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SEARCH AND RESCUE IN THE ARCTIC: A MYTH OR A REALITY?

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LIST OF ABBREVIATIONS

AL ..... Alberta

AOR ..... Area of Responsibility

ASCC ..... Air Standardization Coordinating Committee

BC ..... British Columbia

CAS ..... Chief of Air Staff

CASARA ..... Civil Air Search and Rescue Association

CF ..... Canadian Forces

CFACC ..... Combined Force Air Component Commander

CFB ..... Canadian Forces Base

CFS ..... Canadian Forces Station

CJOC ..... Canadian Joint Operations Command

CMCC ..... Canadian Mission Control Centre

CONPLAN ..... Contingency Plan

CS SQN ..... Combat Support Squadron

DND ..... Department of National Defence

EO/IR ..... Electro-Optic/Infra-Red

FOL ..... Forward Operating Location

FW ..... Fixed Wing

FWSAR ..... Fixed Wing Search and Rescue

ICAO ..... International Civil Aviation Organization

ICMSAR ..... International Convention on Maritime Search and Rescue

ICSAR ..... Interdepartmental Committee on Search and Rescue

IMO ..... International Maritime Organization

JRCC ..... Joint Rescue Coordination Centre

Km^2 ..... Square Kilometres

LMSAR ..... Lead Minister Search and Rescue

MAJAID ..... Major Air Disaster

MAJMAR ..... Major Marine Disaster

MARLANT ..... Commander Maritime Forces Atlantic

MARPAC ..... Commander Maritime Forces Pacific

MN ..... Manitoba

MOB ..... Main Operating Base

NATO ..... North Atlantic Treaty Organization

NL ..... Newfoundland and Labrador

NM ..... Nautical Miles

NORAD ..... North American Aerospace Defence Command

NORDREG ..... Northern Canada Vessel Traffic Services Zone

NS ..... Nova Scotia

NSP ..... National Search and Rescue Program

NSS ..... National Search and Rescue Secretariat

NU ..... Nunavut

NWP ..... Northwest Passage

NWT ..... Northwest Territories

OIC ..... Officer in Charge

ON ..... Ontario

OPCOM ..... Operational Command

OPCON ..... Operational Control

QC ..... Quebec

RCAF ..... Royal Canadian Air Force

RCMP ..... Royal Canadian Mounted Police

RW ..... Rotary Wing

SAR ..... Search and Rescue

SARTEC ..... Search and Rescue Technician

SOLAS ..... International Convention for Safety of Life at Sea

SOR ..... Statement of Requirement

SRR ..... Search and Rescue Region

SRU ..... Search and Rescue Unit

STL ..... Search and Rescue Technician Team Leader

T&R SQN ..... Transport and Rescue Squadron

TACON ..... Tactical Control

UK ..... United Kingdom

US ..... United States

YK ..... Yukon

ABSTRACT

The level of interest for the Arctic has reached unprecedented heights in the last decade, leading many Canadians and experts to question the country's abilities to react to various crises in the north, including Search and Rescue (SAR) events. Recent northern SAR occurrences, the Arctic Council SAR agreement and the increasing level of activities in the north have all contributed to re-ignite this debate. Many critics have argued that Canada lags behind; virtually suggesting that Arctic SAR in Canada is rather a myth than a reality. As a solution, they campaign for the establishment of permanent SAR units in the north. But is it really the answer in the current circumstances?

Arctic SAR in Canada is not a myth; it is a reality offering substantial capabilities that are actually envied and praised by other countries. Canada has the largest and one of the most challenging areas of responsibility in the world, characterized by extremes in climate, topography and weather conditions. The successful completion of the vast majority of the northern SAR missions is a testimony of Canada's ability to conduct Arctic SAR. But it is also recognized that the current system offers very little flexibility, residual capacity, and particularly needs improvements to expedite the casualty extraction time in the north as the environment dictates the fastest response possible. Given the low and disparity of demand, the challenging time and space environment, and the cost associated to SAR operations, the quest for a solution herein entails a holistic approach to enhance the current program. The way ahead advocated in this study capitalizes on one of the major strengths of the current SAR program; its integrated and multi-agency dimension; to bolster the Arctic SAR capabilities and deliver a better service to those in distress; and to realize the motto of "THAT OTHERS MAY LIVE."

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Foremost, I wish to offer my sincere gratitude to my thesis advisor, Dr. Richard Goette, for his outstanding dedication throughout this endeavour. His untiring and remarkable level of commitment, keen insights, and timely feedback were greatly appreciated and crucial to the final product.

> I was the head of delegation during the negotiations of the Arctic SAR treaty….What was very interesting is that of the eight nations that signed that treaty, Canada provides a gold standard for response into the Arctic that almost no other nation there even attempts. I didn't know that until I showed up and saw it. It spoke to the desire of other nations to team with Canada for the very reason that they believe there's a higher probability that Canada will get up to save one of their members somewhere around the Arctic Circle than they may be able to do themselves.
>
> - Chief of Defence Staff, General Thomas Lawson, 29 November 2012[1]

INTRODUCTION

Global warming has tremendously changed the Arctic in recent years, generating an unprecedented interest for this part of the globe. Whereas the environmental impacts are generally seen as having a negative effect, these changes and a more reachable Arctic have also created more opportunities. For some, a more accessible Arctic equates to enormous economic prospects which led many authors to suggest apocalyptic scenarios describing the economic Arctic development as the new "gold/cold rush" or a "race" for natural resources exploitation. Canadian Prime Minister Stephen Harper even used the now famous "we either use it or lose it" expression when referring to Arctic sovereignty and its potential for the country's future.[2] Notwithstanding the accuracy of those comments, this renewed interest and increasing level of activities in the Arctic has prompted many Canadians to question the country's abilities to operate and to respond to crises in that region, and this has included Search and Rescue (SAR) capabilities.

Arctic SAR is not new in Canada. The Royal Canadian Air Force (RCAF) involvement in northern SAR can be traced back to 1927 when aircraft were employed in

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[1] House of Commons. Standing Committee on National Defence. *Minutes of Proceedings and Evidences*, no. 59, Thursday, November 29, 2012, 16:30.

[2] Stephen Harper (Speech, Prime Minister Stephen Harper Announces New Arctic Offshore Patrol Ships, Esquimalt, British Colombia, July 9, 2007), last accessed 29 March 2013, http://www.pm.gc.ca/eng/media.asp?id=1742.

search operations during the Hudson Strait Expedition.[3] This capability has evolved significantly over time and Canada's endorsement and signature of the Arctic Council SAR agreement represents the latest evolution of SAR cooperation in the Arctic. The renewed interest for the Arctic, the signature of the Arctic Council SAR agreement and other events such as the 2011 crash of First Air's Flight 6560 in Resolute Bay and the grounding of two vessels in 2010 have naturally refocused attention on SAR in northern Canada.[4] The country's ability to respond to a SAR incident in the Arctic and the lack of SAR units in the north have been questioned for quite some time but these recent events have contributed in re-igniting the debate about the overall Canadian Arctic SAR capabilities.[5]

In 2011, the Standing Senate Committee on National Defence conducted a special study on sovereignty and security in Canada's Arctic. They made two basic observations about SAR in the region: first, the requirement for the capability is on the rise; and second, the current response times are potentially too slow. Many witnesses, including retired military members, academics and politicians, who testified at the committee, condemned the lack of permanent SAR units in the north.[6] The Canadian Coast Guard reached similar conclusion in their 2007 SAR needs analysis: "An evaluation of future trends in each SAR area revealed that generally client activity will increase and that the

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[3] Ernest Cable, "Air Force: Leader in the Arctic," in *Sic Itur Ad Astra: Canadian Aerospace Power Studies Volume 4: De-Icing Required! The Historical Dimension of the Canadian Air Force's Experience in the Arctic*, ed. P. Whitney Lackenbauer and W.A. March, 6 (Ottawa: Her Majesty the Queen as represented by the Minister of National Defence, 2012).

[4]Canadian American Strategic Review (CASR), "Arctic Sovereignty - Arctic Search-and-Rescue: First Air Crash at Resolute Bay was within Sight of CF SAR Personnel preparing for a 'Major Air Disaster', August 2011," last accessed 22 February 2013, http://www.casr.ca/id-arctic-sar-first-air.htm.

[5] Pierre Leblanc, "Canada Ducked an Arctic Bullet," *The Hill Times*, (3 October 2011), 23.

[6] Senate, Standing Senate Committee on National Security and Defence, *Sovereignty & Security in Canada's Arctic, Interim Report*, (Ottawa: Senate Committees Directorate, 2011), 11-12.

current SAR system in many areas of Canada may not be able to meet the increased demand."[7] Of primary concern, the Canadian Coast Guard identified the overall lack of SAR units in northern Canada. Some have also argued that not much progress has been made in the last two decades to improve Canada's ability to respond to northern SAR events.[8] Listening to the ongoing criticisms, it is fair to wonder if SAR in the Canadian Arctic is a myth or a reality.

This paper aims to analyze the Canadian National Search and Rescue Program (NSP) in an Arctic context. The intent is to illustrate the actual and factual impact of the economic growth in the Arctic in terms of SAR incidents and demand and to bring to light the complexity of establishing a robust Canadian Arctic SAR program. The Arctic is vast, remote and thinly populated, and the harsh weather conditions require the best equipment available to support missions year-round. On the other hand, the current number of SAR occurrences in the Arctic is still exceptionally low. Canadian Forces (CF) aircraft or ships are tasked in approximately 1,100 of the 8,000 annual cases triggering a response from the federal aeronautical and maritime SAR system.[9] Less than 1 percent (typically under 60 per year) of all SAR incidents are located north of 60^{o}N latitude.[10] The facts and interpretations presented herein will show that while the activity level is unquestionably increasing in the Arctic, the number of events prompting a SAR response has remained consistently low, and has not translated into a discernible trend. In these

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[7] Department of Fisheries and Oceans(DFO), Canadian Coast Guard, *Search and Rescue Needs Analysis 2007* (Ottawa: Canadian Coast Guard, 2007).

[8] Tony Balasevicius, "Toward a Canadian Forces Arctic Operating Concept," *Canadian Military Journal* 11, no. 2 (Spring 2011): 26.

[9] Department of National Defence (DND), "Backgrounder: Canada's Air Force: A Proud Partner in the National Search and Rescue Program, CAS BG-11.0001, February 17, 2011," last accessed 15 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=11505.

[10] Department of National Defence (DND), "Royal Canadian Air Force in the North," last accessed 22 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/page-eng.asp?id=1512.

circumstances, the real challenge clearly remains to find an adequate balance between the disparity of demand, the particularly demanding time and space environment, and the cost associated to SAR operations in a resource constrained framework. Unfortunately, when it comes to saving lives, many often use an emotional discourse rather than a more logical and rational approach. Whereas money is never a detrimental factor when responding to a SAR incident, there is a harsher reality that needs to be acknowledged when dealing with the establishment of SAR capabilities and units. Resources are limited and accordingly, they must be positioned to best respond to the majority of SAR occurrences.

It is argued herein that the NSP and the CF contribution to respond to Arctic SAR incidents is not a myth but rather a reality that needs to be understood in its particular context. As the opening epitaph suggests, many actors underestimate the real challenges associated with Arctic SAR and also the CF achievements in that domain. Whereas the Canadian public is questioning the country's Arctic SAR capabilities, the same system is actually praised and envied by other countries. In the vast majority of northern SAR cases, the military and other NSP stakeholders have always managed to fulfill their mandate. The success of many of these missions was attributable mostly to the incredible determination and courage of SAR crews and it often came at the greatest risk, including loss of lives. Despite this commitment and these achievements, it is also argued herein that Arctic SAR in Canada is a reality that requires continuous strengthening and improvements to provide a faster response to rescue those in distress.

Canada has a substantial Arctic SAR capability, but resource scarcity and constraints hinder depth and flexibility, making the whole system rather fragile and arguably already working at its maximum capacity in a northern environment. When considering the increasing level of activities in the Arctic, the current system offers

almost no residual capacity and it is already on the verge of reaching its tipping point unless improvements are aggressively pursued and implemented. Acknowledging that primary assets are located in the south to better respond to the majority of SAR incidents, this distribution also results in having the slowest response where the severity of the environment actually dictates the fastest intervention. This paradox is one of the biggest challenges for the Canadian system and the search for workable solutions should not be underestimated. The arguments presented in this paper promote a holistic course of action to augment and improve the northern SAR capabilities which is consistent with the whole-of-government approach taken by Canada's Northern Strategy.[11] The examination will focus heavily, but not exclusively, on the CF participation in the NSP with a special attention on the casualty extraction capabilities, as it will be identified as one of the major weaknesses of the current system in the north.

This study is divided in four chapters. The first chapter describes the NSP and highlights the integrated and multi-departmental dimension of the Canadian program. It constitutes a brief summary of roles and responsibility of the major stakeholders, focusing on the Department of National Defence (DND) to provide the necessary background information for the discussion. Chapter Two points out the challenges associated with Arctic survival and discusses the current location of CF SAR assets and the overall performance of SAR system. A review of few Arctic SAR missions underlines the challenges associate with this unique environment. It will also highlight one of the major weaknesses of the current system in the north: even with new technology and more

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[11] Department of Aboriginal Affairs and Northern Development Canada, *Canada's Northern Strategy. Our North, Our Heritage, Our Future* (Ottawa: Minister of Public Works and Government Services, 2009), 1-2.

capable fleets, the time required to extract the victims from the austere Arctic climate still remains problematic. This will serve as the foundation in providing potential solution.

