.[32]

Although still adjusting to the massive changes of the 1990s, the Canadian air force was immediately tasked on counterterror operations both at home and overseas. Within a NORAD context, Canada's shrunken fighter force was engaged from the onset of the 9/11 attacks with shepherding civilian aircraft through Canadian airspace. CF188s were called upon to adopt a more forward leaning posture under the auspices of Operation NOBLE EAGLE, providing combat air patrols over Canadian cities and potential high-value targets, such as nuclear power plants.[33] There had been some discussion with respect to employing Canadian fighters in Afghanistan, but given the ongoing refinement of domestic requirements, combined with an over-abundance of fighter resources offered by other allies, no CF188s were deployed overseas. Nevertheless, Canadian air transport and maritime air assets were part of Canada's contribution to coalition operations as part of Operation ENDURING FREEDOM.[34]

A CC177 Globemaster III strategic transport aircraft from 429 Transport Squadron in Trenton, Ontario, rests on the airstrip at Kandahar Airfield.

In 2003, Canada entered an active warfighting and state-building role in Afghanistan, giving the country (and its military) enhanced credibility in the eyes of its allies. When the US decided to invade Afghanistan to depose the Taliban and target al-Qaeda, Canada quickly responded to the request to send troops. In July, Canadian forces were deployed with the UN-mandated, NATO-led International Security Assistance Force (ISAF) peace-support mission operating in Kabul. Operation ATHENA, the Canadian contribution to ISAF, consisted of two six-month rotations of approximately 1,900 CF personnel each and was the largest contingent in ISAF at the time. Canadian LGen Rick Hillier assumed command of ISAF in 2004. Including the Canadians serving with NATO forces in Bosnia, more than 2,500 Canadian troops were committed with "boots on the ground" under the NATO alliance in 2004.[35] The Canadian air force's contribution consisted of the following: the continuation of tactical airlift support, primarily centred on the

CC130 Hercules; air personnel serving with NATO and US airborne warning and control aircraft; specialist joint terminal attack controllers; and maritime personnel as well as CH124 Sea King helicopters on deployed Canadian warships.

Paul Martin became Prime Minister in late 2003 and, although he had only achieved a minority Liberal Government in the 2004 federal election, he began to push a more activist Canadian place in the world. In 2005, the Canadian government released a new document: *Canada's International Policy Statement: A Role of Pride and Influence in the World* (*IPS*). The *IPS* was akin to a White Paper on Defence, but with important differences. Described as a defence-policy statement for the twenty-first century that was "firmly grounded in the realities of the post–Cold War, post–September 11th world,"[36] it was both a defence-policy and foreign-policy statement wrapped into one. In particular, the *IPS* recognized the importance of defence in an unpredictable international environment, and it established three priorities:

1. Protecting Canadians
2. Defending North America in cooperation with the United States
3. Contributing to international peace and security[37]

In fulfilling these priorities, the *IPS* recognized that Canada had to expand its approach to international policy focused on defence, diplomacy, development and commerce (3D+C). Not only was the CF to expand its capabilities in order to operate fluidly with allies on international missions, but these capabilities had to be consistent with the new types of roles that Canada's military was expected to undertake in new "demanding and complex environments, where civilians mix with friendly, neutral and opposing forces, often in urban areas."[38] These roles included the traditional Canadian military role of combat operations as well as other capabilities, such as humanitarian assistance and stabilization missions. The CF was to be flexible and versatile; be effective, relevant and responsive; and perform these various roles all at the same time. Therefore, the spotlight was on a national, integrated, domestic and international effort in which DND and the CF played an important role hand in hand with other government agencies, allies and even non-governmental organizations in a state-building role. The *IPS* included not only traditional warfighting roles for the CF, but also those more focused on greater coordination with other agencies, particularly "soft power"[39] human security. This was most vividly demonstrated in Afghanistan, where—within Canada's new national, integrated "whole-of-government" international effort—the CF played an important role hand in hand with other partners to assist in rebuilding the country.[40]

The *IPS* also included a call for "a fundamental restructuring of our military operations … [to] make certain that in a time of crisis, Canada's military has a single line of command and is better and more quickly able to act."[41] This call reflected the vision that the new Canadian Chief of the Defence Staff (CDS), General Rick Hillier, had for Canada's military; as a result, he has become the one senior officer most identified with CF Transformation. Hillier's initiative resulted in a fundamental change to the organization and culture of Canada's military, reorienting the CF to make it more operationally relevant, responsive and effective in order to "better meet the emerging security demands at home and abroad."[42]

With overall guidance provided by the *IPS*, the air force developed two key documents outlining its vision for transformation: *The Aerospace Capability Framework: A Guide to Transform and Develop Canada's Air Force* was published in 2003, articulating "a clear strategic vision to guide

the transformation and development of Canada's air force over the near- and mid-term."[43] In 2004, it was followed by *Strategic Vectors: The Air Force Transformation Vision*, which spoke about the need to transform the service from "a primarily static, platform-focused air force to an expeditionary, network-enabled, results-focused aerospace force."[44] Although used extensively by the air force as source documents, the primary purpose of these documents was for external consumption by the other environments and the government. They spoke to the fragile nature of an air force that was still struggling to deal with a decade's worth of budget cuts, personnel and equipment reductions, and organizational shifts. Both documents underlined that the service was committed to change—to transformation—but there was also a major risk of the air force being overwhelmed. To bring a modicum of order to the transformational process, *The Aerospace Capability Framework* outlined a three-phased approach, the first phase of which was dedicated to stabilization, wherein the air force would assess its current "operational health" and what it could, and could not, accomplish.[45] To develop and assist with air force transformational initiatives, the Canadian Forces Aerospace Warfare Centre (now the Royal Canadian Air Force Aerospace Warfare Centre) was established. Unfortunately, this systematic approach did not account for a growing involvement in Afghanistan.

The high-tempo and limited-capabilities issue was reaching a head by the early 2000s. As a result, by 2005, this situation caused the CAS, LGen Ken Pennie, to remark that Canada's air force is "beyond the point where even constant dedication is sufficient to sustain the capabilities needed to meet assigned defence tasks"[46] and "remains fragile due to chronic underfunding and asymmetric cuts to personnel. Our wings and squadrons are too hollow to sustain the current tempo of operations."[47]

Pennie had some excellent ideas, several of which are outlined in his *Strategic Vectors* vision and his article on transformation.[48] However, Pennie—like much of Canada's air force at the time—had become worn out by the constant operations. In any event, Pennie's ideas on how to transform Canada's air force were trumped by the phenomenon of CF Transformation, led largely by Canadian Army General and CDS Hillier.

CF Transformation under Hillier also recognized a need for greater funding for the CF to meet the increased operational tempo of the post–9/11 era. Defence spending increased from 1.1–1.2 percent of the gross domestic product to 1.5 percent, and overall aggregate defence spending increased by 51.8 percent in the first decade of the twenty-first century.[49] In particular, there was an emphasis on the sustainability of operations overseas through CF expansion and revitalization focused on people and equipment. Transformation called for significant modernization of technology and equipment to allow the CF "to operate effectively in today's challenging security environment alongside [its] allies and other government and non-government agencies." This did not entail a complete re-equipping or restructuring of the CF, but rather a blending of "existing and emerging systems and structures to create greatly enhanced capabilities relevant to future missions, roles and tasks."[50]

Increased funding brought greater expectations from the Canadian public (and government) that the CF use its resources and capabilities properly.

When a Conservative Government came to power in Canada in 2006, Prime Minister Stephen Harper implemented the *Canada First Defence Strategy* (*CFDS*). It largely adhered to aspects of the 2005 *IPS* in that the three main priorities remained defending Canada, defending North America in conjunction with the United States, and contributing to

national peace and security. However, the *CFDS* placed greater emphasis on Afghanistan, as well as CF expansion and revitalization to develop new defence capabilities. It entailed increasing the commitment and roles of troops as well as other resources in support of the UN-mandated mission to Afghanistan.[51] As part of this revitalization of the CF, the Canadian government increased defence funding by $1.1 billion over two years and $5.3 billion over five years.[52]

This investment in the CF included the revitalization and expansion of people (including greater CF force numbers, education and training) and the procurement of new equipment "to support a multirole, combat-capable maritime, land and air force."[53] For Canada's air force, this included the procurement of several new aircraft, including four (now five) strategic air transport CC177 Globemaster III aircraft, CC130J Hercules airlifters and CH147 Chinook air-mobility helicopters. New funding was also directed towards modernizing the combat systems and electronics of certain platforms to ensure they could fulfil new capabilities.[54] However, increased funding brought greater expectations from the Canadian public (and government) that the CF use its resources and capabilities properly.

Canadian Army soldiers disembark a CH147 Chinook helicopter during Exercise COMMON GROUND II 2016 at 5th Canadian Division Support Base Gagetown, New Brunswick, November 25, 2016.

As previously noted, senior air officers were trying to slow the pace of CF Transformation to avoid overwhelming the existing organization and permit a rational and logical way ahead. In theory, the acquisition of new equipment and capabilities should be welcomed by a military service, but in practice—especially if the overall number of personnel is not increased proportionately—increased

defence spending can become another stressor. Throughout the 1990s, the Canadian air force partially adapted to its reduction in numbers via a widespread elimination of aircraft fleets and capabilities (one of which was the abandonment of the Chinook helicopter). The purchase of new aircraft fleets, transformational as they might have been with respect to augmented or additional capabilities, was not matched with a corresponding increase in personnel resources; the approved size of the air force was relatively unchanged at 13,500 personnel, but that level was never actually achieved.

Exacerbating the situation was the increased participation of the air force in Afghanistan. Although public support for the CF had never been higher, the repatriation of Canadians who were killed in combat, many by improvised explosive devices, resulted in a sense of frustration and a belief that something more should be done. Responding to the pressure, Harper established a panel of experts in October 2007 to examine Canada's role in Afghanistan. Commonly known as the Manley Report, after the panel chair John Manley, the report was published in January 2008 and became a key document, as most of its recommendations were adopted by the government. With respect to the air force, the report recommended the acquisition of medium-lift helicopters and high-performance uncrewed air vehicles.[55] These commitments, when combined with the acquisition of Globemasters and J-model Hercules aircraft, added to the transformational woes of the Canadian air force.

Colonel Al Meinzinger (right), commander of the Air Wing, Task Force Silver Dart, greets Brigadier-General Charles Lamarre, commander of the Mission Transition Task Force, on 22 July 22, 2011, in Kandahar, Afghanistan.

Through a combination of purchasing, borrowing and leasing, these new platforms were put in place, permitting the deployment of an air wing to Afghanistan in December 2008. Task Force Silver Dart, as the air wing was called, consisted of approximately 450 air force personnel grouped into a tactical helicopter force (CH147 Chinooks and CH146 Griffons), an uncrewed-air-vehicle detachment (CU170 Heron), a tactical-airlift component (CC130 Hercules), and HQ and support personnel.[56] This was a major undertaking for the air force. Once the wing was finally withdrawn in August 2011, an estimated 14,000 air force personnel had deployed, when the various operations supporting Canada's mission in Afghanistan were combined; not bad for an air force totalling less than 13,500 personnel.[57]

Even while the mission in Afghanistan was drawing down, the RCAF found itself engaged in humanitarian operations in Haiti and flying combat missions over Libya as part of a NATO-led mission, commanded by Canadian LGen Charlie Bouchard.[58] More recently, the RCAF has been engaged in combating terrorists in Iraq and Syria.[59] There was also a renewed focus on NATO in Europe with air-policing missions in Iceland[60] and the Baltic, as well as a demonstration of solidarity in Ukraine.[61] At the same time, the RCAF's huge domestic responsibilities—especially those of the air-mobility community—have not decreased. Given the continued high operational tempo, the air force had scant additional resources to dedicate to transformation, yet it could not ignore the major changes that were taking place with respect to the CF's overall organization.