Chapter Three offers a trend analysis and underscores a second paradox. While there is no doubt that the level of activities in the Arctic is increasing, it has not yet translated in an increase of northern SAR incidents. It is essential to acknowledge this reality as it favours a much more measured and gradual approach to solve the problem. Chapter Four is a review of ongoing projects and offers suggestions to improve response SAR capabilities in the north and to minimize their occurrence in the first place. Once again, the centre of gravity will be to reduce the extraction time and consequently, there will be a particular focus on improving the rotary wing (RW) SAR capability in the Arctic.

Before proceeding further, there is a need for definition and clarify the methodology taken in this paper. Although there are numerous definitions of the Arctic available, this study will use DND's definition, which is the region north of 60^{o}N latitude. The High Arctic is the region above 66.5^{o} North Latitude (the Arctic Circle).[12] As it is the case in many publications and reports, the word "north" and "Arctic" are often interchanged throughout the text but they essentially refer to the same area. It is also important to note that there is very little academic literature specifically dedicated to Arctic SAR. The vast majority of the academic work currently available focuses on Arctic sovereignty and policies in broader terms. Accordingly, the bulk of the literature and references used in this study to discuss Arctic SAR was mainly drawn from Government

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[12] Department of National Defence (DND), "Backgrounder: The Canadian Forces in the North, February 28, 2012," last accessed 15 February 2013, http://www.emeraldsiberians.com/nr-sp/bg-do/12.003-north-nord-eng.asp.

publications and research reports whereas northern policy and development references were sourced from academic work when possible.

This document also incorporates a significant amount of statistics and the methodology used might seem orthodox from an academic point of view. Canadian SAR incidents data are collected in the Search and Rescue Program Information Management System based on input from Joint Rescue Coordination Centres (JRCCs). The system in place has some significant limitations and data extraction is sometime quite laborious. Ideally, a tailored set of statistics should have been requested for this study. However, it was determined early that the core argument presented herein could be made without creating additional work for DND personnel by using data already available in other research reports. This approach was taken to avoid duplication of efforts but it created some information distribution restriction issues. Accordingly, some data presented herein have been taken from open secondary sources instead of the primary document to avoid referring to a restricted report not accessible to general public. Lastly, SAR in Canada is a multi-agency responsibility. There are many actors involved and each has different roles, responsibilities and various capabilities to better serve the population. The next chapter describes the Canadian SAR system in general, the main stakeholders and narrows on the CF participation to provide a common knowledge basis for the discussion.

Chapter 1 - DESCRIPTION OF THE CANADIAN SAR SYSTEM

Canada is a unique environment which calls for an equally unique SAR system. The NSP is an integrated service provided by numerous agencies and volunteer associations. Thousands of persons from different organizations are involved and it can be challenging to understand the relationship among them. In this chapter, the role and responsibilities of the major stakeholders are presented, the Canadian SAR Area of Responsibility (AOR) is defined and Canada's participation in various international agreements is discussed. The CF SAR capabilities, location of assets and some of the fundamental operating principles are also reviewed to provide the necessary background for the subsequent chapters starting with the origin of the current system.

Origin of Canadian National Search and Rescue Program

The foundation of the current Canadian SAR system originated from the participation on the RCAF in the closing days of the Second World War.[13] In 1942, an Air Sea Rescue Organization was created to improve the search efforts of downed aircraft during the war. It was based on a similar organization used by the United Kingdom (U.K.) during the Battle of Britain.[14] At the time, numerous British Commonwealth Air Training Plan schools were created in Canada to support the war effort. One school was involved in search efforts for downed aircraft and recognized quickly the need to expand the SAR capabilities. Two years later, in 1944, the concept included the parachuting of military paramedical personnel and the training evolved to include enhanced survival

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[13] Department of National Defence (DND), *Canadian Forces Search and Rescue: 50 Years of Service to Canadians* (Ottawa: Art Direction CFSU(O) Creative Services, 1997), 9.

[14] Sandy Babcock, "Operation Canon: A case Study of Early RCAF Arctic Search and Rescue Capabilities," in *Sic Itur Ad Astra: Canadian Aerospace Power Studies Volume 4: De-Icing Required! The Historical Dimension of the Canadian Air Force's Experience in the Arctic,* ed. P. Whitney Lackenbauer and W.A. March, (Ottawa: Her Majesty the Queen as represented by the Minister of National Defence, 2012), 31.

skills, advanced medical training and mountain climbing. The same year, the Interdepartmental Committee on Search and Rescue (ICSAR) was created and chaired by the Royal Canadian Mounted Police (RCMP), giving birth to the multi-departmental dimension of the NSP.[15]

In 1947, the RCAF took over the leadership of the ICSAR and became responsible for the provision and coordination of air rescue in Canada with the signature of the Cabinet Directive Number 18. During the same period, the Convention on International Civil Aviation (also known as the Chicago Convention) came into effect and the International Civil Aviation Organization (ICAO) was born. The ratification of this agreement is one of the cornerstones of the current system and resulted in harmonizing the Canadian SAR system to an international SAR framework. The agreement established responsibilities for aeronautical SAR incidents which prompted Canada to create the Rescue Coordination Centres in 1947 to meet its obligations.[16] The SAR responsibilities of the RCAF were further extended to maritime SAR coordination in 1951 and the Minister of National Defence became the Lead Minister (LMSAR) in 1976 to establish a single spoke person for the Government on SAR matters.[17]

National Search and Rescue Program

> The national SAR objective is to prevent loss of life and injury through SAR alerting, responding and aiding activities using public and private resources.
>
> -Canadian Forces National Search and Rescue Manual[18]

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[15] *Ibid.*

[16] International Civil Aviation Organization (ICAO), "ICAP in Brief," last accessed 24 February 2013, http://www.icao.int/Pages/icao-in-brief.aspx; DND, *Canadian Forces Search and Rescue: 50 Years…,* 9-10.

[17] Before 1976, there was no lead minister for SAR matters. Department of National Defence/Canadian Coast Guard (DND/CGC), B–GA–209–001/FP–001 – DFO 5449, *National Search and Rescue Manual* (Ottawa: DND/CCG Canada, Revised May 2000), chapter 1, 4-6.

The Government of Canada directed the establishment of the NSP in 1986. It is led by the Minister of National Defence as the LMSAR. The focus on SAR as a distinct integrated activity at the federal level is maintained through the ICSAR and the National Search and Rescue Secretariat (NSS).[19] The ICSAR is composed of applicable senior federal officials and provide interdepartmental coordination and advice to the Ministers in the area of SAR policy, planning, resources, and effectiveness. The NSS, as supporting agency, has the mandate to coordinate, promote and review the program.[20] Figure 1.1 illustrates the relationship between the various stakeholders.

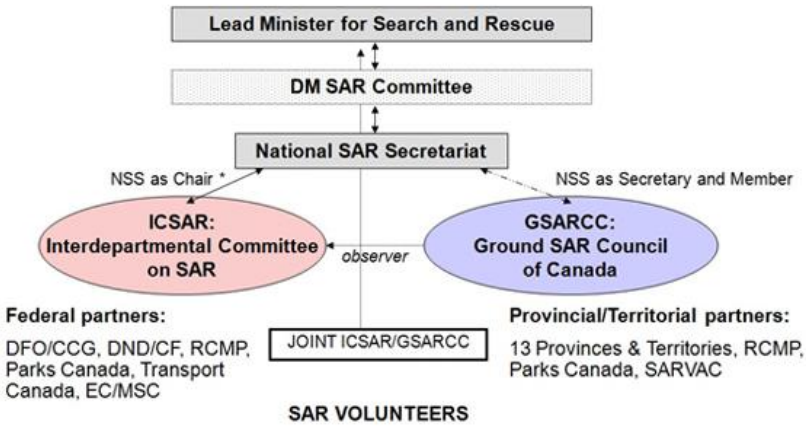

Figure 1.1 – National SAR Program - Relationship[21]

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[18] *Ibid*., chapter 1, 3.

[19] *Ibid*., chapter 1, 3-4.

[20] The ICSAR is chaired by the NSS. Members include representation from the six participating federal departments (Park Canada, Environment Canada, Transport Canada, DND, Public Safety Canada (RCMP) and the Department of Fisheries and Oceans) and delegates from other departments. For more, see: National Search and Rescue Secretariat, "Who we Are, Interdepartmental Committee on Search and Rescue (ICSAR)," last accessed 15 March 2013, http://www.nss.gc.ca/site/whoWeAre/icsar_e.asp.

[21] National Search and Rescue Secretariat, "Reports: Annual Report 2008-2010," last accessed 31 March 2013,http://www.nss.gc.ca/site/reports/nsp/AnnualReports-Rapportsannuel/2008-2010/NSP-2008-10AnnualReport_2-0_e.asp.

The NSP is an integrated service and a co-operative effort by federal, provincial and municipal governments along with other SAR organizations.[22] It could be best described as the domestic version of the whole-of-government approach taken by the Government of Canada in overseas operations.[23] The mandate and responsibilities to provide the SAR services is shared primarily by the CF, the RCMP and Canadian Coast Guard. Provinces, territories, municipalities, Transport Canada, Parks Canada and other volunteer organizations also play an indispensable role in providing SAR services.[24] The federal government is responsible for responding to all aeronautical and maritime SAR incidents. The aeronautical responsibilities are defined under the ICAO while the maritime responsibilities are based on the International Maritime Organization (IMO) agreement which encompasses 15 million square kilometres of open sea, the Great Lakes, the St. Lawrence System and waters falling within National Parks.[25] Provincial/Territorial authorities are responsible for all ground SAR responses, as well as those that occur within inland waters. The Provincial/Territorial responsibility is typically delegated to the police force of jurisdiction.

Federal responsibilities are further divided among various departments. The core responsibilities of DND are "the provision of aeronautical SAR services and effective

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[22] DND/CGC, *National Search and Rescue Manual…*, chapter 1, 3.

[23] Whole-of-government approach denotes public service agencies working across portfolio boundaries to achieve a shared goal and an integrated government response to particular issues. For a detailed discussion on the whole-of-government approach to fragile states, see: Organization for Economic Co-operation and Development. *Whole of Government Approaches to Fragile States* (Paris: OECD Publishing, 2006), http://www.oecd.org/development/incaf/37826256.pdf.

[24] National Search and Rescue Secretariat, "Who We are," last accessed 31 March 2013, http://www.nss.gc.ca/site/whoWeAre/index_e.asp.

[25] National Search and Rescue Secretariat, "Reports," last accessed 22 February 2013, http://www.nss.gc.ca/site/reports/nsp/AnnualReports-Rapportsannuel/2008-2010/NSP-2008-10AnnualReport_3-0_e.asp.

operation of the coordinated aeromedical and maritime SAR system."[26] Public Safety Canada, through the RCMP, has been delegated the responsibility for land and inland waters SAR in eight of ten provinces and in the territories as the police force of jurisdiction.[27] The department of Fisheries and Oceans Canada, through the Canadian Coast Guard, is responsible for the detection, coordination, control and conduct of SAR operations related to maritime incidents within federal responsibility.[28] Both the Canadian Coast Guard and DND work closely together and they also provide assistance to provincial, territorial or municipal emergency services when necessary. Lastly, Transport Canada is involved as a regulatory body for air, land and maritime transportation and Parks Canada is the lead agency for incidents occurring within the boundary of a National Park.[29]

There are several other organizations partaking in the provision of SAR services. Of note, numerous local communities provide SAR services through their respective emergency responder teams and local ground SAR associations. At the national level, the Civil Air Search and Rescue Association (CASARA), a body of volunteer aircraft owners funded by DND, constitutes a major enabler to SAR operations. The 2,800 CASARA volunteers, mostly active in southern Canada, assist in air search operations with their own aircraft, provide spotters for the RCAF, and promote flight safety for general aviation to reduce overall SAR incidents. Similarly, the Canadian Coast Guard Auxiliary was established in 1978 and is made of volunteers who assist the Canadian Coast Guard

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[26] DND/CGC, *National Search and Rescue Manual…*, chapter 1, 5.

[27] The provinces of Quebec and Ontario are excluded as they have their own police forces providing SAR services. For more details, see: Royal Canadian Mounted Police, "RCMP Search and Rescue," last accessed 24 February 2013, http://www.rcmp-grc.gc.ca/ccaps-spcca/rs-eng.htm.

[28] Canadian Coast Guard, "Search and Rescue," last accessed on 24 February 2013, http://www.ccg-gcc.gc.ca/eng/CCG/SAR_About_Sar.

[29] Senate, *Sovereignty & Security in Canada's Arctic, Interim Report…*, 9-10.

for marine SAR operations and prevention. The Search and Rescue Volunteer Association of Canada, supported by the NSS, is another important national organization promoting and implementing the NSP.[30] All these volunteer organizations are indispensable elements of Canada's response to SAR events at the core of the comprehensive approach taken by the NSP.[31]

Based on the above information, it is clear that the NSP is not a monolithic program run by one organization. There are many stakeholders from various government levels and volunteer organizations bringing highly specialized services and skills that cannot be interchanged easily among each other. The rationale behind the multi-organization approach taken by the NSP arises from challenging Canadian particularities such as the size of the AOR. It would be unrealistic to believe that a single department/agency could provide the SAR services for all types of occurrences anywhere in the country. This is especially true in the Arctic where the system needs to provide services across an enormous area with a peculiarly low population density. The cost and scarcity of highly specialized SAR resources, combined with the fact that no single organization possesses all the equipment, training and skills to respond to all types of SAR incidents everywhere in Canada, are driving factors necessitating an inter-agency approach. The differences in geography and national approaches makes international

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[30] Civil Air Search and Rescue Association (CASARA), "About CASARA," last accessed 24 February 2013, http://www.casara.ca/about-casara/; Canadian Coast Guard Auxiliary, "Volunteer Marine Search and Rescue," last accessed 13 March 2013, http://ccga-gcac.ca/; Search and Rescue Volunteer Association of Canada, "Welcome," last accessed 13 March 2013, http://www.sarvac.ca/.