An important aspect of ongoing CF Transformation was the establishment of a new operational command structure. Hillier felt that the CF needed a more "integrated and unified approach to operations" to ensure greater effectiveness and efficiency in the twenty-first century security and defence environment.[62] He attempted to achieve this through a significant restructuring of the CF command structure in 2006, which saw the establishment of four new unified operational commands:

1. Canada Command for domestic and continental operations
2. Canadian Expeditionary Force Command for all of CF's international operations to counter overseas threats
3. Canadian Special Operations Forces Command for all special-operations-forces operations
4. Canadian Operational Support Command, focusing on support for the other commands[63]

Therefore, CF Transformation was based on a more command-centric approach to C2 and a focus on operations, resulting in a significant shift in Canadian military culture away from the more bureaucratic management culture that had previously dominated the CF since the unification of the Canadian military services in 1968.[64] It was a "progressive shift of the command structure" from one that, at the time, was centred on the three Canadian military environments (air force, navy and army) to one that was more unified and consisting of "fully integrated units capable of a high-readiness response to foreign and domestic threats."[65] Each unified command (all of which became known as the "dot COMs") was headed by a commander with a joint staff, and their purpose was to improve operational effectiveness fordomestic and overseas missions. "Guided by a mission-command leadership philosophy,"[66] each unified commander would "direct and coordinate operations with forces and capabilities generated from the three environments and other formations."[67]

Each of the new HQs created under Hillier required an air staff to ensure air power requirements were met. In many ways, this harkened back to unification and the creation of functional commands when the old RCAF was dismembered. Senior air officers involved in the discussions leading to the establishment of the dot COMs fought long and hard to maintain an air force HQ that was equal in status to its joint counterparts. They argued that an air force HQ was necessary to fulfil the NORAD mission and to serve the broader air requirements inherent in the *CFDS*. In the joint arena, the 1 Cdn Air Div / Canadian NORAD Region HQ in Winnipeg would function as the combined joint force air component commander. The 2012–13 amalgamation of the joint operational commands into a new Canadian Joint Operations Command (CJOC), instigated by post-Afghanistan defence spending reductions, sought to avoid inefficiencies and redundancies, relieve staffing strains, and further streamline the now rebranded Canadian Armed Forces. The formation of CJOC had minimal impact on the RCAF.[68]

CRITICISM OF CF TRANSFORMATION

Although CF Transformation was generally popular with those in uniform and coincided with a rise in support for the military from the Canadian public, the initiative was not without its critics. Indeed, as with all major changes to a country's military, there was strong resistance in some quarters.[69] Some have argued that Hillier's efforts to transform the CF structure "produced questionable results,"[70] while others posited that the effort to reorient CF culture essentially failed because it undermined the Canadian military's internal institutional legitimacy, especially as it pertains

The Chief of Defence Staff, General Rick Hillier, greeted on the tarmac of 427 Squadron by its Commanding Officer, Lieutenant-Colonel Chris Coates, on January 19, 2006.

to the cultural identity of the three environments.[71] In particular, there are those who argued the CF Transformation vision and its nature were flawed, especially when it came to the Canadian air force.[72]

Soon after the implementation of CF Transformation, some senior navy and air force officers began to describe Hillier's transformation initiative as "army-centric," with the air force and the navy largely relegated to supporting the overall land-oriented missions.[73] Allan English describes this focus as diverging from the espoused CF Transformation vision and argues that it was "a key reason why Hillier had trouble gaining the confidence and trust of the elements of the CF's senior leadership,"[74] notably sailors and aviators. With the larger size of the Canadian Army, critics have described CF Transformation's focus on jointness as really a "jarmy" vision for the CF, wherein an army-centric, boots-on-the-ground philosophy (inspired by the United States Army) predominated at the expense of the other two environments.[75] Furthermore, referring to the air force procurement plan, which focused on intertheatre and intratheatre airlift capabilities, Robertson opined that Canada's air force was moving away from front-line combat capability, "evolving into a *taxi service* for the army."[76] [emphasis in original]

As English further noted, the army-centric, boots-on-the-ground philosophy of CF Transformation entailed a heavy interventionist focus, which limited Canadian governments "to arguably the most risky and costly form of intervention."[77] Put simply, having boots on the ground runs the risk of suffering casualties. As Canada saw an increasing number of coffins draped in its flag being returned home—one of the more sombre tasks the RCAF air-mobility community had to perform—the Canadian public's already shaky support for the mission in Afghanistan continued to fall.[78] This interventionist, army-centric focus contrasts with air force operations, which are inherently less risky and less costly in terms of the lives and resources expended. Indeed, it is these benefits of air power that led to the Canadian government's decision to choose air power as the force of first resort, or the first weapon of choice, for Canada's contribution to the fight against ISIS.[79]

Lastly, Hillier's efforts to create an integrated CF culture "did not fully appreciate how the nature of warfare at sea and in the air produced separate cultures."[80] This phenomenon is what Major-General Daniel Gosselin (Retired) has termed the "strong-service idea."[81] Similar to unification's focus on a purely unified and distinctive CF with its own distinct CF culture, CF Transformation underestimated the pull of the strong-service idea, which is still embedded in the culture. Those who support this idea, including traditionalists, place a lot of credence, emotion and identity in the three former services or environments (the navy, army and air force).[82] Such emphasis on emotion and identity has definitely happened with Canada's air force, as the re-emergence of the RCAF moniker and traditional uniforms indicates.[83] It could also be argued that the strong-service idea was a primary reason for the air force's decisive push to retain command over the air element for the dot COMs and CJOC, which reinforced the concept of air power's indivisibility. If anything, since the commencement of the CF Transformation initiative in the mid-2000s, Canada's air force has strengthened its institutional air power identity. However, this transformation is far from complete, as the RCAF still faces a number of challenges.

The biggest challenge to the RCAF is that it is tactically focused and has a very high operational tempo.

OTHER CHALLENGES

The biggest challenge to the RCAF has been—and continues to be—that it is tactically focused and, since the end of the Cold War, has had a very high operational tempo. This puts high demands on RCAF equipment and especially on personnel. The overwhelming focus of personnel on operations has led to neglect in other areas that are important for a healthy air force. For instance, when we examine the four pillars of Canadian military professional development, a high operational tempo *will* allow personnel to capitalize on the experience aspect, it also means reduced time to improve in the other three areas: training, self-learning and education.[84] When combined with a limited number of command positions practising air power at the operational level, the RCAF has an inherent inability to inculcate a pan–air force outlook in its senior officers. This is detrimental both to the development of the air force and the air power savvy necessary to influence defence-policy discussion in Ottawa. Recent initiatives have been introduced to rectify this problem, such as the "Flying in Formation" concept, the Air and Space Power Operations Course, and a greater emphasis on developing professional air power mastery.[85]

In addition, as the "baby boomers" retire, the RCAF is faced with the challenge of retaining experience. There is an uneven bell curve in terms of experience within the RCAF: There are several personnel with more than 20 years of service on one side, and a significant number of newer personnel on the other. In between is a large deficit of personnel, with a mid-range time in service, caused by the force reductions during the 1990s Decade of Darkness and the reduction in recruiting. The challenge is how to make up this deficit by trying to convince seasoned personnel to stay in the air force a little longer and accelerating the development of new recruits. Consequently, since the early 2000s, there has been a large retention challenge in the RCAF.[86] Initiatives such as better family services, improved career opportunities and options for greater work flexibility—all of which are aspects of modern Canadian society—are measures to address these issues.

Lastly, the RCAF—as with the whole of DND and all federal government departments—is facing budget cuts; a not uncommon practice once a war is over and government priorities shift to other areas, such as the economy and healthcare. These cuts will limit the RCAF's capabilities and cause it to make do with what it has by living within its means—again, another historical theme of Canada's air force. This is a particularly acute problem for air forces, as the traditionally high cost of air power (which continues to grow with greater technological advancements), combined with the growing, global economic and financial interdependency of increasing globalization, means that possible economic instability in the future will negatively affect air force capabilities and procurement plans. Indeed, since the global financial crisis in 2008, and although the Harper Government was verbally supportive of the Canadian military, it also implemented a number of budget cuts and cost-cutting measures that limited the ability of the CAF to truly carry out *CFDS* objectives.[87]

CONCLUSIONS

The period of CF Transformation (1990–2015) saw an unprecedented level of change for the CAF and RCAF. Potential enemies disappeared only to re-emerge on the world stage. New threats, global and asymmetric in nature, have arisen to complicate the security picture. At the same time, the RCAF—as with every military force—continued to wrestle with shifting government priorities, ever-changing budgets, interservice rivalries, domestic responsibilities, new and expensive technology, and the never-ending demand to do more with less. Although this article is focused on a

specific twenty-five-year period, there is an argument to be made that these very problems, perhaps different in scale, have been faced by the RCAF throughout its existence. Change is a way of life.

But transformation is different. Transformation supposes a doctrinal, cultural and, perhaps, occupational shift within an organization. This is difficult to achieve without a monumental re-engineering of the organization or a "significant emotional event," such as a defeat on the battlefield, to act as the impetus. Certainly, unification transformed the RCAF, as it was shattered into functional pieces and reinforced a community-based culture. However, there were no significant changes in doctrine, technology or employment. AIRCOM was a largely unsuccessful attempt to reintegrate the fragments of the RCAF into a coherent whole.

With its personnel and budget reductions, the end of the Cold War (or perhaps it was a strategic pause) had a major impact on the RCAF, but was it transformational? Doctrine, or a lack thereof, did not change; nor did employment, although the emphasis shifted from alliances to the UN. Even technological changes, such as PGMs and computers, did not transform the RCAF; they simply increased the utility of the air force. Arguably, the introduction of jointness had the largest transformational impact on the RCAF by forcing it to master a new realm of warfare and organizational infighting. A joint environment also reinforced the fragmented nature of the Canadian air force, weakening whatever gains had been made by AIRCOM.

The advent of the global war on terror, operations in Afghanistan and the *CFDS* transformed the Canadian air force in that it was forced to do more than pay lip service to working with the Canadian army and navy. This was a logical evolution due to changes in the strategic environment and the joint approach to operations, at least in the areas of warfighting and new technologies or capabilities. Still, the air force has always been concerned that, if it is not careful, it might be "transformed" out of organizational existence, with elements that are still capable of tactical and operational excellence but suffer from institutional weakness. The RCAF's experience with transformation from 1990–2015 shows that transformation should not be crisis management; effective institutional change must be a well-structured process emphasizing a strong, central institutional air power identity, culture and ethos.

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ABBREVIATIONS

1 Cdn Air Div	1 Canadian Air Division
AIRCOM	Air Command
C2	command and control
CAF	Canadian Armed Forces
CAS	Chief of the Air Staff
CDS	Chief of the Defence Staff
CF	Canadian Forces
CFDS	*Canada First Defence Strategy*
CJOC	Canadian Joint Operations Command
DND	Department of National Defence
dot COMs	Canadian Forces Commands
IPS	*Canada's International Policy Statement: A Role of Pride and Influence in the World*
ISAF	International Security Assistance Force
PGM	precision guided munition
RCAF	Royal Canadian Air Force
SAR	search and rescue

NOTES

1. Established by royal assent on April 1, 1924, the RCAF has undergone a number of institutional name changes, ranging from the Royal Canadian Air Force, the Canadian Armed Forces "air element," AIRCOM, the Canadian Air Force and, most recently, a return to the Royal Canadian Air Force. The terms "RCAF" and "Canada's air force" will be used interchangeably throughout this article to refer to Canada's professional air power institution.