[31] Not to confuse with the comprehensive approach described in Canada's Northern Strategy which aims to ensure conservation is keeping pace with development. The NSP inter-agency framework is similar to the comprehensive approach to CF operations as described in: Leslie, Andrew, Peter Gizewski, and Michael Rostek, "Developing a Comprehensive Approach to Canadian Forces Operations," *Canadian Military Journal* 9, no. 1 (Fall 2008): 11-20, last accessed 29 March 2013, http://www.journal.forces.gc.ca/vo9/no1/doc/04-leslie-eng.pdf.

comparison very difficult but "what can be stated is the Canada's SAR service is considered a model of effectiveness by other countries."[32] The Canadian AOR and coordination framework are described below to better capture what it entails for the NSP.

SAR Regions and Mission Coordination in Canada

Canada has the second largest landmass and the longest coast line in the world. Not surprisingly, the country has to handle the world's largest SAR area with an area of responsibility corresponding to approximately 15.5 million square kilometres (km^2). It is characterized by sparsely settled regions with limited infrastructure in some areas and great extremes in geography and weather conditions. The topography includes vast territorial waters on the coasts and the Rocky Mountains with peaks exceeding 12,000 feet. Arctic conditions are present in the north and the country's temperature ranges from -45 degree Celsius (^oC) to plus 35^oC.[33] The combination of those factors makes the Canadian AOR one of the most challenging in the world for SAR operations.

The boundaries of the Canadian SAR AOR are defined under the ICAO and IMO agreements. It is further divided in three distinct square kilometres (SRRs) named Victoria, Trenton and Halifax which are depicted at Figure 1.2 below.

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[32] Department of National Defence (DND), *Evaluation of the CF/DND Component of the National Search and Rescue Program* (Ottawa: Chief Review Services, 2008), 14.

[33] National Search and Rescue Secretariat, "Reports: Annual Report 2007-2008," last accessed 31 March 2013, http://www.nss.gc.ca/site/reports/nsp/AnnualReports-Rapportsannuel/2007-2008/NSP-2007-08AnnualReport_1-0_e.asp.

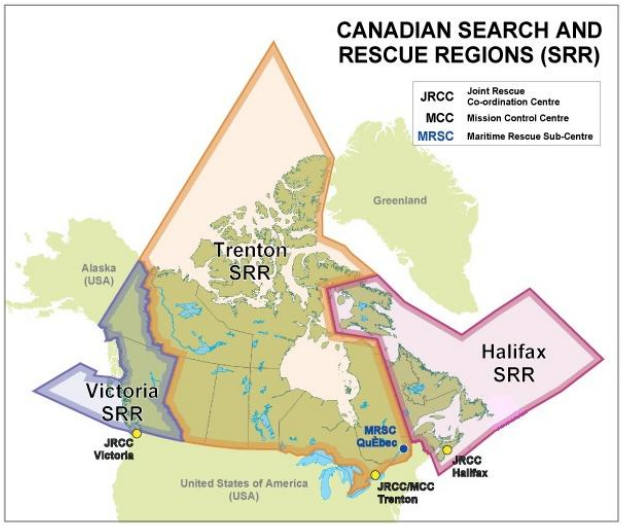

Figure 1.2 – Canadian SAR Regions[34]

Each SRR is named based on the location of its respective JRCC. The JRCCs are staffed by CF and Canadian Coast Guard personnel to coordinate aerial and marine SAR operations in their respective SRR.[35] They act as the nervous system in support of SAR operations as they provide coordination among all the stakeholders involved in domestic and international SAR incidents under the responsibility of the federal government. The Commander of the Canadian Joint Operations Command (CJOC) retains the overall responsibility of the CF participation in the NSP. More specifically, he is responsible for the establishment of operational policy for force employment, the provision of advice and liaison with the ICSAR and other departments. He retains operational command for the force employment of all CF assets and ensures proper functioning of the JRCCs and operational employment of CASARA. This is done through three SRR commanders who

[34] National Search and Rescue Secretariat, "Reports," last accessed 22 February 2013, http://www.nss.gc.ca/site/reports/nsp/AnnualReports-Rapportsannuel/2007-2008/NSP-2007-08AnnualReport_1-0_e.asp.

[35] DND, "Canadian Joint Operations Command: SAR in Canada," last accessed 24 February 2013, http://www.cjoc-coic.forces.gc.ca/cont/search-recherche/index-eng.asp.

are accountable for the coordination, control and conduct of SAR operations in their regions through their respective JRCCs.[36]

Lastly, the Canadian Mission Control Centre (CMCC), staffed by DND, is also under the responsibility of the CJOC and plays an important role in the initial phase of a SAR mission. It is located in Trenton and it supplies the satellite downlink of emergency beacon signals from the international COSPAS/SARSAT system.[37] Once an emergency locator beacon distress is confirmed by CMCC, the information is forwarded to the applicable JRCC for mission staffing and resolution. Canada's participation in the COSPAS/SARSAT is only one of many examples of international agreements.

International Agreements

Canada participates in a number of international organizations such as the ICAO and the IMO. Canada also agreed to adopt SAR standards and practices in accordance to the Convention on International Safety of Life at Sea (SOLAS), the Convention on

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[36] CJOC was stood-up in October 2012 to replace Canada COM, CEFCOM and CANOSCOM as part of the second phase of the CF transformation. Unfortunately, the new command and control SAR construct has not transpired in doctrinal publications yet. Under this new structure, Commander CJOC exercises operational command (OPCOM) of all SAR activities in Canada and therefore, he has the lead for the force employment of aeronautical SAR services through the three SRR commanders. SRR commanders have operational control (OPCON) of SAR resources for SAR activities in their respective region as follow: Commander Maritime Forces Atlantic (MARLANT) is responsible for the Halifax SRR, Commander Maritime Forces Pacific (MARPAC) is responsible for the Victoria SRR and Commander 1 Canadian Air Division (Comd 1 Cnd Air Div) is responsible for the Trenton SRR. There is an Officer in Charge (OIC) in each JRCC who has tactical control (TACON) of SAR standby assets and directs SAR responses on behalf of the SRR Commander. Note that Comd 1 Cnd Air Div is also the Combined Force Air Component Commander (CFACC). As such, he is delegated OPCOM of all operational air assets for force employment and coordinates SAR air activities and mission on behalf of Comd CJOC. Force generation responsibilities are assigned to the Chief of Air Staff (CAS) through Comd 1 Cdn Air Div. For a good summary of SAR governance and command and control relationship, even though outdated as it reflect the former Canada COM structure, see: DND, *Evaluation of the CF/DND Component of the National SAR Program*…, 4-6 and CANFORGEN 012/06 CDS 007/06 311900Z JAN 06.

[37] Cospas-Sarsat became operational in 1982. Participants implement, maintain, co-ordinate and operate a satellite system capable of detecting distress alert transmissions from radio beacons that comply with Cospas-Sarsat specifications and performance standards, and of determining their position anywhere on the globe. The distress alert and location data is provided by Cospas-Sarsat participants to the responsible SAR services. For more details, see, http://www.cospas-sarsat.org/en/about-cospas-sarsat/about-the-programme-g/international-cospas-sarsat-programme.

international civil aviation, the International Convention on Maritime SAR (ICMSAR), the Air Standardization Coordinating Committee (ASCC) and the North Atlantic Treaty Organization (NATO). Bilateral agreements with the United States (U.S.) have also been in place for a number of years, ensuring and enhancing coordination and mutual support operations adjacent to common border.[38]

In May 2011, Canada and the seven other Arctic Council member states signed the Agreement on Cooperation in Aeronautical and Maritime SAR in the Arctic.[39] The agreement is a legally binding instrument defining an area of the Arctic in which the signatory member will have lead responsibility in organizing responses to SAR occurrences.[40] The respective AOR of each Arctic Council member is shown at Figure 1.3. The agreement is a framework for cooperation including combined SAR training in the Arctic, and the first table-top exercise under this accord was held in Whitehorse, Yukon Territory (YK), in October 2011. The first live SAR exercise among the eight Arctic states took place in September 2012 in Greenland.[41] Whereas the agreement is a milestone and an important step in increasing Arctic SAR cooperation, it does not impose a minimum standard with respect to response time or number of assets to be available. It is left to the individual countries to define their own level of service, capabilities and distribution of assets.

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[38] DND/CGC, *National Search and Rescue Manual…*, chapters 2, 7and 3-5.

[39] Arctic Council Member States include: Canada, Denmark, Finland, Iceland, Norway, The Russian Federation, Sweden and the United States. For more details, see: http://www.arctic-council.org/index.php/en/about-us/members/89-resources/about.

[40] Arctic Council, "Task Force on Search and Rescue," last accessed on 24 February 2013, http://www.arctic-council.org/index.php/en/about-us/task-forces/282-task-force-on-search-and-rescue.

[41] The Arctic Council, "First Arctic Council SAR exercise in Whitehorse, Canada," last accessed 24 February 2013,http://www.arctic-council.org/index.php/en/oceans/search-and-rescue.

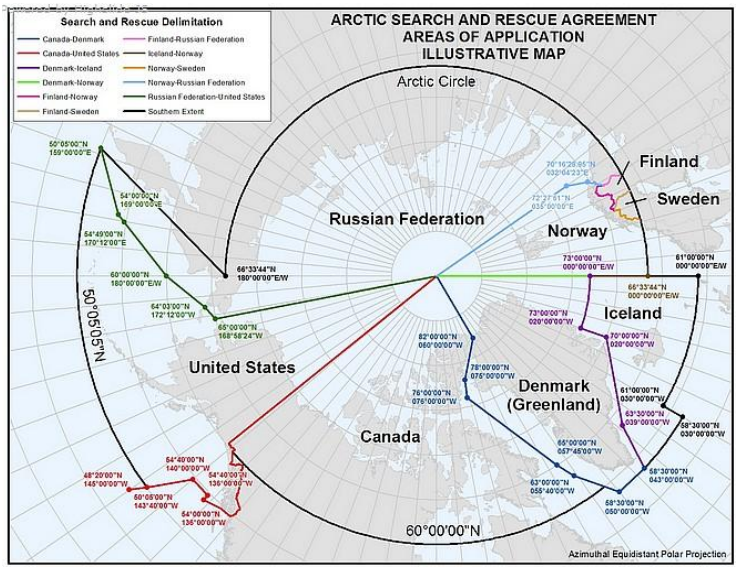

Figure 1.3 – Arctic SAR Agreement Areas of Responsibility[42]

CF SAR Capabilities – Assets and Location

When one of the JRCC responds to a distress call, a number of assets are available to carry out the mission. The CF and the Canadian Coast Guard have a number of primary and secondary SAR Units (SRUs) on standby to respond to the emergency. Assets are also available through CASARA, the Canadian Coast Guard Auxiliary and other SAR organizations. Private industry may also be hired in support to SAR mission when they are essential in the completion of the mission.[43] As this study focuses on the CF SAR capabilities, only these assets are covered in detail. Table 1.1 shows the distribution of the CF air SRUs within each SRR.

[42] Canadian Forces Canada Command. Presentation. *Search and Rescue (SAR) Overview.* Arctic Caucus Meeting, 17-19 August 2011, last accessed 24 February 2013, http://www.pnwer.org/Portals/18/Arctic%20Caucus%20SAR%20Overview%20Presentation.pdf.

[43] DND/CGC, *National Search and Rescue Manual…*, chapter 4, 8.

Table 1.1 – CF Primary and Secondary Air SRUs within SRRs[44]

Type of Unit	SRR Victoria	SRR Trenton	SRR Greenwood
Primary SRU	**442 T&R Sqn** (Comox, BC) FW: Buffalos RW: Cormorants	**435 T&R Sqn** (Winnipeg, MN) FW: Hercules **424 T&R Sqn** (Trenton, ON) FW: Hercules RW: Griffons	**103 Rescue Sqn** (Gander, NL) RW: Cormorants **413 T&R Sqn** (Greenwood, NS) FW: Hercules RW: Cormorants
Secondary SRU	Nil	**417 CS Sqn** (Cold Lake, AL) RW: Griffons **440 T&R** (Yellowknife, NWT) FW: Twin Otters	**439 CS Sqn** (Bagotville, QC) RW: Griffons **444 CS Sqn** (Gosse Bay, NL) RW: Griffons
T&R Sqn: Transport and Rescue Squadron / CS Sqn : Combat Support Squadron FW : Fixed Wing / RW: Rotary Wing BC: British Columbia / MN: Manitoba / NL: Newfoundland / ON: Ontario / NS: Nova Scotia / AL: Alberta / QC: Québec / NWT: Northwest Territories			

It is important to note that all CF aircraft have SAR as a secondary role and may be tasked to support SAR operation at any time.[45] In particular, Sea King helicopters and Aurora aircraft, not shown in Table 1.1 as they are not designated primary SAR assets, are essential in providing more depth to the CF SAR capabilities as they could be used either as secondary or primary SAR assets depending on the situation. The Aurora also

[44] Department of National Defence (DND), "Backgrounder: Canada's Air Force: A Proud Partner in the National Search and Rescue Program, CAS BG-11.0001, February 17, 2011," Last accessed 24 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=11505.