2. Canada, DND, "March 2020 - Royal Canadian Air Force (RCAF) - Lieutenant-General Al Meinzinger," Canada.ca, modified September 30, 2021.

3. This description is attributed to then-Major (recently retired Brigadier-General) Phil Garbutt, who was a student at Canadian Forces College from 2003–2004. Garbutt participated in the 2004 Air Symposium at Canadian Forces College, in which the former Commander 1 Cdn Air Div, Major-General Marc Dumais, also utilized the term. Richard Goette, "Concluding Remarks by the Commander 1 Canadian Air Division and the Chief of the Air Staff" in Allan D. English, ed., *Silver Dart Canadian Aerospace Studies*, vol. II, *Air Campaigns in the New World Order* (Winnipeg: Centre for Defence and Security Studies, 2005), 119.

4. For a good overview of the RCAF's history and unification from an air force perspective, refer to Dr. Allan English and Colonel John Westrop (Retired), *Canadian Air Force Leadership and Command: The Human Dimension of Expeditionary Air Force Operations* (Ottawa: DND, 2007), Chapters 2–3 and Chapter 4, 55–60.

5. The best account of AIRCOM's formation is S. L. James, "The Formation of Air Command: A Struggle for Survival" (master's thesis, Royal Military College of Canada, 1989).

6. Note that, until their withdrawal in 1993, the CF188s with NATO remained under Canadian Forces Europe and outside of AIRCOM's formal responsibility, although AIRCOM exercised considerable influence over them.

7. LGen Fred Sutherland (Ret'd), remarks to the Defence Studies 591: Command in A Canadian Context class, National Security Programme, Canadian Forces College, Spring 2013. Quoted with permission.

8. The best account of the RCAF communities is found in English and Westrop, *Canadian Air Force Leadership and Command*, 156–161.

9. Stephen L. James, "The Air Force's Cold War Struggle with Its National Purpose" (presentation, Annual Air Force Historical Conference, Kingston, 1997), 86.

10. James, "The Air Force's Cold War Struggle," 86.

11. James, "The Air Force's Cold War Struggle," 86–87.

12. Scot Robertson, "What Direction? The Future of Aerospace Power and the Canadian Air Force – Part 1," *Canadian Military Journal* 8, no. 4 (Winter 2007–2008): 10.

13. Rachel Lea Heide, "Canadian Air Operations in the New World Order," in English, *Silver Dart Canadian Aerospace Studies*, vol. II, *Air Campaigns in the New World Order*, 79–80.

14. The 1994 government White Paper on Defence was framed with financial stringency in mind during the post–Cold War period. It resulted in the defence budget being cut from approximately $12 billion to $9 billion, civilian personnel reduced from 20,000 to 10,000, and the CF Regular Force trimmed from 90,000 to 60,000 personnel. Canada, DND, "1994 Defence White Paper," White Paper, 1994, accessed October 3, 2015.

15. English and Westrop, *Canadian Air Force Leadership and Command*, 61.

16. This label, popularized by General Rick Hillier during his tenure as CDS, can in fact be attributed to the Commander of Canada's air force, LGen Allan DeQuetteville. Christian Leuprecht and Joel Sokolsky, "Defense Policy 'Walmart Style': Canadian Lessons in 'Not-So-Grand' Grand Strategy," *Armed Forces and Society* 41, no. 3 (July 2015): 12–13.

17. Canada, Director General Air Force Development, A-GA-007-000/AF-002, *The Aerospace Capability Framework: A Guide to Transform and Develop Canada's Air Force* (Ottawa: DND, 2003), Annex A.

18. AIRCOM consisted of an HQ in Winnipeg plus Fighter Group, Maritime Air Group, 10 Tactical Air Group and 14 Training Group; additionally, it maintained a close relationship with 1 Canadian Air Division located in Europe. For additional details on AIRCOM as a whole, refer to Canada, *Defence 1990* (Ottawa: Minister of Supply and Services, 1991), 39–46.

19. English and Westrop, *Canadian Air Force Leadership and Command*, 63–66.

20. For a comprehensive overview of the incident, refer to Canada, *Dishonoured Legacy: The Lessons of the Somalia Affair; Report of the Commission of Inquiry into the Deployment of Canadian Forces to Somalia* (Ottawa: Minister of Public Works and Government Services Canada, July 2, 1997).

21. Canada, Chief Review Services, 7050-10 (CRS), *NDHQ 99: Review of Restructuring and Re-Engineering*, vol. 1, *Executive Overview* (Ottawa: Chief Review Services, February 2001), accessed August 12, 2015, 2.

22. Canada, Chief Review Services, 7050-10 (CRS), *NDHQ 99*, 4–5.

23. For an overview of all of these transformational changes, refer to Canada, 1905-5 (Dir FP 97), *Flight Plan 97 Executive Summary* (Ottawa: Canada, June 6, 1997). A copy is held by the Director RCAF History and Heritage in Trenton, Ontario.

24. Canada, 1905-5 (Dir FP 97), *Flight Plan 97 Executive Summary*, 3.

25. English and Westrop, *Canadian Air Force Leadership and Command*, 67–70.

26. Heide, "Canadian Air Operations," *passim*, but especially 84.

27. For an overview of Canada's role in this campaign, refer to Lieutenant-Colonel David L. Bashow et al., "Mission Ready: Canada's Role in the Kosovo Air Campaign," *Canadian Military Journal* 1, no. 2 (Spring 2000), 55–61.

28. Canada, 1 Cdn Air Div, *Out of the Sun: Aerospace Doctrine for the Canadian Forces* (Winnipeg: Craig Kelman and Associates, Limited, 1997). A draft copy of *Out of the Hangar* is held by RCAF History and Heritage at 8 Wing Trenton.

29. Graham Fraser, "Liberal Continuities: Jean Chrétien's Foreign Policy 1993–2003," in *Canada Among Nations, 2004: Setting Priorities Straight*, ed. David Carment, Fed Osler Hampson and Norman Hillmer (Kingston: McGill-Queen's University Press, 2005), 177.

30. This renewal added maritime surveillance to NORAD's aerospace defence mandate. Agreement Between the Government of Canada and the Government of the United States of America on the North American Aerospace Defence Command, U.S.-Can, April 28, 2006, E105060; and Joseph T. Jockel, *Canada in NORAD 1957–2007: A History* (Kingston: McGill-Queen's University Press, 2007), 182–83.

31. Canada, DND, *Canada's International Policy Statement: A Role of Pride and Influence in the World* (Ottawa: DND, 2005), 11–12. DND defined transformation as a "process of strategic re-orientation in response to anticipated or tangible change to the security environment, designed to shape a nation's armed forces to ensure their continued effectiveness and relevance." LGen Ken Pennie, "Transforming Canada's Air Force: Vectors for the Future," *Canadian Military Journal* 5, no. 4 (Winter 2004–2005): 40.

32. Richard Gimblett, *Operation Apollo: The Golden Age of the Canadian Navy in the War against Terrorism* (Ottawa: Magic Light Publishing, 2004), Chapter 7.

33. For an overview of Canada's participation in Operation NOBLE EAGLE, refer to Jockel, *Canada in NORAD*, 165–70.

34. Canada's early contribution to Operation ENDURING FREEDOM was titled Operation APOLLO and lasted from October 2001 to October 2003. For an overview of Canada's commitment to this operation, refer to Canada, House of Commons, *Canadian Forces in Afghanistan* (Ottawa: House of Commons, June 2007).

35. For an overview, refer to J. L. Granatstein, *Canada's Army: Waging War and Keeping Peace*, 2nd ed. (Toronto: University of Toronto Press, 2011), Chapter 11; and *No Easy Task: Fighting in Afghanistan*, ed. Colonel Bernd Horn and Dr. Emily Spencer (Toronto: Dundurn Press, 2012).

36. Canada, DND, *Canada's International Policy Statement*, i.

37. Canada, DND, *Canada's International Policy Statement*, 2.

38. Canada, DND, *Canada's International Policy Statement*, 3.

39. Soft power is defined as "a persuasive approach to international relations, typically involving the use of economic or cultural influence." *Concise Oxford English Dictionary*, 12th ed. (2011), s.v. "soft power."

40. Canada, DND, *Securing an Open Society: Canada's National Security Policy* (Ottawa: DND, April 2004), 1–2. For more information on the CF's role in Afghanistan, refer to the sources listed in note 34.

41. Canada, DND, *Canada's International Policy Statement: A Role of Pride and Influence in the World; Overview* (Ottawa: DND, 2005), iv. Also, refer to Daniel Gosselin, "Navigating the Perfect Wave: The Canadian Military Facing Its Most Significant Change in 50 Years," *Canadian Military Journal* 8, no. 4 (Winter 2007–2008): 83–88.

42. Brigadier-General Daniel Gosselin and Dr. Craig Stone, "From Minister Hellyer to General Hillier: Understanding the Fundamental Differences between the Unification of the Canadian Forces and Its Present Transformation," *Canadian Military Journal* 6, no. 4 (Winter 2005–2006): 9; and Canada, DND, 1950-3, *CDS Planning Guidance – CF Transformation* (Ottawa: DND, October 18, 2005), 3–5. Also, refer to LGen Michael K. Jeffery (Ret'd), *Inside Canadian Forces Transformation: Institutional Leadership as a Catalyst for Change* (Kingston: Canadian Defence Academy Press, 2009).

43. Canada, Director General Air Force Development, A-GA-007-000/AF-002, *The Aerospace Capability Framework: A Guide to Transform and Develop Canada's Air Force* (Ottawa: DND, 2003), 3.

44. Canada, DND, A-GA-007-000/AF-004, *Strategic Vectors: The Air Force Transformation Vision* (Ottawa: DND, 2004), 2.

45. Canada, DND, *Aerospace Capability Framework*, 49–50.

46. "Canadian Military Says Underfunding Serious Problem for Defence Forces," CBC News, May 27, 2005.

47. Stephen Thorne, "Military Money Too Little, Too Late: Money in Budget Likely Not Enough for Overstretched Military," *Halifax Herald*, April 25, 2005, accessed June 14, 2015. Pennie described an acute "sustainability gap," noting that "the [Canadian air force] is at a critical time in its evolution, somewhat fragile after being incrementally reduced by half since the end of the Cold War. In fact, as we halved our strength, we have only reduced our infrastructure by 20 percent, leaving a stretched force." Pennie, "Transforming Canada's Air Force," 39.

48. Pennie wanted the air force to focus on a number of areas, including results-focused operational capability; responsive expeditionary capability; transparent interoperability; the transformation of aerospace capabilities; transformation-enabling leadership; multiskilled and well-educated people; expanded strategic partnerships; and improved resource stewardship. Pennie, "Transforming Canada's Air Force," 40–45. Also, refer to T. F. J. Leversedge, "Transforming Canada's Air Force: Creating a Strategic Planning Process," in English, *Silver Dart Canadian Aerospace Studies*, vol. II, 123–55.

49. Leuprecht and Sokolsky, "Defense Policy 'Walmart Style,'" 11.

50. Gosselin, "Navigating the Perfect Wave," 84. General Hillier described non-state enemies in the new security and defence environment as "snakes" compared to "the bear," which represented the more conventional enemy armed forces from the Cold War. Also, refer to General Hillier's CDS vision briefing.