[45] DND, *Canadian Forces Search and Rescue: 50 Years…,* 16.

brings a unique Electro-Optic/Infra-Red (EO/IR) sensing capability that is lacking on the primary SAR fleet which can be extremely useful in SAR operations.[46]

There are significant differences in response time and capabilities between primary and secondary units. Primary SRUs maintain a standby posture with mandatory response time (discussed below). Secondary SRUs are not specifically dedicated to the NSP and therefore they do not maintain the same readiness posture. Combat Support units shown in Table 1.1 are SAR capable but primarily assigned to base rescue duties. Whereas secondary SRUs do not maintain a SAR standby posture to support the national SAR mandate, they may be tasked on SAR incident if they are available.[47] This flexibility is instrumental in strengthening the CF/DND structure as it provides the ability to redirect other units from their primary employment to support SAR operations when required.[48] The 2008 rescue of an explorer in the high Arctic by a Griffon helicopter deployed on a utility mission illustrates well the flexibility and benefits of using secondary assets when possible.[49] The explorer was located 130 Nautical Miles (NM) northwest of Canadian Forces Station (CFS) Alert. In that case, using a secondary asset in proximity of the incident avoided more than 2,600 NM / 21 hours of transit to a primary SRU helicopter.[50]

While undeniably advantageous, it is also equally important to note that secondary units do not always provide the same level of SAR capability as the primary SRUs. As

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[46] For more on the sensing capabilities of the Aurora, see: Arsenault, Daniel, and Josh Christianson, "Punching Above its Weight: The CP140 Aurora Experience within Task Force Libeccio and Operation Mobile," *The Royal Canadian Air Force Journal* 1, no. 3 (Summer 2012): 26-37.

[47] DND/CGC, *National Search and Rescue Manual…*, chapter 4, 5.

[48] DND, *Evaluation of the CF/DND Component of the National SAR Program*…, 3.

[49] Department of National Defence, "Air Force News – 444 Squadron Rescues British Adventurer in Arctic, March 28th, 2008," last accessed 29 March 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=5779.

[50] Estimation provided by the author based on a Cormorant helicopter departing from Gander, NL, with an approximate transit of 2600 NM and an average ground speed of 125 knots. Routing: CYQX-CYKL-CYFB-CYUX-CYRB-CYEU-CYLT with five 30 minute fuel stops included. Routing may differ pending on crew but it is still a generous best case scenario.

examples, CS units operating the Griffon helicopter are not authorized to conduct a night boat hoisting extraction and generally fly with only one SAR technician (SARTEC). In addition, the Griffon helicopter, the largest RW fleet in the CF, cannot fly in icing conditions which limits greatly its potential usage in the Arctic for a significant portion of the year.[51] Lastly, given the fact that secondary SRUs or other CF units are not mandated to support the NSP, it is extremely hard to predict their availability and consequently, they cannot be relied upon on a daily basis to support SAR incidents.

SAR Response Posture

The SAR response posture is not standardized within the NSP. For example, the Canadian Coast Guard maintains a 30 minutes posture 24 hours/day, 7 days/week. Other federal entities such as the RCMP and other provincial/territorial emergency services have different response posture pending on their own departmental policy. For the CF, current policy dictates "that each SRR have one of each type of aircraft per SAR squadron airborne within 30 minutes during weekdays from 8 a.m. to 4 p.m. local time, and within two hours at other times."[52] This represents the maximum time allocated to the crew to be airborne.

The impact of primary air SAR response time posture on incident outcomes has been the subject of many critics over the last few years. In April 2012, the Official Opposition attempted to put forward a motion in the House of Commons suggesting that Canada SAR standards are lagging behind international norms.[53] Media have also

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[51] iPolitics, "Griffon Helicopters in Search and Rescue Deemed at 'Risk': Air Force Report," last accessed on 11 March 2013, http://www.ipolitics.ca/2011/02/22/griffon-helicopters-in-search-and-rescue-deemed-a-risk-air-force-report/.

[52] DND, "Backgrounder: Canada's Air Force: A Proud Partner…," last accessed 24 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=11505.

reported on the subject and presented a fairly negative picture of the CF standby posture, describing it as a two tier system lagging behind international standards.[54] It is accurate to say that there are differences among countries with respect to standby posture. However, it is erroneous to suggest that Canada lags behind and does not meet established international standards as no such standards actually exist. It is left to each country to determine its own SAR readiness levels based on its territorial specificities, resources and other factors.

In response to critics, a few studies were conducted. One CF analysis concluded that of 2,700 lives at risk in 1,054 CF SAR cases over a four-year study period (2000-2004), "six people might have had an increased chance of survival if a 30-minute posture had been in effect."[55] Another study often used and cited is the 2005 Bourdon and Rempel historical analysis covering incidents over a three year period. One observation highlighted in their research is the fact that the highest SAR demand does not coincide with the 0800-1600 timeframe. In fact, according to the study, only 17% of the cases happen during the 30 minute standby posture while the other 83% falls outside and result in a 2 hour standby posture. This leads to the conclusion that a shift in the 30 minute response time would be beneficial. The same study also noted that maintaining a 100 percent 30-minute standby response is very expensive.[56]

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[53] House of Commons, *House of Commons Debates. Official Report (HANSARD)* 146, no. 138, Monday, June 11, 2012, 11:05.

[54] Canadian Broadcasting Corporation (CBC) – The Fifth Estate, "Mayday." Broadcasted 30 September 2011, last accessed 24 February 2013, http://www.cbc.ca/fifth/2011-2012/mayday/.

[55] National Research Council Canada (NRC), CR-FRL-2010-0025, *Review of the Statement of Operational Requirement for the Fixed Wing Search and Rescue Aircraft – Final Report* (Ottawa: NRCC, 2010), 15.

[56] *Ibid.*, 15-18.

While these facts are quite interesting and deserve consideration, they are not further analyzed herein as their impact is much more limited in an Arctic SAR context. Other factors such as transit time, re-fuelling stop-overs and severity of the Arctic weather environment have a much greater impact on the time required to proceed to the scene than the actual standby posture. More importantly, in an Arctic scenario, it is generally more advantageous to task a crew holding a 2 hour standby posture than a crew on a 30-minute standby as it maximizes the authorized crew day.[57] CF aircrew crew day is limited to 15 hours (extendable to 18 hours) with a maximum flying time of 12 hours (extendable to 14 hours).[58] Unless a mission requiring extended transit starts within the first 90 minutes of the start of the day crew during a normal working day, having a fully rested crew on 2 hour standby is more beneficial as a full 15 hour crew day remains available to execute the mission.

The information above constitutes standard operating procedures for conducting day-to-day SAR operations. They can be modified and tailored pending on the demand or specific events such as the opening of the fishery season where the risk is deemed higher than normal. There is also a contingency plan in place, described below, for major disasters or events that would overwhelm the system in place.

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[57] The crew day for a crew holding a 2 hour standby posture starts when the first crewmember reports for duty. Therefore, it provides the maximum allowable crew day for the execution of the mission which becomes quite advantageous when long transit is involved such as in Arctic SAR. It is also important to note that crews on 2 hour standby are, in average, airborne just over 50 minutes after the call comes in. For more about the response time debate in Canada, see: House of Commons, *House of Commons Debates. Official Report (HANSARD)* 146, no. 113, Monday, April 30, 2012, 11:30, last accessed 30 March 2013, http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=5532242&Mode=1#TOC-TS-1130.

[58] Department of National Defence (DND). *1 Canadian Air Division (1 CAD) Orders: Volume 2, Flying Orders* (Winnipeg: November 30, 1999), 2-003, Annex F.

Major Air Disaster (MAJAID)

DND is responsible for preparing the response to a Major Aeronautical Disaster (MAJAID) within Canada's AOR.[59] The plan focuses on major air disaster in remote areas such as the Arctic but it is also recognized that it could be activated for a variety of other disasters such as major marine SAR incident in the north, flooding, massive evacuation due to forest fires, etc. The latest revision of the MAJAID Contingency Plan (CONPLAN) was promulgated in August 2010 and it "provides resources and measures to respond to a MAJAID incident involving up to 320 survivors."[60] Essentially the plan would involve the response of the normal SAR primary assets enhanced with other primary assets from adjacent SRRs. In theory, the MAJAID CONPLAN would be activated on request and the initial response would include the air drop of a MAJAID kit pre-positioned in Trenton.[61] A 12 person Airborne Support Group (ASG) would also deploy with the first MAJAID load to support the primary SAR responders that would be already on the ground. The concept calls for having the first MAJAID load and personnel launching within 12 hours and air-dropped on scene within 20 hours.[62] It is also planned to use a forward base and CF Health Services Support "to conduct patient triage, treatment, and preparation for aeromedical evacuation."[63]

Availability of helicopters to carry out the evacuation is a critical element of the operation, and their early deployment is imperative given their much longer transit time to

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[59] DND/CGC, *National Search and Rescue Manual…*, chapter 4, 13.

[60] Department of National Defence (DND), *Canada Command CONPLAN 10250/10 MAIJAID – CF Response to a Major Air Disaster* (Ottawa: Commander Canada Command, 2010), 1.

[61] The kit contains survival store to support personnel including a 24 hours of consumable for 320 individuals.

[62] It is assumed that the incident would be located within 8 hours of Trenton using a CC-130. A second MAJAID load would also be sent as soon as possible to build some redundancy in the operation.

[63] DND, *Canada Command CONPLAN 10250/10 MAIJAID…,* 3.

a remote location. According the CONPLAN, "SAR helicopters can be expected to transit approximately 1500 NM per crew day. As an example, this equates approximately to a 15-hour response for all of Canada's SAR AOR south of 65° N latitude."[64] It is also expected that the transport of helicopters (Griffons or potentially the Chinook) via FW aircraft will be considered to expedite the deployment over great distance. The RCAF's CC-17 Globemaster II strategic lift aircraft is a great enabler of this capability, as two Griffons helicopters could potentially be deployed and flown to a forward location within hours of notification.[65] Even though it could happen very quickly and result in a very fast deployment of RW assets, some perspective is necessary. It is very unlikely that air-lifted RW aircraft would be part of the initial response as all assets and crews involved in this concept do not maintain a formal SAR readiness posture. Odds are that primary RW SAR assets will have already reached the scene and the RW assets deployed with CC-17 would be used for follow-up actions after the rescue efforts would be completed.[66]

The CONPLAN includes many more details and describes the participation of other elements with their associated deployment timelines. It also describes the Chain of Command to facilitate its execution, but needs revision to reflect the CJOC creation. Nevertheless, it still provides a sound framework for the CF response to a MAJAID in remote areas. The Canadian Coast Guard has a similar responsibility with respect to

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[64] *Ibid*., 6.

[65] Boeing, Defence, Space and Security. "Backgrounder: C-17 Globemaster III," last accessed 24 February 2013, http://www.boeing.com/defense-space/military/c17/docs/c17_overview.pdf.

[66] Canadian American Strategic Review (CASR), "Canadian Sovereignty - A Reality Check: Can Canada Really use a C-17 Transport to Airlift SAR Helicopters to the Arctic to Perform Aerial Search & Rescue Missions? May 2011," last accessed 24 February 2013, http://www.casr.ca/id-arctic-sar-transport.htm.

Major Marine Disaster (MAJMAR). As such, they are responsible for the development and implementation of plans to respond to the marine version of a major air disaster.[67]

Summary

In this chapter, the origins of the current SAR system were discussed. From the early days in 1947, the federal SAR response has evolved to become an integrated multi-agency responsibility with a predominant role for the CF. Each stakeholder has specific roles and responsibilities and the requirement for specialized skills combined with the scarcity of resources over such a large AOR favours a whole-of-government approach such as the NSP. International agreements have also contributed heavily in driving significant changes and they still continue to influence positively the current program by clearly defining areas of responsibilities, promoting cooperation and facilitating response among bordering countries.

Canada's AOR is the largest and certainly one of the most challenging in the world and this unique operating environment will be further analyzed in the next chapter. The size of the Arctic and its extreme environmental conditions combined with the sparsely located population are all factors contributing to this challenge. In response, the CF has developed standard operating procedures to respond to day-to-day incidents and also contingency plan for overwhelming events. In the end, however, the task should not be underestimated, especially in the Arctic.

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[67] National Search and Rescue Secretariat, "Reports: National Search and Rescue Program Annual report 2003," last accessed 24 February 2013, http://www.nss.gc.ca/site/reports/nsp/2003%20Annual%20Report/programplan_e.asp.

Chapter 2 - SEARCH AND RESCUE IN THE ARCTIC

There is no doubt that the Arctic environment poses a tremendous amount of challenges for all the Arctic nations. To make matters worse, Canada has a number of particularities that makes establishing a balanced SAR program even more strenuous. It is the aim of this chapter to introduce and discuss some of the issues associated with Arctic SAR operations. This will help to better understand the difficulties faced by the NSP and provide context when assessing the actual CF capability to respond to northern incidents. It will also help in demonstrating that there are limitations to be placed on expectations from the NSP as there are no easy practical solutions that could provide a perfect coverage in the Canadian Arctic.