51. Canada, DND, *Canada First Defence Strategy* (Ottawa: Canada Communication Group, 2008), 7, 21.

52. Canada, Department of Finance, *The Budget Plan 2006: Focusing on Priorities; Canada's New Government – Turning a New Leaf* (Ottawa: Department of Finance, 2006); and Gosselin, "Navigating the Perfect Wave," 84.

53. Canada, Department of Finance, *Budget Plan 2006*, 135.

54. André Deschamps, "Into the 21st Century – An Overview of Canada's Air Force in 2010," *Canadian Military Journal* 10, no. 4 (Autumn 2010): 59–63; and Robertson, "What Direction?," 34.

55. Canada, Minister of Public Works and Government Services, *Independent Panel on Canada's Future Role in Afghanistan* (Ottawa: Minister of Public Works and Government Services, January 2008), 38.

56. For an overview of Task Force Silver Dart, refer to Major Bill March, "Impact of a Combat Air Wing – Canadian Air Power in ISAF," *Joint Air Power Competence Centre Journal* 13 (Spring 2011): 15–19.

57. This number was calculated by RCAF History and Heritage in preparation to submit recommendations for battle honours. The number accounts for individuals who deployed multiple times and reservists; however, it does underline the operational tempo of the air force at that time.

58. The NATO mission was named Operation UNIFIED PROTECTOR, and the RCAF contribution, Operation MOBILE, lasted from March 19 to November 1, 2011. It consisted of transport, fighter, refuelling and maritime aircraft. For an overview of Operation MOBILE, refer to Canada, "Operation MOBILE," Canada.ca, modified January 22, 2014; and Richard O. Mayne, "The Canadian Experience: Operation Mobile," in *Precision and Purpose: Airpower in the Libyan Civil War*, ed. Karl P. Mueller (Santa Monica: RAND Corporation, 2015), 239–66.

59. The Canadian contribution (Operation IMPACT) to coalition operations against the so-called Islamic State of Iraq is ongoing and consists of fighter, transport and surveillance aircraft. For an overview of Operation IMPACT, refer to Canada, "Operation IMPACT," Canada.ca, modified September 20, 2022; and LGen Lloyd Campbell (Ret'd), "Op Impact: Canada and the Battle against Middle East Terrorism," *Airforce Magazine*, 2015, 21–27.

60. Canada, "Operation IGNITION," Canada.ca, modified February 3, 2021.

61. Canada, "Operation REASSURANCE," Canada.ca, modified March 25, 2022.

62. Canada, DND, *Canada's International Policy Statement*, 4.

63. Canada, DND, "News Release – New Canadian Forces Operational Commands Take Charge of Domestic, Special and International Operations," January 31, 2006. The Deputy Chief of the Defence Staff (DCDS), and in particular his DCDS Group, previously had command over all CF operations. The DCDS Group was dissolved in 2007.

64. Major Devin Conley and Dr. Eric Ouellet, "The Canadian Forces and Military Transformation: An Elusive Quest for Efficiency," *The Canadian Army Journal* 14, no. 1 (Spring 2012): 77–79; and Gosselin, "Navigating the Perfect Wave," 84–85. For further discussion on Canadian military culture, refer to Allan D. English, *Understanding Military Culture: A Canadian Perspective* (Kingston: McGill-Queen's University Press, 2004).

65. Gosselin, "Navigating the Perfect Wave," 84.

66. Gosselin and Stone, "From Minister Hellyer to General Hillier," 11.

67. Gosselin, "Navigating the Perfect Wave," 85. In addition, CF Transformation also led to the creation of a new Strategic Joint Staff tasked "to assist the CDS in his role as strategic commander and senior military advisor to the government." Gosselin and Stone, "From Hellyer to Hillier," 11.

68. Canada, DND, "Canadian Joint Operations Command (CJOC)," Canada.ca, modified July 12, 2018; and Philippe Lagassé, "A Mixed Legacy: General Rick Hillier and Canadian Defence, 2005–2008," *International Journal* 64, no. 3 (Summer 2009): 615.

69. Gosselin and Stone, "From Hellyer to Hillier," 10; and Jeffery, *Inside Canadian Forces Transformation*, 48–50.

70. Lagassé, "A Mixed Legacy," 606.

71. Conley and Ouellet, "Canadian Forces and Military Transformation," 79–81. Of note, the recent re-emergence of the term "service" vice "environment" into the CAF's lexicon and the return of traditional service-uniform characteristics (e.g., navy rank curls, army pips and crowns, and black- and pearl-coloured air force rank insignias) suggest the growing strength of the "strong-service idea."

72. Allan English, "Outside CF Transformation Looking In," *Canadian Military Journal* 11, no. 2 (Spring 2011): 15–16.

73. Conley and Ouellet, "Canadian Forces and Military Transformation," 80; and Jeffery, *Inside Canadian Forces Transformation*, 49.

74. English, "Outside CF Transformation Looking In," 14.

75. Jeffery, *Inside Canadian Forces Transformation*, 49; and English, "Outside CF Transformation Looking In," 14, 16. English notes that, when Hillier was Chief of the Land Staff in 2003, he advocated "that army transformation should be funded by cuts to navy and air force capabilities." English, "Outside CF Transformation Looking In," 14.

76. Robertson, What Direction?," 5.

77. English, "Outside CF Transformation Looking In," 15.

78. Leuprecht and Sokolsky, "Defense Policy 'Walmart Style,'" 14. On casualty aversion, refer to Hugh Smith, "What Costs Will Democracies Bear? A Review of Popular Theories of Casualty Aversion," *Armed Forces & Society* 31, no. 4 (Summer 2005): 487–512.

79. Canada, DND, "Operation IMPACT"; and Mark Kennedy, "Canada to Send CF-18 Jets to Iraq in Six-Month Mission," *Ottawa Citizen*, October 4, 2014.

80. English, "Outside CF Transformation Looking In," 16. Also, refer to Jeffery, *Inside Canadian Forces Transformation*, 44–45.

81. Brigadier-General J. P. Y. D. Gosselin, "A 50-Year Tug of War of Concepts at the Crossroads: Unification and the Strong-Service Idea," in *The Operational Art: Canadian Perspectives; Context and Concepts*, ed. Allan English, Daniel Gosselin, Howard Coombs and Laurence M. Hickey (Kingston: Canadian Defence Academy Press, 2005), 129.

82. Gosselin, "A 50-Year Tug of War," 129; and English, "Outside CF Transformation Looking In," 16.

83. Conley and Ouellet, "Canadian Forces and Military Transformation," 76; and RCAF Public Affairs, "RCAF Receives New Rank Insignia," *Airforce Magazine*, 2015, 7–9. However, this phenomenon has not included the return of traditional RCAF rank names (e.g., squadron leaders, group captains, air marshals).

84. Deschamps, "Into the 21st Century," 63.

85. Michael J. Hood, "Why Canadian Airmen Are Not Commanding," *Canadian Military Journal* 11, no. 3 (Summer 2011): 41–48; and Dr. Brad Gladman et al., "Professional Airpower Mastery and the Royal Canadian Air Force: Rethinking Airpower Education and Professional Development," *Royal Canadian Air Force Journal* 5, no. 1 (Winter 2016): 8–23.

86. Deschamps, "Into the 21st Century," 63–64.

87. In particular, as Christian Leuprecht and Joel Sokolsky note, "between 2010 and 2015, Canada's defence budget will have shrunk from 1.4 percent of [the gross domestic product] to 1.08 percent—a far cry from the goal of 2 percent envisioned as recently as the 2008 update to the *Canada First Defence Strategy*." Leuprecht and Sokolsky, "Defense Policy 'Walmart Style,'" 14.

COMBAT NAVIGATION

CHALLENGES AND PROPOSED SOLUTIONS

By Paul Anderson, CD, BASc

PNT warfare will place aerial resupply—such as this CC130J cargo drop performed during Exercise PÉGASE NORDIQUE in February 2018—at risk, but alternate PNT sources could foster successful aerial resupply in contested environments.

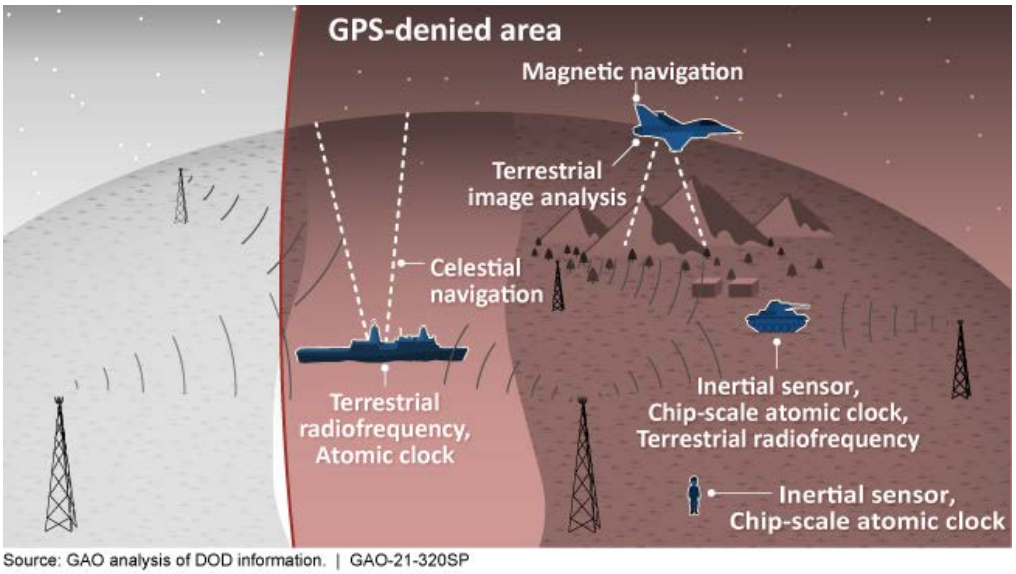
In the last 25 years, air navigation has evolved from using the magnetic compass to celestial computations to satellite-based navigation. Initially, this led to a simplification in required navigation skills, but the level of complexity involved in delivering reliable, accurate navigation is growing in both civil and military missions.

In civil airspace, the International Civil Aviation Organization (ICAO) has driven the Royal Canadian Air Force (RCAF) to move to performance-based navigation (PBN) based on global navigation satellite systems (GNSSs) such as the United States (US) global positioning system (GPS). But navigation in military environments—contested airspaces and remote destinations of military importance—faces challenges that GPS-reliant systems alone cannot resolve. This article addresses two of these military navigation challenges and proposes pan-RCAF solution paths.

GPS OVERRELIANCE

Jamming, spoofing and antisatellite operations place precision-guided capabilities such as munitions, aerial resupply, surveillance and secure communications at risk. In consequence, "the Department of National Defence (DND) is looking for non-GPS solutions for positioning, navigation and timing (PNT)."[1]

The Innovation for Defence Excellence and Security recently presented this challenge to industry. The Canadian Armed Forces (CAF) recognizes that navigation reliance on the GPS creates a single point of failure in critical mission systems. While this research challenge does not relate to aircraft, GPS-denied operations challenge the entire spectrum of military operations, including the navigation function.



Source: GAO analysis of DOD information. | GAO-21-320SP

DoD uses satellite-based GPS for critical operations with its aircraft, ships, munitions, land vehicles and ground troops. DoD is developing PNT technology to complement GPS or as an alternative when GPS is unavailable.