Survivability in the Arctic

When referring to the Arctic, one of the first thought to come in mind is the extreme weather conditions associated with this particular environment. It is a severe and very unforgiving climate pounded by frequent storms, blizzards, fog and icing conditions which all hinder maritime and aviation operations. The severity of the whiteout conditions can limit and even deny mobility on the ground. The Temperature in the Arctic can easily reach -50^{o}C and the combination of the wind can quickly produce deadly conditions.[68] The environment has also little to offer in term of vegetation, natural shelters and flammable material, making survival tasks much more arduous than in the south.

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[68] Canada's coldest wind chill was recorded in 1975 at Kugaaruk, Nunavut (NU), when the air temperature plunged to -51 ^{o}C with sustained winds of 56 km/h, producing a bone-chilling wind chill of -78 ^{o}C. The Weather Network, "Glossary: Wind Chill Across Canada," last accessed 24 February 2013, http://www.theweathernetwork.com/glossary/windchill_across_canada.

RCAF doctrine appropriately states that "since the probability of survival of incident victims decreases rapidly with the passing time, particularly if injuries or severe climatic conditions exist, the most essential characteristic of SAR forces is the ability to provide a rapid response."[69] A recent study goes as far as claiming that the chance of survival statistically decreases by about 3 percent for every hour that passes after an incident occurs.[70] The unquestionable fact is that the extreme climatic conditions found in the Arctic amplify considerably the requirement for a rapid response and extraction from the elements. Figure 2.1 represents hypothermia survivability probability as a function of outside temperature and survival days.

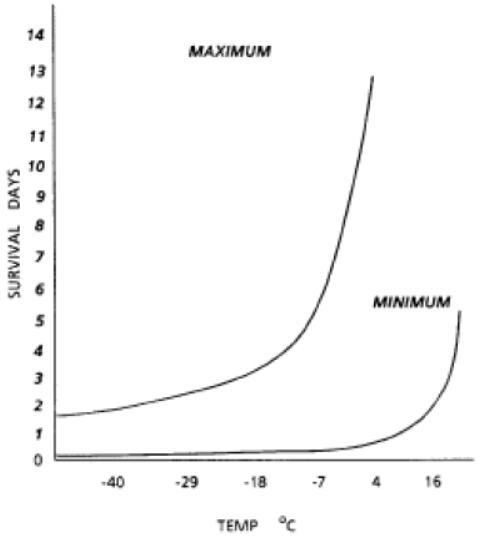

Figure 2.1 – Hypothermia Survivability Graph[71]

[69] Department of National Defence (DND), B-GA-404-000/FP-001, *Canadian Forces Aerospace Move Doctrine* (Winnipeg: Canadian Forces Aerospace Warfare Centre, 2011), 49.

[70] NRC, *Review of the Statement of Operational Requirement for the Fixed Wing SAR…,* 15.

[71] The graph describes the range of days for fatal exposure or hypothermia survivability, in days, for a given temperature. The information calculated is a guide only and is based upon a healthy 25 year old male wearing the equivalent of normal clothing, including a jacket. Source: Australian National Search and Rescue Council, *National Land Search Operations Manual version 6* (Australian Federal Police, 2010), 151.

Of course, the graph has some major limitations as many factors influence the chance of survivability, but it is still beneficial as it provides a visual illustration of the urgency requirement to extract the casualty from the element in a cold weather scenario. Similarly, Figure 2.2 gives an estimated life expectancy based on immersion time in cold water. It clearly illustrates the fact that the survival time in a cold water immersion scenario is matter of few hours, if not minutes.

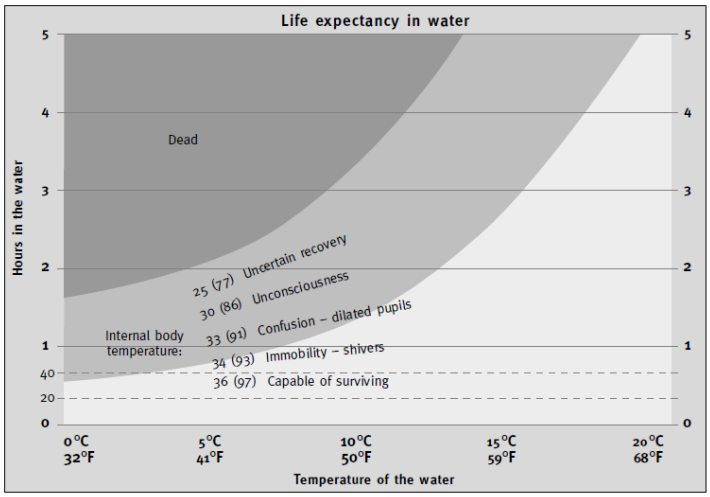

Figure 2.2- Chart of Survival Time as a Function of Water Temperature (Assuming no cold protection)[72]

Both figures ascertain the requirement to extract the victim from the cold weather environment as quickly as possible. It also draws the attention to one of the fundamental problem of conducting SAR operations in the Canadian Arctic. It calls for the fastest intervention possible over a huge AOR that is characterized by severe climate, low population density, a lack of infrastructure and limited SAR assets in the area.

[72] Fisheries and Oceans Canada, Coast Guard, *SAR Seamanship Reference Manual* (Ottawa: Minister of Public Works and Government Services, 2000), chapter 3, 4.

The Population Density and SAR Incidents Distribution

One of the Canadian particularities is purely demographic. The Canadian Arctic represents approximately 40% of the country's land mass, the equivalent of Europe in size, with only 0.3% of the Canadian population living there.[73] In terms of numbers, this represents approximately 110,000 residents located in Nunavut (NU), NWT and the YK. It barely equates to 0.1 persons per km^2. In comparison, Alaska has approximately 725,000 residents with an area 2.5 times smaller than the Canadian Arctic giving a population density of 3.1 persons per km^2.[74] Figure 2.3 provides a visual illustration of the Canadian population density based on the 2011 census, revealing that about 90% of the residents are concentrated within 160 km of the Canada-U.S. border.[75]

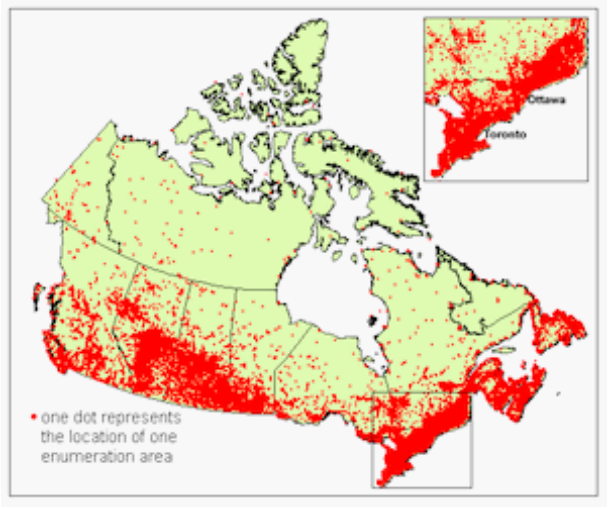

Figure 2.3 – Population Density in Canada (Census 2011)[76]

[73] Statistics Canada, "Population and dwelling counts, for Canada, provinces and territories, 2011 and 2006 censuses," last accessed 25 February 2013, http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/hlt-fst/pd-pl/Table-Tableau.cfm?LANG=Eng&TABID=1&T=101&SR=1&RPP=25&S=10&O=A&CMA=0&PR=0#C2.

[74] Department of Commerce, United States Census Bureau, "State and Country QuickFacts," last accessed 25 February 2013, http://quickfacts.census.gov/qfd/states/02000.html.

[75] About.com, Geography, "Canadian Sperlatives-Super Canada!" last accessed 25 February 2013, http://geography.about.com/library/weekly/aa052500a.htm.

[76] Origin, "Canada Population 2012," last accessed 25 February 2013, http://worldpopulationreview.com/canada-population/.

Understandably, it is no surprise that most SAR cases happen in the southern portion of the country where the level of activity is the highest. The annual distribution of SAR incidents, shown at Figure 2.4, reflects indisputably this logic and consequently, the visual representation of SAR incidents location coincides with the population distribution shown at Figure 2.3. Since SAR resources are positioned to better respond to the majority of the incidents, their location also correspond to the population distribution.

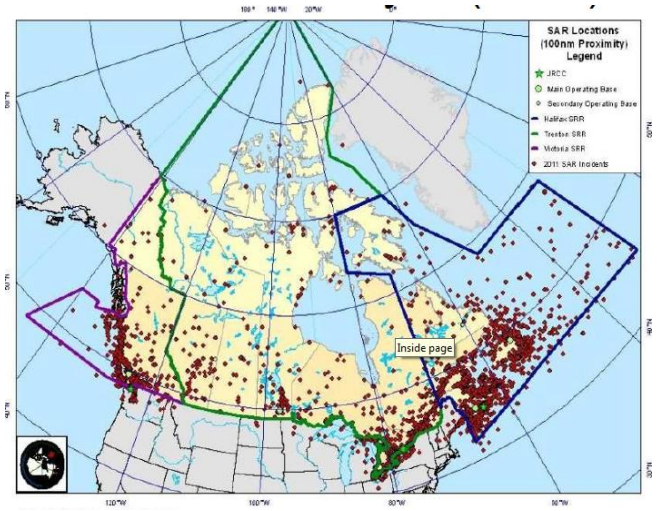

Figure 2.4 – SAR Incident Distribution (2011)[77]

CF Primary SAR Assets Locations

The CF manages and positions primary SAR assets throughout Canada with the aim of maximizing "their effectiveness in responding to the majority of calls for assistance."[78] In a 2005 study related to SAR response time, it was determined that there was a strong correlation between the locations of the primary SAR assets Main Operating Bases (MOBs) and where the highest numbers of SAR incidents occurs. It concluded that

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[77] Canadian Forces Canada Command, Presentation by Major Jay Nelles, *CF Overview of SAR in Canada-Airline Post Brief*, Northern SAR Roundtable, 31 January 2012.

[78] DND, "Backgrounder: Canada's Air Force: A Proud Partner…," last accessed 24 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=11505.

SAR helicopters were currently "very well positioned" and SAR FW aircraft were "suitably positioned" to respond to SAR incidents in Canada.[79] It is hard to argue to the contrary when looking at Figures 2.3 and 2.4, but when the SAR system is analyzed in isolation within an Arctic context, it produces the paradox hinted earlier. Since most primary SAR assets are logically located to the South to respond to the majority of incidents, it results in having the slowest response time in the Arctic where the fastest response is actually sought after due to the extreme environmental conditions. This paradox is one of the biggest challenges for the Canadian SAR system. There are no easy solutions and it comes down to striking an adequate balance between the ability to respond quickly, the distribution of limited resources and the cost associated to SAR operations. This is assuming that one can actually assess and somewhat measure the effectiveness of the program in order to judge if that balance is actually achieved or not.

CF SAR Response in the Arctic and Measure of Effectiveness

In a classic northern scenario involving a CF response, the first responder on scene will almost certainly be a FW aircraft given their speed and range. Consequently, the initial response under this assumption is normally limited to the air-drop and dispatch of survival equipment and/or the parachuting of SARTECs to provide medical care and survival assistance. Parachuting operations are extremely useful and critical in the success of many SAR missions, especially in remote areas such as the Arctic, but they are also limited by winds velocity and ceiling height and as a result, they are not always

[79] Department of National Defence (DND). *DRDC-ORD Technical Report TR 2005/15, Support to Air Transformation (Search and Rescue)*. Ottawa: DND Canada, 2005, 27.

possible.[80] Furthermore, in an air drop scenario, the mission completion and success rely on the ability to extract the personnel from the accident site and minimize exposure from the elements. But the casualty extraction time from the Arctic environment has always been and still remains problematic. The lack of infrastructure in the north limits significantly the means that can be employed for the extraction, favouring the usage of helicopters and boats to recover the victims back to safety. As the options to effect the extraction are significantly limited, it unsurprisingly becomes the weakness of the system if the demand does not substantiate the establishment of a unit in the area.

When looking at Figures 2.1 and 2.2, it is quite apparent that the level of service has serious limitations for SAR incidents in the Arctic. A person immersed in cold water (no immersion suit) in the Arctic has very little chance to be rescued alive by a CF aircraft given the distance and transit time required. But in fairness, to assume that SAR assets could be available and located in such way that a victim immersed in cold water could be recovered within the survival time everywhere in the Canadian SAR AOR is simply unrealistic. However, the discussion still raises a fundamental question regarding the SAR level of service and its overall effectiveness in accomplishing the mission.

Assessing the current performance of the NSP is quite difficult as the program fails to define a minimum level of service to be provided. In 2002, the Chief of Air Staff provided criteria to the NSS regarding CF SAR levels of services, roles and responsibilities.[81] The same criteria were used in the development of the Statement of

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[80] Operational jumps shall not be carried out at altitudes of less than 1,200 feet Above Ground Level/Above Water Level (AGL/AWL). The maximum surface wind speed for operational jumps shall be at the discretion of the team leader. Department of National Defence. SMM 60-130-2605, *Standard Manoeuvre Manual CC130(E/H) Search and Rescue Operations* (Winnipeg: 1 Canadian Air Division, 2010), chapter 1, 1.

Requirement (SOR) for the Fixed-Wing SAR (FWSAR) aircraft replacement project.[82] More specifically, the criteria provided by the Chief of Air Staff states that:

> … a primary CF SAR aircraft will be capable of arriving in the search pattern (Commence Search Point) for any aeronautical or maritime SAR incident occurring in a Canadian SRR within 4 hours of being tasked for 90% of SAR incidents and within 11 hours of being tasked for 100% of SAR incidents. The above response times may be susceptible to delays due to extreme weather conditions, mechanical failures, or to adhere to flying regulations…[83]

These criteria were promulgated in 2002 in response to a request by the NSS for operational departments to produce a SAR service-level document. They are the only criteria referring to the CF SAR level of service but it is important to realize that even if they are occasionally used in various forums and documentations, they have never been adopted as a national standard.[84] The Chief of Air Staff directive never originated from a formal government policy and has never transpired in formal military doctrine. Therefore, the numbers are still open for debate from a policy standpoint and one could question if they actually meet the Canadian public's expectations as they are not currently supported by Government of Canada policy.[85]

In comparison, the U.S. Coast Guard SAR mission response time minimum standard is set as no greater than a two-hour total response time to arrive anywhere within an assigned sector or unit's AOR.[86] Note that this standard could be misleading in a

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[81] Department of National Defence (DND), L.C. Campbell, *Canadian Forces Search and Rescue Level of Service and Roles and Responsibilities, letter from Chief of Air Staff to the National Search and Rescue secretariat, 21 August 2002* (Ottawa: DND Chief of Air Staff).

[82] NRC, *Review of the Statement of Operational Requirement for the Fixed Wing SAR…,* 7.

[83] Department of National Defence (DND), L.C. Campbell, *Canadian Forces Search…*

[84] DND, *Evaluation of the CF/DND Component of the National SAR Program…*, 10.

[85] NRC, *Review of the Statement of Operational Requirement for the Fixed Wing SAR…,* 7.

Canadian context as it does not apply to over land SAR incidents. Whereas such standard would be unrealistic in Canada given the size of the AOR, the low number of SAR incidents and the limited assets available, the discussion underscores the need to better manage expectations. In a Canadian environment, 4 hours for 90 percent of the incidents and 11 hours for 100 percent of the incidents might be, after all, a reasonable level of service to be expected in the Arctic.

Another difficulty in assessing the CF effectiveness regarding Arctic SAR operations is the lack of "strategic-level performance measures for its SAR capability."[87] The only real measures available are in terms of readiness and response with no focus on performance measurement.[88] In contrast, the Canadian Coast Guard produced an analysis in 2007 that included some benchmarks to make such an assessment. Ironically, the Canadian Coast Guard operates under the same NSP umbrella as the CF; and given the integrated aspect of the program, it does capture the CF participation but it is limited to the maritime cases where CF assets were involved. Nevertheless, in their *2007 SAR needs analysis*, the Canadian Coast Guard was able to assert that the federal SAR system is extremely effective, achieving a success rate of 96.2% of lives saved from lives at risk for maritime distress cases of all classifications between 2000 and 2004.[89] They were able to declare that their pre-established national benchmark of 90% was met during that period

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[86] This includes the standby posture period and equates to a total of 90 minutes from notification to on-scene (U.S. Coast Guard maintains a 30 minutes standby posture 24 hour a day). Department of Homeland Security, United States Coast Guard, "SAR Program Information," last accessed 25 February 2013, http://www.uscg.mil/hq/cg5/cg534/SAR_Program_Info.asp.

[87] DND, *Evaluation of the CF/DND Component of the National SAR Program*…, 9.

[88] It is important to clarify the terminology as the CF readiness level refers to the minimum proficiency standards that aircrew must maintain and the CF response level refers to the actual time required to respond to an incident (i.e. ability to be airborne within the prescribed 30 minute or 2-hour window). DND, *Evaluation of the CF/DND Component of the National SAR Program*…, 11.

[89] DFO, Canadian Coast Guard, *Search and Rescue Needs Analysis 2007…,* introduction.

of time for *conventional incidents* in all regions excluding the western Lake Erie area and the Arctic.[90] According to their benchmarks, the Arctic cannot be compared to other regions of Canada given the harsh and difficult conditions found in that particular environment. Arctic cases are characterized as *difficult incidents* for which a 50+% level of service is typically acceptable.[91] The Canadian Coast Guard draws two conclusions from the analysis. First, despite the unique challenges presented by the Arctic, the SAR system effectiveness evaluation revealed higher-than-expected levels of services and were considered acceptable. Second, they also conclude and highlight the overall lack of primary SAR response units in northern Canada despite meeting their benchmarks. [92]

The approach taken by the Canadian Coast Guard is somewhat similar to the U.S. Coast Guard, which measures the whole SAR system performance in term of *lives saved* after notification:

> The current performance benchmark for our maritime safety mission strives to measure the effectiveness of our collective prevention and response efforts. Simply stated it measures the number of "lives saved" versus the number of "lives in distress."… Our performance benchmark goal is based on calculations of historical performance and estimations of attainable levels of success. As future improvements are made in the SAR System we expect these improvements to be reflected in our performance.[93]

This provides them a tool to measure their performance not only on an incident response effectiveness basis but also in term of efficiency of the various improvements that are

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[90] In the western Lake Erie region, SAR effectiveness was brought below the benchmark (82.98%) due to an airplane crash, in which 10 lives were lost.

[91] DFO, Canadian Coast Guard, *Search and Rescue Needs Analysis 2007…*, future trends.

[92] The SAR system effectiveness evaluation in the Arctic revealed higher-than-expected levels of service (based on 50%): 69.23% for the waters of the NWT Area; 86.67% for the James Bay Area; 81.48% for the eastern Arctic Area; and, 93.10% for the NU Area. For more details, see: DFO, Canadian Coast Guard, *Search and Rescue Needs Analysis 2007…*, future trends.

[93] Department of Homeland Security, United States Coast Guard, "SAR Program Information," last accessed 25 February 2013, emphasis added in italic, http://www.uscg.mil/hq/cg5/cg534/SAR_Program_Info.asp.

made to the overall program in fields such as prevention, technology, regulation, etc. It is not the intent to validate the performance measurements used by either the Canadian Coast Guard or the US Coast Guard herein as it constitutes a research topic by itself. But the point being made is that a similar system is inexistent for the CF or the overall NSP in Canada, making it almost impossible to measure the overall effectiveness of the program over time. This approach would also take into account the integrated aspect of the Canadian NSP as the combined effect of the various stakeholders would be better captured. It would be helpful not only to capture the effectiveness in term of lives saved but also to assess the program as a whole by reflecting the impact of new technology and preventive and regulatory initiatives which often could have a greater impact than just re-locating assets. This shortfall was identified in 1999 by the NSS and more recently by the DND Chief Review Service in January 2008.[94]

Given the lack of established measures of performance in the NSP, there is a need for using other means to determine if the current SAR capabilities are able to cope with the actual challenge and demand. Therefore, looking at individual Arctic SAR missions to evaluate the current performance of the CF in that specific area might be one of the best approaches available to assess the current capabilities. In the following sections, a few high profile northern SAR missions are examined to evaluate the degree of success of the CF in support of those missions. It is understood that the methodology chosen is rather subjective as the cases were selected by the author; nonetheless, this approach is still suitable to achieve the desired intent. The cases chosen will illustrate the level of difficulty associated with northern operations and demonstrate that even if the CF

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[94] DND, *Evaluation of the CF/DND Component of the National SAR Program*…, 9.

currently fulfills its mandate successfully in the vast majority of occurrences, improvements should be actively sought to strengthen Arctic SAR capabilities.

BoxTop 22 – October 1991

On October 30, 1991, a CF CC-130 Hercules aircraft, call sign BoxTop 22, crashed while on final approach to CFS Alert with 18 persons onboard. The aircraft crash site was located approximately 10 NM south of the station and the subsequent rescue operation became the most notorious Arctic SAR mission in Canadian history. The mission was undertaken under darkness with temperature of -22^{o}C with howling winds giving wind chill as low as -66^{o}C at times. Hundreds of personnel from the CF, U.S. and civilian organizations were involved. In total, 26 aircraft participated in the rescue totalizing an astonishing 516 hours of flying time.[95]

The Box Top Flight 22 crash represents the worst case scenario for the Canadian SAR system. The downed CC-130 was one of three Hercules aircraft tasked to re-supply CFS Alert with fuel.[96] The station, the most northern permanently inhabited settlement in the world, is located on the northern tip of Ellesmere Island, NU, in the Canadian high Arctic. The aircraft involved in the crash hit a rocky cliff while on final approach to the station. Miraculously, only four of the eighteen people on board died on impact. Given the closeness of CFS Alert, the survivors believed that help would arrive within few hours. But a fierce Arctic blizzard set in and the rescuers faced the worst environment

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[95] Robert Mason Lee, *Death and Deliverance: The Haunting True Story of the Hercules Crash at the North Pole* (Toronto: MacFarlane Walter and Ross, 1992), 201, 271.

[96] The re-supply operation, named BoxTop, is a bi-annual mission undertaken by the CF to sustain the station. Department of National Defence (DND), "Royal Canadian Air Force, Articles: RCAF delivers fuel to Canada's most northerly post, May 2, 2012," last accessed 23 March 2013, http://www.rcaf-arc.forces.gc.ca/8w-8e/nr-sp/index-eng.asp?id=12810.

possible including perpetual darkness, extreme cold, howling winds, and white out conditions.[97]

BoxTop 22 was the first major air disaster ever to confront the CF SAR system. A draft MAJAID plan was in progress at the time and was activated, although never officially declared. Numerous assets were tasked in support of the mission from various locations across Canada, the U.S. and Iceland.[98] Even with the impressive number of assets assigned throughout the mission, the first SARTECs to make it to the crash site were parachuted in extremely hazardous conditions (darkness, blizzard conditions with winds and low ceiling reported as 40 knots and 800 feet) almost 32 hours after the crash.[99] The SARTECs demonstrated an unprecedented level of courage and determination and amazingly, there were no injuries during the parachuting operation. They were subsequently joined by a ground rescue party from CFS Alert using Go-Tracks all-terrain vehicles. The ground party succeeded in reaching the crash site after three attempts as the harshness of the terrain, the extreme weather conditions and difficulty in navigating forced them to return twice to the station.[100] This illustrates the fact that even if an incident occurs relatively close to some sort of infrastructure in the Arctic, it is not always possible or it might be very arduous to reach the scene with ground equipment.

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[97] David Hughes, "The Rescue of BoxTop 22. The Crash of a C-130 Pits a Massive Rescue Force against the Deadly Arctic Night," *Popular Mechanics* (June 1992), 50.

[98] Aircraft departed from Edmonton (AL), Trenton (ON), Greenwood (NS), Gander (NL), Anchorage (Alaska), and Keflavik (Iceland) at various times during the mission to support of the operation. Lee, *Death and Deliverance: The Haunting True Story of the Hercules Crash…,* xiv-xv, 51.

[99] Rachel Lea Heide, "Frigid Ambitions: The Venture of the Alert Wireless Station and Lesson Learned for the Canada First Defence Strategy," in *Sic Itur Ad Astra: Canadian Aerospace Power Studies Volume 4: De-Icing Required! The Historical Dimension of the Canadian Air Force's Experience in the Arctic,* ed. P. Whitney Lackenbauer and W.A. March, 6 (Ottawa: Her Majesty the Queen as represented by the Minister of National Defence, 2012), 121.

[100] Hughes, *The Rescue of BoxTop 22*…, 50-51.

The crash site was cleared of all survivors and deceased after 47 hours. One crew member of BoxTop 22 died and two other survivors sustained permanent disabilities due to exposure to the elements.[101] Survivors were extracted from the crash site using a CF Twin Huey helicopter and the SARTECs and deceased were extracted by two US Pave Hawk helicopters. All three helicopters used for the extraction were transported into Alert on FW aircraft. To single out the challenge for RW aircraft to fly to such remote areas, it took 37 hours for a Trenton primary SAR Labrador helicopter, without shutting down, to reach Ellesmere Island. The aircraft was stood down at Eureka, NU, one leg short of CFS Alert.[102]

The story of the BoxTop 22 is a magnificent display of courage and determination and was the most decorated peacetime event in Canadian military history.[103] It also highlights the incredible challenges of performing SAR operations in the Arctic. When looking at the present capabilities versus what was available at the time, one can observe that some improvements have been made but it would still take a considerable amount of time to respond to a similar emergency. The time required to parachute the first SARTECs on scene (33 hours), given the same conditions, would be the same as the CC-130 is still the primary CF FWSAR aircraft. A noticeable change could be the time required to deploy RW aircraft using a FW asset. The CC-17 Globemaster II would make this task much easier but the caveats mentioned earlier still exist. The CC-17 platform is a scarce strategic asset and does not maintain a SAR standby posture, making the

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[101] Matthew, Lacroix, "BOXTOP 22 Survivor Remembers Fatal Crash," *The Maple Leaf* 11, no 26 (Summer 2008): 6.

[102] Lee, *Death and Deliverance: The Haunting True Story of the Hercules Crash…,* 252. The helicopters used for the extraction were air-lifted by CF CC-130 Hercules and U.S. C-5 Galaxy transports. CF Bell Twin Hueys (CH-135) were replaced by the Griffon Helicopters in 1995-1997.