Accurate PNT information is critical to operations. The United States Department of Defense (DoD) Chief Information Officer has set PNT warfare—also called navigation warfare (NAVWAR)—policy in the last three years. This policy includes both offensive PNT operations and hardening of the military against PNT attacks. "The DoD will effectively employ NAVWAR capabilities to ensure a PNT advantage in support of military operations."[2] The secretaries of the military departments are responsible to ensure all platforms and systems using PNT information are NAVWAR compliant.

> A system is NAVWAR compliant if it continues to provide trusted PNT information over the time period required by a specific mission at the level of accuracy required by the mission in the expected physical, electromagnetic, and cyber environment.[3]

The key to this capability is to maintain tactical PNT resiliency—to be able to conduct precision operations in the absence of GPS. All platforms undergoing PNT modifications or upgrades must undergo "NAVWAR compliance effectiveness, including vulnerabilities associated with reliance on a single source of PNT information."[4] The GPS is one such single source for PNT data.

The US Government Accountability Office (GAO) released a report on the DoD's recognition of the threat that PNT warfare poses to military operations.[5] The May 2021 report covers some of the activities the DoD is pursuing to reduce the reliance on GPS for mission success. The threat is stated clearly: "Recognizing US reliance on GPS, potential adversaries are developing and using increasingly capable jammers and spoofers to deny the use of GPS by US military forces."[6]

The CAF relies heavily upon the US for GPS PNT data and much of the equipment using PNT data; therefore, any US government concern about GPS-denied operations and subsequent equipment requirements has a direct implication on CAF capabilities as well.

The technological arms race is outpacing the fielding of more secure Military Code (M-Code) GPS systems, which have suffered extensive delays in development.[7] The DoD intends to use GPS as the primary source of PNT information but is also working to provide alternative PNT information in the face of adversarial activities.[8]

Aspects of the DoD's "Summary of the 2018 National Defense Strategy of the United States of America"[9] mirror *Strong, Secure, Engaged: Canada's Defence Policy*,[10] placing great emphasis on joint effects and high value on alliances. State actors have re-emerged in long-term strategic competition from China and Russia as well as rogue regimes like Iran and North Korea. These adversaries possess PNT warfare technology.

Unfortunately, Canada cannot rely on emergent solutions from the US. The US DoD is splintered in its approach to meeting the PNT threat. While the Office of the Secretary of Defense is responsible for developing and maintaining a PNT road map, there is not a central agency responsible for developing alternative PNT solutions.[11] PNT, despite being mission critical, is considered a second-tier requirement, and alternative PNT solutions are considered by bureaucrats to be threats to the GPS program. The GAO report indicates concern over relying upon GPS without backup as the core of the military PNT solution.

The RCAF is expected to operate in contested airspace. PNT resilience in GPS-denied environments should be a fundamental requirement. Canadian solutions should be developed. DoD policy

will support Canadian initiatives to improve PNT warfare capabilities. "Through existing information and technology transfer control processes, DoD will ensure a PNT information advantage for US and allied forces."[12]

Positional accuracy is important to both civil and military operations. ICAO PBN relies on a 95% probability that the aircraft is within a certain boundary (e.g., within 0.03 nautical miles of centreline on approach with a 99.999% probability of remaining within twice the bounded limit of 0.06 nautical miles).[13] Military airdrop operations rely on accurate flight to the computed air release point (CARP) or remaining in low-level-transit-route "safe" lanes while other military activities are conducted nearby.[14] PNT accuracy is essential to the successful conduct of military operations in contested airspace. Adversarial GPS jamming and spoofing can have a negative effect on this accuracy.

M-Code GPS is a planned future enhancement to the GPS system, but it remains years away.[15] While M-Code strengthens the GPS solution against current jamming and spoofing measures, it does not offer PNT resilience in the absence of a GPS signal.

Visual navigation updates are not sufficient for military operations. They are highly dependent on the weather; therefore, reliance on even the most precise visual update will not guarantee mission success.

Radar updates offer an all-weather capability. However, emissions offer the opportunity for enemy detection and the update can be poor; ground target updating will assume perfect cursor target positioning by aircrew. Often, the actual update accuracy can be worse than no update at all.

The crew of a CC130J Hercules aircraft drop a major air disaster kit into York Sound, Nunavut, during Operation NANOOK 2014 on August 26, 2014.

Inertial navigation systems (INSs) are not susceptible to PNT warfare but have inherent positional-error increase over time. The drift rate of aviation-grade INS systems is on the order of 0.8 nautical miles per hour.[16]

A fusion engine can combine sources of PNT information to refine vehicle position, velocity and orientation. The United States Air Force (USAF) uses Link 16 Relative Navigation (RelNav) as a fusion engine.[17] Each participant transmits their precise position location information (PPLI) on the network, providing a constellation similar to GPS satellites. Each participating computer can derive a location solution from this data. RelNav is an encrypted, anti-jam PNT solution that inherently monitors its accuracy with capabilities similar to ICAO PBN solutions.[18] Canada's CF188 fleet is capable of using RelNav to deliver ordnance.

The CC130J Hercules, CP140 Aurora, CH148 Cyclone, CC150 Polaris and CF188 Hornet as well as the Strategic Tanker Transport Capability Project are planned to receive a Defence Cryptographic Modernization Project–compliant tactical data link (TDL) system.[19]

Bringing inherent capabilities within the TDL system into the aircraft avionics solution could provide a PNT solution independent of the GPS in contested airspace. Integrating the Link 16 RelNav solution would improve combat navigational accuracy en route to objectives and support field commanders with accurate aerial resupply and future precision effects.

PNT RESILIENCE

The CC130J has a large Block 8.1+ project about to enter project definition. The navigation system will be upgraded to ICAO PBN capabilities. Navigation for the C130J Block 7 and up relies extensively on both civil and military GPS systems for both navigation and as PNT truth sources for on-board systems.

The CC130J has a hierarchy of navigation solutions available. Various receivers provide ground-based, inertial and space-based combinations, most of which are run through an algorithm to remove statistical noise and arrive at a position calculation that has an associated probabilistic accuracy measurement.[20] Currently, the INS is the only PNT-resilient navigation source. It can be combined with navigation radio signals from very high frequency omnidirectional receivers or distance-measuring equipment for position updates, or it may be blended with the military GPS. Only the independent INS solution is hardened against PNT countermeasures.

When navigation-ready, the CC130J INS solution has a design drift rate of 0.8 nautical miles per hour circular error probable (CEP).[21] Drift is inherent in the INS design and functionally means the INS-only solution accuracy may degrade at 26.6 metres per minute. For example, *in the absence of any other errors,* an INS-only airdrop would only be considered accurate within the limit of current RCAF tolerances (300 metres) in the first 11 minutes of an INS-only navigation solution. Airdrop missions typically take well beyond 11 minutes to get to the drop zone; therefore, an update (or "bias") to the INS solution is necessary.

The INS solution can be improved with either an internal algorithm (Kalman filtering) or an external bias to reset the drifting solution. Kalman filtering can mitigate the magnitude of the INS drift rate, but accuracy continues to degrade over time.[22] Several updates are required to tighten up accuracy. External position updates to the INS can be accomplished in several ways.

Radar updates and visual updates are two available bias methods used by some nations in a NAVWAR environment. Neither will provide a highly accurate position without highly trained aircrew, and both are functionally only a means of position assurance rather than position accuracy.[23] Both the radar and the human eye are primarily a gross-navigational-error check for the INS.

The C-130J Joint User Group is a possible means to expand Canadian PNT capabilities. This multinational group is studying elements of detecting and countering PNT warfare; however, current projects do not extend into alternative PNT sources for the GPS system.

Lockheed Martin has recently investigated and reported on the engineering required to bias the Embedded GPS INS (EGI) INS-only navigation solution with the Link 16 RelNav solution. The approach would be to pull the Link16 RelNav position information from the red side of the Special Mission Data Processor into the flight-management-system integrated navigation solution.

EXPEDITIONARY ADVERSE–WEATHER APPROACH CAPABILITIES

To have an adverse-weather expeditionary approach capability, the RCAF relies on precision approach radar (PAR) units deployed from 8 Air Communications and Control Squadron (8 ACCS). The technology is effective but very old. It requires an extensive workforce to operate and maintain as well as dedicated transportation to a forward location and flight qualification from an instrument check pilot prior to operational use. It is not a stealthy system; electromagnetic radiation removes all doubt about where the unit is located.

A classified NATO standardization agreement exists on "the design requirements for an airborne multi-mode receiver for precision approach and landing."[24] NATO allies have been looking for a better solution for over 20 years.

Conventional GPS approaches offer a cost-efficient solution in non-contested environments. Lateral guidance-only GPS approaches can get aircrew down to non-precision approach weather minima. GPS approach procedures with vertical guidance provide precision approach–like guidance, but are geographically limited to regions that have sufficient satellite-based augmentation system (SBAS) coverage.

Canadian Forces Stations (CFSs) Alert and Eureka are too far north to receive wide-area SBAS coverage. Poor weather can limit timely mission success. CFS Alert resupply missions are limited GPS approaches with cloud ceilings of 400 feet (122 metres) or greater and visibilities of one statute mile (1.6 km) or greater (400/1). Arctic alternate airfields are scarce and CFS Alert is only usable as an alternate with weather of 800/2 or greater.

TACTICAL ADVERSE-WEATHER APPROACHES

Expeditionary adverse-weather approach capabilities on the CC130J are limited. The "CC130J Statement of Operating Intent"[25] implied tasks place great emphasis on airland deployment, sustainment and redeployment operations to meet the aim of *Strong, Secure, Engaged: Canada's Defence Policy*. The CC130J will be operated into austere tactical airfields in all environmental conditions.

The Lockheed Martin Integrated Precision Radar Approach (IPRA) was designed to provide this capability. The IPRA has the adverse-weather potential to allow aircraft to fly down to non-precision weather minima using a blended navigation solution. The landing zone (LZ) feature in the CC130J could also allow non-precision weather minima, but the lack of design assurance level (DAL) on the CNI-SP NAV and Flight Management Application partitions[26] has placed the original equipment manufacturer in the position where it recommends restricting LZ approaches to visual meteorological conditions (VMC) only.

The Secure Radio Modernization Project (SRM) for the CC130J will replace the ultra-high frequency AN/ARC-164 radios with two multiband AN/ARC-210 RT-2036(C) radios to meet DND cryptographic modernization (CM) requirements. These radios will be fully integrated into the Flight Management System on the MIL-STD-1553 Communications/Navigation buses.

Lockheed Martin has been asked by Canada to investigate and report the engineering approach to incorporate the expeditionary Joint Precision Approach and Landing System (eJPALS) waveform into a usable CC130J military-only approach capability with precision weather minima. A Modular Open Systems Approach (MOSA) to systems development is considered a key design approach to address PNT challenges.[27]

The CC130J will remain Canada's tactical aviation workhorse for the next 25 years. The two improvements suggested here counter poor weather and adversary activity to ensure that tactical airland and airdrop remain available anywhere, anytime.

LOWER INSTRUMENT-APPROACH MINIMA IMPROVES OPPORTUNITIES FOR MISSION SUCCESS.[28]

The SRM provides a possible solution path. It will provide multiband AN/ARC-210 RT-2036(C) radios to meet DND CM requirements on the CC130J, CP140, CH148 and CC177 Globemaster. CM projects were not conceived to address navigation, but the AN/ARC-210 radio will be delivered with the Joint Precision Approach and Landing System (JPALS) waveform.

JPALS uses military-encrypted differential GPS technology to provide highly accurate, precision-approach capabilities to aircraft in adverse weather. This was originally developed for the US Navy F-35 program for carrier landings. Raytheon has developed eJPALS[29] from the JPALS concept. It is a differential GPS system using a ground-based antenna array to provide similar capability to any number of LZs within 20 nautical miles of the antenna.

Royal Navy Commander Nathan Gray in his F-35B following the first deck landing aboard HMS Queen Elizabeth.

CFS Alert would benefit from this system. Recognizing the impact of weather on mission success, Operation (Op) BOXTOP resupply missions are supported with a PAR system for a pair of two-week periods annually. When PAR is deployed, the approach weather limits improve to 200 feet (61 metres) and ½ statute mile (0.8 km) [200/½]. It also requires 30 aircraft hours of deployment/redeployment time from 8 Wing Trenton, calibration flights from an instrument check pilot and a full-time staff during each two-week operation. The eJPALS would replace this system with a single antenna placed where power is convenient, allowing year-round operations in weather conditions as low as 200/½.

eJPALS could change Arctic resupply. Rather than spending 60 aircraft hours transporting PAR to and from CFS Alert each year for Op BOXTOP, a permanent antenna could be installed. The transportation cost savings would be in excess of Can$2.2 million per year.[30] Improved instrument-approach weather minima would be available year-round instead of only during Op BOXTOP. Other installations could be made at strategically important locations throughout the Arctic wherever the military deems weather to be a limiting factor to mission success.

> Raytheon and the Marine Corps are also in talks over using JPALS ashore to help pilots find expeditionary runways, which would be particularly relevant under the Marines' Expeditionary Advanced Base Operations concept that involves dispersing small groups of Marines across islands and shorelines where there may not be much established infrastructure. The service has already practised establishing expeditionary airfields to refuel and rearm aircraft, and having a JPALS system on the ground would make it much easier and safer for these planes to come in for a landing in a new and temporary location.

> When you think about island-hopping, the system is so small—right now it's just in transit cases, like pelican cases—you can throw it in the back of a helicopter, land, set it up and you're good to go. … If you need to move to another island, you can pick it back up and go, and it takes about an hour [for] synchronization with the satellites: so you roll out the transit cases, set up your GPS triangle in about 15 minutes, and then you're synchronizing with satellites and you're good to go for precision approach.[31]

The eJPALS *would* change expeditionary operations. The antenna and power supply can be installed and operating in 20 minutes. The antenna may operate as far as 20 nautical miles from the objective airport, making it an outstanding pathfinder solution. Unlike the PAR, it can serve all runways at once. It can provide curved-path approaches. The encrypted signal from the dispersed antenna can prevent unauthorized use and avoid signals intelligence triangulation. The eJPALS shows promise to deliver multi-fleet expeditionary and Arctic adverse-weather approach capability.

THE MASKING EFFECT OF POOR WEATHER WOULD BECOME A TACTICAL ADVANTAGE RATHER THAN AN OPERATIONAL LIMITATION.

Disaster relief, covert ingress and Arctic resupply—low ceilings and poor visibility can delay or hinder mission success. Modernizing tactical-navigation capabilities will ensure the RCAF continues to meet the combat challenges described in *Strong, Secure, Engaged: Canada's Defence Policy*.

Paul Anderson was a pilot on CC130s from 1992–2018, serving 17 deployments in places such as Sarajevo, Belet Huen, Bunia, Baghdad, Kandahar and Tripoli. He has flown C-130E, H, and J aircraft with the RCAF, Royal Air Force and USAF, completing his RCAF career working alongside Aerospace Engineering Test Establishment on the test and evaluation of the Block 7 CC130J variants. He is an aerospace engineer with Assistant Deputy Minister (Materiel) and is currently the CC130J Operational Requirements Manager working on the international Block 8.1, Block 8.1.1 and Block 8.1.2 upgrades.

Canadian Armed Forces personnel prepare to load vehicles on to a CC177 Globemaster aircraft for transportation to CFB Alert during Operation BOXTOP on October 1, 2016, at Thule Air Base, Greenland.

ABBREVIATIONS

CAF	Canadian Armed Forces
CARP	computed air release point
CFS	Canadian Forces Station
CM	cryptographic modernization
DND	Department of National Defence
DoD	Department of Defense
eJPALS	expeditionary Joint Precision Approach and Landing System
GAO	Government Accountability Office
INS	inertial navigation system
JPALS	Joint Precision Approach and Landing System
LZ	landing zone
M-Code	Military Code
NAVWAR	navigation warfare
Op	operation
PAR	precision approach radar
PBN	performance-based navigation
PNT	positioning, navigation and timing
RCAF	Royal Canadian Air Force
RelNav	relative navigation
SRM	Secure Radio Modernization Project

NOTES

1. "Resilient Non-Global Positioning System (GPS) Based Positioning, Navigation and Timing," Government of Canada, modified March 30, 2022.

2. US, DoD, DoD Instruction (DoDI) 4650.08, *Positioning, Navigation, and Timing and Navigation Warfare*, Change 1 (n.p.: DoD, December 30, 2020), para 1.2 (a).

3. US, DoD, DoDI 4650.08., para 3.1.

4. US, DoD, DoDI 4650.08., para 1.2(c) and para 3.4.

5. US, DoD, GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities* (Washington, DC: GAO, May 2021).

6. US, DoD, GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities*, 3.

7. "GPS Modernization: DoD Continuing to Develop New Jam-Resistant Capability, But Widespread Use Remains Years Away," United States Government Accountability Office (GAO) Report to Congressional Committees, accessed October 26, 2022.

8. US, DoD, GAO-21-320SP *Technology Assessment: Defense Navigation Capabilities*, 13.

9. "Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge," DoD, accessed October 26, 2022.

10. Canada, DND, *Strong, Secure, Engaged: Canada's Defence Policy* (Ottawa: DND, 2017).

11. US, DoD, GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities*, 31.

12. US, DoD, DoDI 4650.08, para 1.2 (g).

13. For a description of RNP approach (RNP APCH) standards see "Advisory Circular (AC) No. 700-023: Required Navigation Performance Approach," Canada.ca, modified May 14, 2018.

14. Conventional CARP procedures were based on Circular Error Probable statistics, which were a 50% measure of success. Modernized equipment minimizes the navigation error in a CARP calculation. Aircrew are now capable of monitoring the navigation solution with a 95–98.5% accuracy when using a GPS solution.

15. "GPS Modernization: DoD Continuing to Develop."

16. Lockheed Martin Aeronautics Company, CC130J-1-5: *Flight Manual Communication/Navigation/ Identification-Management System (CNI-MS) Operator Manual Tactical Transport Lockheed Martin Model 382V* (May 1, 2020), 6-6.

17. US, DoD, GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities*, 26. The Kalman filter is a computational version of a fusion engine.

18. Geodetic position, geodetic altitude and time are measured in 15 discrete quanta, with the highest one sigma positional accuracy measured in the order of 15 metres, much like a figure of merit (FOM), which is a conventional navigation measurement of 95% (two sigma) accuracy. A FOM of 1 equates to 25 metres or better accuracy. The two measurements are in the same order of magnitude.

19. The SRM project will deliver Link 16 to the CP140, CH148, CH147 and CC150. The Hornet Extension Project will deliver Link 16 updates to the CC130J and CF188.

20. The CC130J employs Kalman filters to integrate navigation solution source information in both the Flight Management System and the Embedded GPS/INS (EGI).

21. Lockheed Martin Aeronautics Company, *CC130J-1-5: Flight Manual*, 6-6.

22. Currently, the Director Technical Airworthiness and Engineering Support does not have visibility into the calculations within the Kalman filters used on-board. Questions exist as to the accuracy and integrity of current filtered, blended solutions.

23. Position assurance is defined here as a confidence in the reliability of the calculated location, or in other terms, a gross integrity check that raises confidence in the system operation.

24. NATO, Ministry of Defence, Standardization Agency (STANAG) 4565, *Airborne Multi-Mode Receiver (MMR) for Precision Approach and Landing* (September 26, 2003), CLASSIFIED.

25. Canada, DND, "CC130J Statement of Operating Intent," Version 3.0 (June 2020).

26. Lockheed Martin Aeronautics Company, CO-LTM-2020-000519-0, "Lockheed Martin C-130 Safety Notification – Military Block 7 and 8.1 Communication, Navigation, and Identification – System Processor (CNI-SP) Software Applications" (February 11, 2020).

27. US, DoD, GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities*, 22.

28. The author reviewed 16,162 Alert Airport (CYLT) meteorological observations from January 3, 2017, to December 31, 2020. Having 200/½ weather minima available reduces the adverse-weather impact on mission success by nearly 50%. The ceiling and/or visibility dropped below existing non-precision weather minima 8.92% of the time. Precision-approach weather minima reduces the chance of unsuccessful approach due to ceilings and visibility to 4.49% over the entire three-year period. Data available on request.

29. For further details see US, DoD, "Expeditionary Joint Precision Approach and Landing System (eJPALS)," White Paper, January 27, 2021. This document is UNCLASSIFIED but Export Controlled. Not for distribution outside of DND.

30. Canada, DND, "Cost Factors Manual: Air Chapter, 2018 – 2019" (Ottawa: Director General Costing, Investment Planning, & Approvals, March 2019), Table 1-1.

31. Megan Eckstein, "Raytheon's Precision Landing System Could Be Coming to More Allied Ships, Expeditionary Airfields Soon," *Defense News*, September 3, 2021.

RCAF HISTORY & HERITAGE COLUMN

By Dr. Richard Mayne, CD

To launch the very first Royal Canadian Air Force (RCAF) History and Heritage (H&H) Column in this *Journal*, we are excited to announce the RCAF Centennial Conference! The conference is scheduled for May 29–31, 2024, in Ottawa. More details will appear soon; the topics covered will be broad, including contemporary and historical air power.

Some of our readers may be aware of RCAF H&H, but for those who are not, your Air Force does indeed have a small but determined H&H organization. We trace our origins back to the Second World War.[1] During the First World War, Canadians served as individuals within the British flying services, and all too often their stories were scattered and buried within those larger narratives. In the hopes of avoiding such a fate, a small historical staff was formed within the Ottawa RCAF headquarters in January 1940, four months after the declaration of the Second World War. First World War fighter pilot ace Kenneth Conn was appointed to lead the organization. His small office, which existed for the length of the war, originally focused on ensuring that records were kept to support the eventual production of an official history, but by 1943, it had grown to include several pre-war academics and, in 1944, began publishing the anthology series *The R.C.A.F. Overseas*.[2] These popular histories were produced in three volumes and were mainly the work of Wing Commander Fred Hitchins. In December 1945, Hitchins was appointed as the post-war RCAF Air Historian (what would today be called "Official Historian"), with a staff of 14 personnel housed in offices at RCAF Station Rockcliffe. Hitchins' original aspiration was for an eight-volume series, which would cover not just the Second World War but everything from the Silver Dart and activities of Canadian airmen in the First World War to the full breadth of the air operations wherein the RCAF participated in the Second World War, as well as more specialized subjects.