[103] The mission resulted in one Meritorious Service Cross, 18 Meritorious Service Medals and 14 Chief of the Defence Staff Commendations. Sandy Babcock, *Operation Canon*…, 32.

availability of these aircraft to support such task on short notice highly speculative. The Cormorant helicopter would make a huge difference in the time required to fly a RW aircraft at the same location under its own power. The Cormorant helicopter has a much greater range and de-icing equipment, making it much more capable than all other RW aircraft used at the time of the crash. Still, in a best case scenario, it would take approximately 22 hours to fly on scene assuming no weather or mechanical delays.[104] A more recent northern air disaster, First Air Flight 6560, could have tested the CF newly acquired capabilities but circumstantial factors prevented a truly representative assessment.

First Air Flight 6560 – August 2011

On 20 August 2011, First Air Flight 6560 crashed during the approach to Resolute Bay, NU.[105] The aircraft, a Boeing 737 210C with 15 persons onboard, impacted a hill about 1 NM east of the airport a few seconds after initiating a go-around manoeuvre. Reduced visibility and low ceilings were present at the time and the crash has been categorized as a controlled flight into terrain for the time being as the Transportation of Safety Board investigation is still underway. [106] Miraculously, three persons survived the tragic accident.

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[104] The calculation was made by the author. This estimate is based on a Cormorant helicopter departing from Gander (NL) with an estimated transit of 2580 NM and an average ground speed of 125 knots. The routing chosen was: CYQX-CYKL-CYFB-CYUX-CYRB-CYEU-CYLT and five 30 minute fuel stops were included. This represents a very optimistic scenario that includes a crew swap along the way, thus additional FW support would be essential for the successful completion of the mission within this timeline.

[105] CTV News, "Experts say Boeing Crash Shows Need for Arctic Capability," last modified 19 May 2012, http://www.ctvnews.ca/experts-say-boeing-crash-shows-need-for-arctic-capability-1.686250.

[106] Transportation Safety Board of Canada (TSB). "Investigation Progress Update: First Air Flight 6560, Boeing 737 Accident, 20 August 2011, Resolute Bay (A11H0002)," last accessed 02 March 2013, http://bst-tsb.gc.ca/eng/medias-media/progres-update/aviation/2012/a11h0002/a11h0002-20120105.asp.

The First Air crash was only the second time, after BoxTop 22, that the modern SAR system was confronted with an Arctic major air disaster. The crash site was located almost 1,900 NM from Trenton and represented a real test for the CF's ability to respond quickly to a major Arctic SAR scenario. But conceivably the most astonishing aspect of this accident was the coincidental presence of the CF in Resolute Bay at the time. The CF was already on site conducting a two-fold exercise called Operation Nanook 2011. The first part of the annual exercise focused on sovereignty operations. The second portion of the exercise, in a stupefying coincidence, was aimed to exercise the MAJAID CONPLAN involving a simulated 737 crash in Resolute Bay.[107]

The MAJAID exercise reflected the whole-government approach of the NSP. It involved numerous federal and provincial departments and the aim was to practice and evaluate their abilities to provide a timely and coordinated response to a major aircraft crash in remote areas. The simulated scenario was planned to start within 48 hours of the actual crash of Flight 6560 and was obviously cancelled as the focus shifted to the actual response to the real accident.[108] This astounding coincidence resulted in having an important CF presence already deployed on site as "the two-part operation involved more than 1,100 CF participants and approximately 100 personnel from the U.S. and Denmark."[109] It also included two Griffon helicopters and one shipborne Sea King

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[107] Nunatsiaq Online, "Armed Forces Suspends Mock Disaster Response after Crash in Resolute Bay," last modified 21 August 2011, http://www.nunatsiaqonline.ca/stories/article/65674military_was_ready_to_respond_to_aug._20_crash_in_resolute/.

[108] Nunatsiaq Online, "Armed Forces Suspends Mock Disaster Response after Crash in Resolute Bay," last modified 21 August 2011, http://www.nunatsiaqonline.ca/stories/article/65674military_was_ready_to_respond_to_aug._20_crash_in_resolute/.

[109] Ron Wallace, "Emerging Canadian Priorities and Capabilities for Arctic Search and Rescue: A Policy Update Paper," (Calgary: Canadian Defence and Foreign Affairs Institute, 2012), 1.

helicopter to support the operation resulting in the fastest response one could imagine. CF members, including 15 medical personnel, were flown to the scene using the three CF helicopters. When the local ambulance crews arrived on-site, the three survivors had already been evacuated within minutes of impact.[110] Survivors were then flown to Iqaluit in a CF CC-17 Globemaster.

Whereas the coincidental presence of the CF resulted in the best case scenario for the survivors, it also overshadowed and blurred the actual capability of the CF to respond to a major crash in the Arctic. Assuming that ground personnel would not have been able to reach the crash site, which was not the case but highly probable in the Arctic environment given the lack of infrastructure and the roughness of the terrain; the actual response time would have been termed in hours versus minutes and could have led to a much different outcome. If the only aircraft to respond would have come from CF primary SRUs, the best case scenario would have had resulted in having SARTECs parachuted on the ground within 5-6 hours, ceiling permitting. [111] The first CF helicopter would have probably arrived on scene 16 hours after notification.[112] While the estimates above are speculative, they do highlight the fact that luck was a big factor in the success of this operation.

Lastly, this mission had another similarity to the BoxTop 22 crash. In both cases, the incident happened near logistic and supporting bases or an airport which constituted

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[110] CASR, *Arctic Sovereignty - Arctic SAR: First Air Crash*..., last accessed 02 March 2013, http://www.casr.ca/id-arctic-sar-first-air.htm.

[111] Estimated by the author. Based on a 1490 NM transit with 300 knots ground speed for a Hercules departing from Winnipeg. Note that the actual ceiling was reported at 300 feet AGL shortly after the accident and therefore additional delays could have occurred.

[112] Estimated by the author. Based on a Cormorant helicopter out of Gander. The transit was estimated at 1980 NM with average ground speed of 125 knots. Routing selected for the estimation: CYQX-CYKL-CYFB-CYUX-CYRB with three 30 minute fuel stops included.

an undeniable facilitator. Though some may argue correctly that a significant majority of aircraft crashes happen either on take-off or landing and consequently are located near airports, this element has a different significance and implication in the Arctic.[113] In the south, the fact that the majority of air accidents occur relatively close to airport favours a quicker response as local or airport emergency services will, in most cases, be able to reach the site without too much difficulty. This is not so likely in the Arctic given the lack of infrastructure, the roughness of the terrain and the extreme weather conditions; especially during the winter season. BoxTop 22 was a prime example of this Arctic reality where the combination of these factors made the ground rescue almost impossible and very lengthy. It is also fair to question how much more time it would have taken to reach the First Air Flt 6560 crash site under winter conditions and the consequences for the survivors as a ground rescue would have been limited to the usage of snowmobiles and track vehicles. A robust local airport incident response therefore does not necessarily provide an exclusive solution to a stronger SAR system in the north as there is a greater potential that the environment will jeopardize this capability.

SAR Igloolik, NU – 27 October 2011

On 27 October 2011, JRCC Trenton tasked a Hercules aircraft from Winnipeg to rescue a father and son stranded in their small aluminum boat in the icy water of Igloolik, NU. The incident site was located approximately 1,250 NM from Winnipeg and 1,525 NM from Trenton. The two men had activated their personal emergency beacon late the

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[113] Approximately 3o% of commercial jet fatal accidents occurs on take-off or landing. This number increases to 60% if the initial and final approach portions are included. For more, see: Boeing Defence, Space and Security, "Statistical Summary of Commercial Jet Airplane Accident, Worldwide Operations, 1959-2011," last accessed 9 March 2013, http://www.boeing.com/news/techissues/pdf/statsum.pdf.

previous day.[114] The first Hercules aircraft, from Winnipeg, arrived on scene early in the morning and was unsuccessful establishing communication with the two men (a radio was air dropped but not recovered). The aircraft proceeded to Iqaluit, NU, for fuel and returned on scene around noon. Two six-man life rafts and one radio were air dropped and the radio and one life raft were successfully recovered by the distresses. The aircraft left the area as the aircrew were approaching the maximum permissible crew day for SAR operations. Early that morning, a second Hercules aircraft from Trenton, a Cormorant helicopter from Gander, and two small rescue boats from the local community were also tasked to support the mission. The second Hercules arrived on scene at 15:05 hours local time and established visual contact with the two men who were now nauseated, distressed and too cold to access the supplies that had been dropped previously. They had moved to the life raft as the weather conditions were deteriorating.[115] By 16:00, radio contact with the men was lost and they appeared to be unresponsive and potentially suffering from dehydration and hypothermia. JRCC staff and the Hercules crew agreed to parachute the SARTECs in the icy water to rescue the victims. At 17:33, after several delays,[116] the three SARTECs jumped in the water approximately 8 NM south of Igloolik only 30 minutes before full darkness.[117]

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[114] TheStar.com, "Insight: How Did Search-and-Rescue Mission to Igloolik Go Wrong?" Last accessed 8 March 2013, http://www.thestar.com/news/insight/2012/04/20/how_did_searchandrescue_mission_to_igloolik_go_wrong.html.

[115] Weather and sea state conditions estimated at 10-15 feet swells with ice, winds 25-35 knots and air temperature of -8°C.

[116] The Hercules was requested to investigate the status of the two community boats sent earlier to support of the rescue operations. Once Hercules crew confirmed that both boats were safe but unable to carry on with the mission, the crew proceeded back on scene and resumed the SARTEC drop sequence.

[117] Department of National Defence (DND), "From the Investigator," *Flight Comment*, issue 1 (2012): 36.

The first SARTEC was able to swim to the life raft and he provided assistance to the men in distress. The second SARTEC swam until he realized he would not reach the victims and was forced to deploy his personal life raft and wait until recovery. The third SARTEC, the Team Leader (STL), landed further away and managed to make a partial radio transmission before losing contact. After completing the SARTEC drop, the Hercules aircraft provided night illumination (flares) for few minutes and air dropped two additional survival kits near the victims before proceeding to Iqaluit for re-fuelling. The Cormorant helicopter arrived on scene four hours later, nearly 13 hours after departure which included three re-fuelling stopovers. The Cormorant is arguably one the most capable SAR RW aircraft in the world and surely the most appropriate platform to undertake such task in the CF inventory. Still, it took a very experienced and highly capable crew over 13 hours to reach the victims. By the time the crew reached the site, the sea conditions had worsened and the helicopter crew was now facing winds gusting to 47 knots and sea conditions estimated at 20-30 feet.[118] The victims and the SARTECs were recovered successfully but the STL was found unresponsive after spending nearly five hours in the water. The victims and SARTECs were flown to the nearest Health Centre and attempts to revive the STL were unsuccessful.[119]

Once again, this heroic and tragic Arctic mission highlights the courage and determination of the CF members involved. The three SARTECs who jumped in the water received (sadly, one posthumously) the IMO Award for Exceptional Bravery at Sea

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[118] *Ibid.*

[119] TheStar.com, "Insight: How Did Search-and-Rescue Mission to Igloolik Go Wrong?" Last accessed 8 March 2013, http://www.thestar.com/news/insight/2012/04/20/how_did_searchandrescue_mission_to_igloolik_go_wrong.html.

which is the highest honour awarded by this international organization.[120] Numerous other awards were given to crewmembers involved in this rescue. This mission is another testimony of the astonishing challenges and risks associated with Arctic SAR.

Humanitarian Cases

The cases presented so far all fell into the federal SAR mandate. There are times, however, when the provincial/territorial/community SAR capabilities are hindered or overwhelmed by the operating environment or simply require additional resources for humanitarian cases falling under their respective jurisdiction. When this happens, a request for assistance from the CF is made. Humanitarian cases are not the core responsibility of the CF; nevertheless, they represent about 75 percent of the missions north of 60°N latitude involving CF aircraft.[121] There have been a few Arctic cases lately involving the CF that are worth noting for the discussion.

On January 22, 2010, a Cormorant helicopter was dispatched from Greenwood, NS, to rescue a man stranded on an ice floe near Resolute Bay. The temperature at the time was -31°C with a wind chill of -51°C.[122] A Hercules aircraft dropped survival equipment and supplies while the man awaited a helicopter to be rescued. The mission involved an extensive transit (1,950 NM) during the winter, exposing the crews and aircraft to the most challenging environmental conditions one can imagine. Due to weather delays, re-fuelling stopovers and mechanical breakdowns, the man was

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[120] Department of National Defence (DND), "SAR Techs Receive International Award for Bravery at Sea," *The Maple Leaf* 15, no. 11 (December 2012), 7.

[121] DND, *Royal Canadian Air Force in the North*…, last accessed 22 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/page-eng.asp?id=1512.