Post-war cuts resulted in those ambitions being scaled back, and unification merged the RCAF Historical Office into the joint Directorate of History (subsequently renamed to Director History and Heritage [DHH]), which produced three volumes of *The Official History of the Royal Canadian Air Force*.[3] The current version of RCAF H&H was first proposed in 1989 by the Commander Air Command, Lieutenant-General F. R. Sutherland. It serves both the Air Staff and the Royal Canadian Air Force Aerospace Warfare Centre, where it is working in cooperation with DHH to produce a fourth volume of *The Official History of the Royal Canadian Air Force* that covers the Cold War period up to unification. Furthermore, modern RCAF H&H assists with other history, museum and heritage initiatives, and it consists of the following personnel and sections:

- Director: Dr. Richard Mayne, CD;
- Official Historian: Lieutenant-Colonel Paul Johnston, CD, PhD;
- Chief of Staff and Centennial Support: Lieutenant-Colonel Jennifer Weissenborn, CD;
- Museum and Heritage Officer: Major Bruno Paulhus, CD;
- Historical Officer: Major Fred Paradie, CD;
- Operational Records Management: Major Dave Podolchuk, CD;
- Associate Air Force Historian Programme (75+ volunteers); and
- Wing Heritage Officer Programme.

Given the range of activities performed by RCAF H&H, this column will focus on the history as well as official records management (ORM) sections, while museums and heritage will be covered in the next edition of the *Journal*. The history and ORM programmes therefore consist of the following:

- **Publications**. RCAF H&H researches, writes and publishes its own histories in addition to providing direct support to DHH's Official Histories.
- **Interview programme**. RCAF H&H interviews veterans and members who participated in current and recent operations.
- **Bi-annual historical conferences**.
- **Education programme**. The Air and Space Power and History stream of study as well as lectures and outreach to academia are being developed.
- **RCAF digital archives**. RCAF H&H is collecting, collating and digitizing impressive archives of photos and documents.
- **Documentaries**. RCAF H&H provides research and assistance for documentary and film producers working on topics related to the RCAF.
- **Operational records management**. The focus is on document and artefact collection from recent and current operations as well as capturing today's operations for tomorrow's historians and curators (ready-to-go document packages).
- **Operation diaries, in-theatre historians and Annual Historical Reports (support to DHH)**. Examples include providing past technical assistance visits conducted to support historical and museum needs from Operations MOBILE and UNIFIED PROTECTOR as well as Operations IMPACT and INHERENT RESOLVE; capturing RCAF history as it happens; and assisting the DHH with the collection of historical data from RCAF units as well as with quality assurance to meet the Chief of Military Personnel's standards for Annual Historical Reports and operation diaries.
- **Historical inquiries**. RCAF H&H responds to multiple inquiries (mostly from private citizens, Air Staff and ministers).

RCAF HISTORY HIGHLIGHTS

In every Column, we plan to include a paragraph of our fascinating history; for this inaugural Column, we are covering the RCAF's founding. The RCAF's date of birth is April 1, 1924, but—as most of you will know—there were certainly individual Canadian aviators before that time. However, did you know that there were no less than four Canadian military-aviation organizations before we settled upon the RCAF? The first was the short-lived Canadian Aviation Corps (CAC), quickly formed within the Canadian Militia (i.e., the army) upon its mobilization in 1914. The CAC never grew beyond three men and one biplane, and it was disbanded in early 1915 when it was decided that Canadians would simply transfer to the British Royal Flying Corps or Royal Naval Air Service. The second Canadian military-aviation organization was the equally short-lived Royal Canadian Naval Air Service, formed in September 1918 to fly defensive U-Boat patrols launched from Nova Scotia, but it was disestablished in December of the same year. Next, there came not one but two entities known as the "Canadian Air Force," without the "Royal" appellation. The first one resulted from a desire to create a Canadian air service so Canadian aviation personnel could serve in Canadian units (Canadians having joined the British Royal Flying Corps or Royal Naval Air Service as individuals). However, by the war's end, only two squadrons had been established,

and both were still organizing in the United Kingdom. It was dissolved and returned to Canada after the armistice. In 1920, a second Canadian Air Force was formed using surplus war material and Canadians with aviation experience from the war. That Canadian Air Force was an amalgam of bits and pieces from the war, and in 1924, it was decided to form the RCAF, which had the "Royal" appellation and was explicitly modelled after the Royal Air Force.

WATCH THIS SPACE IN ALL FUTURE ISSUES FOR MORE!

ABBREVIATIONS

DHH	Director History and Heritage
H&H	History and Heritage
RCAF	Royal Canadian Air Force
RCAF H&H	Royal Canadian Air Force History and Heritage

NOTES

1. For a concise summary of RCAF historical offices, refer to Tim Cook, *Clio's Warriors: Canadian Historians and the Writing of the World Wars* (Vancouver: UBC Press, 2006), 111–18, 163–88.

2. The three volumes of *The R.C.A.F. Overseas* are available online as PDFs.

3. S. F. Wise, *Canadian Airmen and the First World War*, vol. 1 of *The Official History of the Royal Canadian Air Force* (Toronto: University of Toronto Press, 1980); W. A. B. Douglas, *The Creation of a National Air Force*, vol. 2 of *The Official History of the Royal Canadian Air Force* (Toronto: University of Toronto Press, 1986); and Brereton Greenhous et al., *The Crucible of War 1939–1945*, vol. 3 of *The Official History of the Royal Canadian Air Force* (Toronto: University of Toronto Press, 1994).

POINTS OF INTEREST

USE OF HIGH-FIDELITY FLIGHT TRAINING DEVICES DURING AB INITIO FLIGHT TRAINING

BY MAJOR JAMES TUTTE (RETIRED), CD

A Bell 206 Level 7 FTD in Southport, Manitoba, developed by Frasca International.

As detailed in 2 Canadian Air Division guidance and other policy documents,[1] the RCAF is committed to innovation in, and the modernization of, all types of training, including the use of simulation. During flight training, simulation technology can take several forms, one of which is a flight training device (FTD). FTDs of varying levels of complexity, sophistication and fidelity have been used during flight training for more than 90 years. They are particularly well suited for training-instrument flying, responding to system malfunctions and emergencies, and developing human performance in military aviation (HPMA) skills. FTDs can be used for individual and crew training. Historically, flight schools have relied on lower-fidelity, non-motion desktop trainers, instrument-procedures trainers and cockpit-procedures trainers to help students with the basics of flying generic and specific aircraft without visual or motion cues. However, high-fidelity, motion-based and fixed-wing / helicopter-specific FTDs are now available for a reasonable price, with augmented-reality and virtual-reality options rapidly increasing in capability for largely reduced costs. In many cases, these more capable FTDs have primarily been used to convert experienced pilots to new types of aircraft. But what place do these high-fidelity FTDs have during the ab initio phases of flight training, prior to achieving RCAF "wings standard"? To answer this question, it is necessary to assess the level of FTD required for the desired training outcome, determine which ab initio flying skills are suitable for FTD training, and ensure FTD instructors have the appropriate training, outlook and competencies.

WHY IS AB INITIO TRAINING DIFFERENT?

The differences between conversion (i.e., recurrent) and ab initio flying training are critical to this discussion. Conversion flying training is used to convert qualified fixed- or rotary-wing pilots to a new aircraft or to ensure continued proficiency with a type for which a pilot is already qualified. This training consists of refreshing or honing previously learned skills and/or adapting existing skills to an operating environment. Ab initio flying training is focused on teaching the fundamental and foundational skills needed to safely fly a fixed- or rotary-wing aircraft. Emphasis is placed on using basic control functionality and effects to achieve desired flight parameters. Initially, the trainee is taught to complete basic manoeuvres individually, with the eventual aim of combining these items into more complex sequences, such as a circuit.

WHAT IS A HIGH-FIDELITY FTD?

Unfortunately, there is no universally-accepted definition for "high-fidelity FTD." Regulatory organizations such as Transport Canada and the Federal Aviation Administration provide standards

for certifying various levels of FTDs and full flight simulators. However, there is no specific line dividing the levels of fidelity.[2] The overall fidelity level of an FTD is a combination of multiple factors: the degree of accuracy to which the aircraft flight model is replicated; the level of detail in the visual scene; the availability and accuracy of any proprioceptive[3] cues; and the response time between the pilot's control inputs and the associated visual/proprioceptive changes. For ab initio training, where students are concentrating on basic control inputs and are less sensitive to nuances in control handling, the level of detail in the visual scene and the speed of the visual response to the control inputs are of prime importance. Initially, the FTD's ability to replicate a specific aircraft's flight characteristics is less important as long as the control movements generally replicate the class of the aircraft being used. As training becomes more advanced and higher proficiency levels are required, the accuracy of the flight model (and consequently, an FTD certified to a higher level) is warranted.

WHAT KIND OF HIGH-FIDELITY FTD IS NEEDED?

A Bell 412CF Level D full flight simulator in Southport, Manitoba, developed by FlightSafety International.

It is important to match the FTD's fidelity level to the stage of training, the aim of the specific training event and the resulting competency level expected of the trainee. If the training event is meant to simply familiarize the trainee with the visual indications for specific malfunctions, then a desktop trainer or computer simulation might meet the needs as opposed to a full-motion FTD. However, if the desired competency level is the ability to recognize the malfunction and the applicable response—including switch selections, crew actions, control handling, and the appropriate approach and landing—to a high level of proficiency, then conducting this training using a full-motion FTD would likely be most effective. The act of matching the aim of the specific training event with the most effective training method, known as method and media analysis, is ideally accomplished during the development of the overall course training plan.

Method and media analysis can be conducted from different viewpoints, depending on the needs of the training establishment and the funds available. When the training establishment has limited funding that can be used to purchase an FTD, this analysis can be completed from the viewpoint of "This is what we can afford; what can we do with it?" If the training outcomes are more important, then the analysis can be more centred on "Here's what we want to do; what devices are available that can be used to achieve these outcomes?"

It is also important to understand that, no matter how high the FTD's fidelity level is, an FTD is simply an emulation of the handling and performance characteristics of one version of a specific

aircraft type. Many of the distinct nuances and proprioceptive inputs that are part of flying in an actual aircraft will not or cannot be simulated in an FTD. In any fleet, each individually numbered aircraft has minor differences in the control feel, vibration levels, power available/required and other factors. It is therefore unrealistic to expect that an FTD will completely replicate the in-aircraft experience. However, if training establishments and individual instructors are aware of these limitations, they can maximize the effectiveness of the FTDs for training the applicable skills to an appropriate proficiency level.

WHAT SKILLS CAN BE TRAINED?

During ab initio flight training, the following skills and tasks are well suited to training in an FTD:

A. basic aircraft procedures:

   i. start and shutdown checks, including pre-flight systems checks;

   ii. local area / airfield familiarization, including reporting points, restricted airspace and circuit references;

   iii. the basic mechanics of each sequence, including the attitudes, effects of controls, power settings, amount of control movement required, sight pictures and external/internal references; and

   iv. the sequence of events for each manoeuvre, including checks, clearing turns, briefings and references (i.e., "When should I do what?"; "How much time will each subtask take?"; "When are any applicable radio calls made?").

B. control-handling techniques:

   i. hand grip on controls and hand/arm position;

   ii. the use of force trim, force-trim release, attitude trim (as available) and other trimming techniques;

   iii. the use of automation, including different levels of stabilization or flight-control augmentation; and

   iv. the use of different control-handling techniques or automation levels to determine which works best in each situation.

C. the development of the crew's standard operating procedures and HPMA skills:

   i. targeted HPMA skills through standardized and repeatable scenario-based missions for consistency in training (e.g., crew/flight coordination, task and workload management, decision making, hazard/threat and error management, situational awareness, and the use of automation); and

   ii. the responsibilities of each crewmember during various phases of flight (clear hood, instrument flying, navigation and night).

D. the recognition of and response to malfunctions:

   i. more complex systems in modern aircraft necessitate the ability to accurately analyse and diagnose malfunctions, particularly with electrical systems and automation;

   ii. trainees can learn what information is displayed where and determine what the displays indicate regarding the mission;

   iii. at first, malfunctions can be introduced at lower workload times and, during future missions, these malfunctions can be given during times of increased workload to exercise HPMA skills; and

   iv. trainees must have the ability to complete all cockpit actions and shut down engines to see the indications and systems lost.

WHY IS FTD INSTRUCTION DIFFERENT THAN IN-FLIGHT INSTRUCTION?

FTD instructors must be appropriately trained and proficient in the use of the FTDs as well as in some FTD-specific instructional techniques. Traditionally, an in-aircraft flight instructor is seated at a control position, which enables them to feel the trainee's control movements in order to assist in analysing any faults in the trainee's performance. In many cases, the FTD instructor is not seated in a control position and must use cues that are not related to feeling the trainee's control movements to analyse any errors. They must rely more heavily on verbal cues from the trainee or on observing the trainee's control handling from a non-control position. Additionally, the FTD instructor must monitor the simulated aircraft's flight parameters in relation to the desired flight profile, potentially using a monitoring station outside the cockpit environment. Since proprioceptive cues (e.g., g force) are limited during FTD missions, FTD instructors must emphasize the need to fly using foundational flying techniques when altering or maintaining the aircraft's attitude. This emphasis leads to the requirement to "fly by what you see, not by what you feel and not by your expectations."[4] While "standard" attitudes and power settings are taught in the early flying missions, pilots must routinely adjust the attitudes, power settings, and pitch and roll rates of the aircraft in response to individual aircraft differences as well as external influences, such as wind and turbulence. This requirement is no different in an FTD, where the trainee will select the "standard" attitude or power setting for a specific manoeuvre, then adjust that attitude or power setting as required to achieve the desired performance. In both environments, the same learning goals are achieved. For these reasons, it is important for FTD instructors to regularly complete proficiency flying in the FTD as they would in the aircraft. This will increase their awareness of any differences between the FTD and the aircraft as well as improve their ability to use the non-proprioceptive cues in the FTD more effectively.

Finally, an FTD instructor's outlook and competencies play a large part in the effectiveness of student training. An FTD instructor who emphasizes the positive aspects of conducting missions in the FTD will promote a better learning environment for their trainee. In contrast, an FTD instructor who only sees limited value in the FTD—because it's not exactly like the aircraft—will likely experience worse results and a poor transfer to future in-aircraft training. FTD instructors must have a detailed understanding of the overall intent of each specific FTD mission as well as the proficiency levels required. An FTD instructor trying to enforce high levels of flying accuracy in an FTD—instead of reinforcing the use of correct attitudes, power settings and procedures—will

likely frustrate their student. It is also important to ensure that FTD missions are not designed to replicate the exact mission profile that would be flown during an in-aircraft mission. The FTD may have a limited number of specific areas with high visual fidelity for practicing visual manoeuvres, which may not be the areas where sequences are normally practiced in the aircraft. As long as the trainee knows the reason behind using the high-fidelity areas in the FTD for the introduction or practice of various sequences (such as improved references or better ground cues), then the intent of the mission will be effectively met.

WHAT PLACE DO HIGH-FIDELITY FTDS HAVE DURING THE AB INITIO PHASES OF FLIGHT TRAINING?

High-fidelity FTDs absolutely have a place in ab initio flight training. However, as with the use of any training aid, there are limitations to their use as well as overarching training-programme considerations. The FTD must be assessed during the development of the training programme to ensure that the FTD's fidelity level matches the stage of training, the aim of the specific training event and the expected level of competency. Careful consideration must be given when selecting the skills or manoeuvres to be trained in the FTD. Likewise, FTD instructors must have the appropriate training, outlook and competencies to effectively conduct missions in an FTD. When these factors are considered in the design and execution of an ab initio flight-training programme, high-fidelity FTDs can greatly enhance the programme's effectiveness and efficiency while increasing flexibility and decreasing risk. High-fidelity FTDs should therefore form an indispensable part of the future of RCAF ab initio flight training.

Major James Tutte (Retired) joined the Canadian Forces (CF) in 1983 and received his CF Pilot's Wings in 1987. He served one tour at 403 Helicopter Operational Training Squadron flying the Kiowa and Twin Huey, including a six-month deployment as part of the Multinational Force and Observers (Sinai). He also completed two tours at 3 Canadian Forces Flying Training School as a rotary-wing qualified flight instructor. Staff tours included three years working in the Missile Warning Center at the Cheyenne Mountain Operations Center in Colorado Springs, Colorado, and six years at 1 Canadian Air Division Headquarters in Winnipeg. He retired from the CF in 2006; since then, he has been employed as Chief Rotary Wing Instructor for Canadian Helicopters Limited in Southport, Manitoba, supporting the Contracted Flying Training and Support Contract. During his flying career, Major Tutte (Retired) has flown more than 6,500 hours, including over 3,000 hours of in-aircraft flight instruction. He has also completed more than 2,500 instructional hours in varying levels of FTDs and flight simulators.

ABBREVIATIONS

FTD	flight training device
HPMA	human performance in military aviation

NOTES

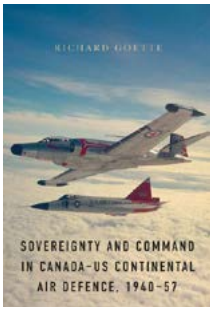
1. Canada, Department of National Defence (DND), *CDS/DM Directive for CAF Reconstitution* (Ottawa: DND, September 28, 2022); Canada, DND, 3000-2 (COS), *Commander 2 Canadian Air Division (2 CAD) Force Generation Directive and Guidance – FY 22/23* (Ottawa: DND, May 5, 2022); and Canada, DND, 3000-2 (SSO ATT), *Commander 2 Canadian Air Division (2 CAD) Planning Guidance for RCAF Reconstitution* (Ottawa: DND, May 18, 2022).

2. For FTDs, "fidelity" refers to the degree to which the characteristics of an FTD match those of the actual aircraft.

3. "Proprioceptive" is defined as "of or denoting stimuli produced and perceived within an organism, especially those relating to position and movement of the body." *Concise Oxford English Dictionary*, 11th ed. (2004), s.v. "proprioceptive."

4. "Fly by what you see" is a common expression in aviation.

BOOK REVIEWS



SOVEREIGNTY AND COMMAND IN CANADA–US CONTINENTAL AIR DEFENCE, 1940–57

By Richard Goette

Toronto: University of British Columbia Press, 2018
312 pages
ISBN: 978-0774836883

Review by **Lieutenant-Colonel Paul Johnston, CD, PhD**

This book is a welcome addition to the literature both for its contribution to Royal Canadian Air Force (RCAF) history and wider debates about Canadian sovereignty in an increasingly perilous world. The main theme it examines, which is the workings of command and control (C2) arrangements for air forces, will probably seem arcane and highly technical to many readers; however, with the resurgence of the great power competition, the F-35 purchase, North American Aerospace Defence Command (NORAD) modernization and all Western nations looking increasingly to their alliance relations—all in a time of increasing protectionism by American governments of any ilk—this book is especially pertinent. Richard Goette's argument is that in the early 1950s, building upon Second World War experience, the RCAF was able to make skilful use of the principle of "operational control" to integrate the air defence of Canada with that of the United States (US), without sacrificing Canadian sovereignty.

This conclusion is in response to a significant contrary school of thought: the argument that military cooperation with others—in particular the NORAD Agreement with the US—threatens Canadian sovereignty. The standard bearer for that school of thought, it is probably safe to say, is University of British Colombia legal scholar Michael Byers.[1] Former Minister of Foreign Affairs Lloyd Axworthy has also written in the same vein.[2] It is perhaps unsurprising that Liberal commentators like Axworthy have expressed such concerns, but so have at least some mainstream Canadian military historians; Desmond Morton, in his famous *A Military History of Canada*, described NORAD as "unwittingly" signing away when the country would declare war.[3] Those worries, Goette argues, are misplaced. "Despite the overwhelming power of the US, Canada took an active role in arranging an effective continental air defence command and control relationship [which] avoided a defence-against-help situation ... and maintain[ed] Canadian sovereignty."[4]

After an admirably clear and concise introduction, Goette provides two chapters of C2 theory from first principles. The first of these two chapters examines C2 itself, going right back to the ultimate sources of national sovereignty and basic principles of the profession of arms, and the second considers the very important issue of how different military cultures apply C2. Based upon that theoretical background, there then follow two chapters tracing in detail how C2 arrangements for the air defence of North America evolved during the Second World War. Goette shows that Canada resisted various US initiatives to sweep everything up under their strong preference for "unity of command," and that the modern concept of operational control as the solution to such dilemmas was well developed by the war's end. "Canada was able to protect its sovereignty during the Second World War," Goette concludes, but his next chapter traces the increasing pressure this came under as the Cold War took hold.[5]

The next three chapters examine in detail how C2 arrangements were hammered out, mostly at the military-technical level, based upon the shared Second World War experience, to effectively integrate North American air defence, even *before* NORAD was established. Indeed, Goette argues that because elaborate and adroit C2 and detailed operational procedures were well developed by the mid-1950s, actually "establishing NORAD's bi-national organizational structure proved an easy task."[6] The real work had already been accomplished. Students of air power will appreciate the detail on C2 theory that Goette utilizes to argue his case. Whether more politically minded commentators such as Byers or Axworthy will be convinced is less certain.

The book is further enhanced by 10 pages of appendices that provide considerable detail on things such as the rules of engagement and definitions developed in the 1950s for hostile and suspicious acts. Over 60 pages of notes and a 7-page bibliography demonstrate the work's scholarly rigour (and origins as a doctoral dissertation at Queen's University). The index is also well done, something all too often sadly lacking in contemporary publishing. Special mention should be made of the more than 20 pages of high-quality black and white photos, some of which are of aircraft, but many of which are of the personalities involved in hammering out the arrangements described in the text as well as the radar and air operations centres created for that same purpose. Finally, the book is well served by four excellent maps, drawn by Mike Bechthold.

Readers should understand that this book is not the typical tale of aircrew derring-do, nor is it an examination of weapons or tactics. It is a dense, scholarly work on C2 for air operations that is highly recommended for serious students of air power history. It is particularly valuable for its explanation of the evolution of C2 in an air-operations context and for its rigorous documentation of how this was made to work in North America, not as a consequence of the 1958 creation of NORAD but prior to its inception.

Lieutenant-Colonel Paul Johnston is an intelligence officer who has been posted at the tactical, operational and strategic levels and served on various deployments. For his last job he is now with RCAF History and Heritage at the Royal Canadian Air Force Aerospace Warfare Centre.

NOTES

1. Michael Byers, "Canadian Armed Forces under United States Command," *International Journal* 58, no. 1 (Winter 2002–2003): 89–114, 91, 92–93. Refer also to his longer report: Michael Byers, "Canadian Armed Forces Under US Command" (Final Report, University of British Columbia, 2002).

2. Lloyd Axworthy. *Liberals at the Border: We Stand on Guard for Whom?* (Toronto: University of Toronto Press, 2004), 23–25.

3. Desmond Morton, *A Military History of Canada* (Toronto: McClelland & Stewart, 1992), 242.

4. Richard Goette, *Sovereignty and Command in Canada–US Continental Air Defence, 1940–57* (Toronto: University of British Columbia Press, 2018), 10.

5. Goette, *Sovereignty and Command in Canada*, 104.

6. Goette, *Sovereignty and Command in Canada*, 185.

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