[122] Department of National Defence (DND), Royal Canadian Air Force, "New Releases: Man Stranded on Ice Floe Rescued by 413 Squadron in the Arctic, Jan. 28, 2010," last accessed 2 March 2013, http://www.rcaf-arc.forces.gc.ca/14w-14e/nr-sp/index-eng.asp?id=10010; Kelowna.com, "Rescue Underway for Hunter Trapped on Northern Ice Floe," last accessed 2 March 2013, http://www.kelowna.com/forums/topic/rescue-underway-for-hunter-trapped-on-northern-ice-floe.

successfully hoisted off the ice and taken to safety more than 60 hours after the Cormorant's departure.[123]

On April 2011, a hiker waited more than 20 hours after falling into a 25 metre crevasse in Auyuittuq National Park, NU, before being rescued.[124] Unable to support the mission, Parks Canada requested support from JRCC, and a CF Hercules and one Cormorant aircraft were dispatched. The weather was clear and the outside temperature was -30 to -40^{o}C, but the harsh terrain prevented safe parachuting operations; mission success therefore relied heavily on having a helicopter on scene. After an estimated 17 hours of transit for the helicopter, the injured man was rescued by the SARTECs using a rope rescue system from the top of the crevasse. In the end, it took nearly 21 hours from the time of notification to rescue and fly the victim to safety.[125]

All the case studies presented in this chapter had several points in common. First, in most cases, mission success was largely due to an incredible amount of courage and determination by the crews involved, as they were not afraid to put their lives at risk and pushed themselves beyond expectations. Second, these missions also underscored the harsh conditions and the severity of the environment under which they were undertaken. SAR in the Arctic is never benign; it is a high risk operation that requires the best training and equipment possibly available. Lastly, these missions also underline the fragility and weaknesses of the current NSP in the Arctic. In most cases, the time required to perform the extraction was the weak link of the system as CF RW assets had to fly extended hours

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[123] DND, Royal Canadian Air Force, New Releases: *Man Stranded*…, last accessed 2 March 2013.

[124] Northern News Services Online, "French Hiker Rescued after Falling in Crevasse," last accessed 2 March 2013, http://www.nnsl.com/frames/newspapers/2011-05/may2_11fh.html.

[125] Canadian Broadcasting Corporation (CBC) News, "French Skier rescued from Baffin Crevasse," last modified 21 April 2011, http://www.cbc.ca/news/canada/north/story/2011/04/21/glacier-auyuittuq-rescue-hintermeier.html.

in treacherous weather to reach the incident scene. Of course, this is a very small sample of missions that were hand-picked to make the argument. But even if other missions were successfully completed faster, there are also many others that experienced similar extraction time.

Given an Arctic SAR scenario, one can clearly see that the CF RW SAR assets already work at their maximum capability and offer very little flexibility or depth to account for unforeseen circumstances. It could be argued that the current capabilities still meet the demand as most of the missions undertaken in the Arctic were completed successfully. But the long transit time and the fragility of the system highlights the requirement for the CF to pursue aggressively any operationally and financially sound opportunities to improve the current capabilities.

Summary

In this chapter, elements and characteristics specific to SAR in the Arctic were presented to better comprehend the complexity of the challenge associated with the provision of this service. The severity of the climate lessens significantly the survivability prospects of the victims but this is also happening in remote and sparsely populated areas generating less than one percent of Canada's annual SAR incidents. Not surprisingly, there are no permanently based SRUs in the Arctic as their location is carefully managed to best respond to the majority of incidents which coincides with the population distribution.

It is important to be able to properly assess NSP performance as the provision of this service, like any other services, is bounded and compelled to limited resources. Given the lack of pre-established measure of effectiveness for the Canadian NSP, few Arctic SAR cases involving the CF were reviewed. The missions selected clearly demonstrated

that Arctic SAR is extremely challenging and requires the best training and equipment possibly available. In many cases, it is the determination and courage of the crews involved that was the decisive factor in the success of these missions. But even if missions have been completed successfully most of the time, the mini case-studies highlighted the need to expedite the rescue, especially the time required to extract the casualties from the elements. Considering the need for improving the current capabilities, the next chapter focusses on determining the impact of the increasing level of activities in the north on the SAR demand. This will help to tailor a more appropriate solution based on the factual situation.

Chapter 3 - SAR IN THE ARCTIC – AN INCREASING DEMAND?

The environmental impacts of the melting of Arctic sea ice are of great concern and they have been discussed in numerous publications in the last two decades. It is not the intent herein to discuss them in detail but rather their consequences in terms of accessibility and socio-economic trends as the interest for the Arctic has reached historic new heights. The ongoing rhetoric about the exploding level of activity in the Arctic leads to believe that the number of SAR incidents is growing exponentially.

It is the aim of this chapter to present factual data regarding the ongoing development in the north to better capture the overall after effects on Arctic SAR. It will be demonstrated that even if the increase in the level of activity is tangible, it has not generated an augmentation of SAR incidents as one would suspect making the quest for improving the system much more tenuous. This will set the ground for the way ahead and potential solutions presented in the last chapter of this document.

The Arctic – The new "Gold/Cold Rush"?

There is no doubt that the Arctic environment is changing at a tremendous rate. Figure 3.1 shows the latest Arctic sea ice extent and illustrates the 1970-2000 and the 1981-2010 averages including the last two record lows (2007 and 2012). According to various models, researchers' predictions for a summer ice-free Arctic vary greatly and now range from 2013 to 2060.[126] Based on these numbers, the discourse used by some media and politicians tends to give a dramatic twist to the recent environmental changes by painting the Arctic as much more accessible than ever opening doors to an enormous basin of natural resources. It is sometimes referred to as the "new gold rush," or even as a

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[126] Heather A. Conley, Terry Toland, and Jamie Kraut, *A New Security Architecture for the Arctic: An American Perspective* (Washington, D.C.: Center for Strategic and International Studies, 2012), 1.

"new cold war" depending on if it is spoken in terms of natural resources or security.[127] Others go as far as suggesting an ongoing militarization of the Arctic with potential armed conflicts.[128] The discourse used describes the melting of the Arctic ice as the beginning of a race that will be done in an archaic fashion as if countries such as Canada would be at risk of losing their natural resources. While these scenarios might be entertaining to read, there is a need for a reality check before calling the Arctic development an economic explosion or a "crazy race." In the following sections, an attempt is made to depart from the apocalyptic scenarios presented by some authors and present facts to better capture the real impact of these changes on the NSP.

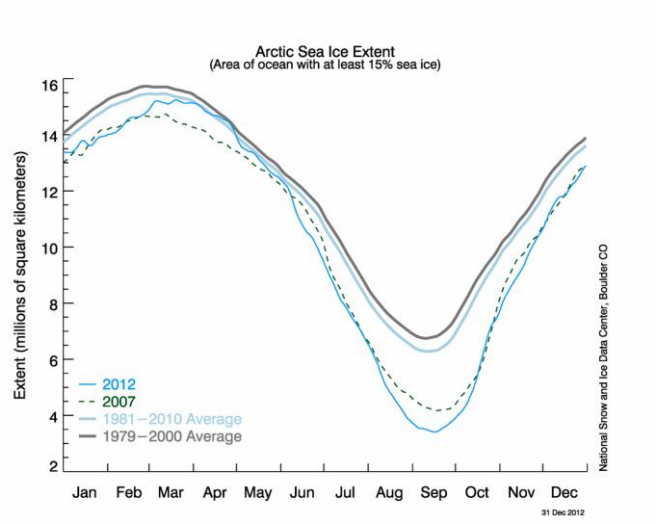

Figure 3.1 – Arctic Sea Ice Extend[129]

Resources Development

The Canadian Arctic has an enormous potential as a basin of unexploited and undiscovered natural resources. The 2007 and 2012 record lows in the extent of summer

[127] Geneviève King Ruel, "The (Arctic) Show Must Go On: Natural Resource Craze and National Identity in Arctic Politics." *International Journal* 66, no. 4 (Autumn 2011): 828.

[128] Rob Huebert, "The Newly Emerging Arctic Security Environment" (Calgary: Canadian Defence and Foreign Affairs Institute, 2010), 22-24.

[129] National Snow and Ice Center, "Arctic Sea Ice News and Analysis," last accessed 3 March 2013, http://nsidc.org/arcticseaicenews/.

ice fuels the idea that resources are now easily accessible for exploitation. The reality is much more complex as these resources are still located in remote and harsh areas, making their exploitation very costly. But in a world thirsty for natural resources, the exploration and exploitation will expand as long as the world market makes the exercise economically sound. In that context, the Canadian Arctic has much to offer and nobody doubts that it holds large reserve of hydrocarbons and minerals.[130]

The 2008 U.S. geological survey estimates "that 90 billion barrels of oil, 1,669 trillion cubic feet of natural gas, and 44 billion barrels of natural gas liquids may remain to be found in the Arctic."[131] Whereas it is true that most of it is located in Russia, Canada still has enormous reserves. The survey suggests that "the extensive Arctic continental shelves may constitute the geographically largest unexplored prospective area for petroleum remaining on Earth."[132] It is estimated that the Canadian north contains one third of the country's remaining potential for conventional oil and natural gas. Not surprisingly, these numbers drove the oil industry for more exploration and resulted in hundreds of exploration wells drilled, mainly in the Mackenzie Valley area, in recent years.[133]

Mining is also promising in the Canadian Arctic and Canada is looking to exploit many minerals such as iron, gold, lead, zinc, nickel, uranium and diamonds. The importance of mining potential and current operations should not be underestimated. As

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[130] Fréderic Lasserre, "Arctic Shipping Routes. From the Panama Myth to Reality," *International Journal* (Autumn 2011): 797.

[131] Department of the Interior U.S. Geological Survey (USGS), *Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle*, Fact Sheet 2008-3049, 2008, last accessed 3 March 2013, http://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf.

[132] *Ibid*.

[133] Department of Aboriginal Affairs and Northern Development Canada, "Oil and Gas in Canada's North – Active Exploration and New Development," last accessed 3 March 2013, http://www.aadnc-aandc.gc.ca/eng/1100100037301/1100100037302.

Frédéric Laserre notes, "diamond mines in NU and NWT have transformed Canada into the world's third-largest diamond producer."[134] Huge nickel discoveries have been made in northern Quebec and NU. On Baffin Island, NU, the Mary River mine is planned to extract approximately 205 million tons of iron deposit. Due to an economic slowdown, the project was reduced in scale but construction should begin in 2013 and the shipping should start in 2015. From 2005 to 2008, mineral exploration and appraisal investments rose by 117% in the Canadian territories before the financial collapse in 2009.[135] Although the economic troubles of 2008-2009 slowed down this momentum, as Whitney Lackenbauer has noted, "longer-term international demand for conventional energy and raw material will continue to rise."[136] The significance of those numbers is important as the mining and hydrocarbon exploitation is a major contributing factor in the increase of aeronautical and maritime traffic in the Arctic which could have a domino effect on the SAR demand.

Maritime Traffic

With the melting of the Arctic sea ice, it would be normal to experience an increase in maritime activities. A lot has been written and reported on the subject in terms of security and accessibility and the most known aspect of the Arctic maritime domain is probably the potential opening of the Northwest Passage (NWP). Various authors have discussed the NWP but it often includes a sensational spin that needs rationalization

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[134] Lasserre, *Arctic Shipping Routes*…, 797.

[135] Pav Jordan, "Baffin Island Sees Silver Lining in Scaling Back Mary River Project," *Globe and Mail*, 25 January 2013; Lasserre, *Arctic Shipping Routes*…, 798.

[136] Whitney P. Lackenbauer, "From Polar Race to Polar Saga: An Integrated Strategy for Canada and the Circumpolar World," *Foreign Policy for Canada's Tomorrow, no.3* (Toronto: Canadian International Council, 2009): 56.

before calling it a fast lane between the Atlantic and Pacific Oceans.[137] First, from a SAR point of view, the debate regarding the legal status of the NWP, whether it is international or internal waters, is not really pertinent as Canada will provide the SAR service regardless of the final decision. The NWP is already included in the SAR AOR and also within the area defined under the Arctic Council agreement (see Figure 2.2). Consequently, it becomes evident that Canada will provide the SAR service in that area regardless of how it is defined.

Second, many are anticipating an increase in traffic as the NWP could provide a shorter route for international shipping. But the reality is much more complex and the risks and costs associated with the usage of the NWP still outweigh the benefits for most users for the foreseeable future. The relatively short Arctic shipping season, the ice unpredictability, the high cost of icebreakers and the limited availability of ice capable vessels will all be a drag on Arctic shipping.[138] Thus, claiming that the NWP "is on the verge of becoming a super seaway is farfetched."[139] Furthermore, even if the ice is melting, sea currents in the Arctic are such that the remaining sea ice always drifts in a counter-clockwise pattern toward the NWP.[140] This will result in having the NWP as the last ice free area of the Arctic. When combining the uncertainty surrounding the ice free prediction and the current just-in-time business philosophy, it is clear that the NWP will not be a determinant factor in term of SAR demands in the short term as traffic is unlikely to be increasing heavily.

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[137] Borgerson, Scott. "Arctic Meltdown: The Economic and Security Implications of Global Warming." *Foreign Affairs* 87, iss.2 (March/April 2008): 63-77.

[138] The Mariport Group Limited, *Canadian Arctic Shipping Assessment - Main report for Transport Canada* (Digby: The Mariport Group Ltd, 2007), 4-5; *The Economist*, "Special Report, The Arctic: The Melting North," *The Economist* (16 June 2012): 15.

[139] Lasserre, *Arctic Shipping Routes*…, 807.

[140] *Ibid*., 801.

However, there has been a steady augmentation in the maritime traffic in the Arctic that cannot be ignored. This upward trend in maritime traffic is largely due to socio-economic developments related to mining, oil and gas exploitation, tourism industry, population growth and the associated local servicing of northern communities. Figure 3.2 illustrates the increase in maritime traffic by type of ships in the Arctic from 1986-2008. Looking at the data, it is evident and undeniable that the increase level of activities in the Arctic has translated into more maritime traffic.

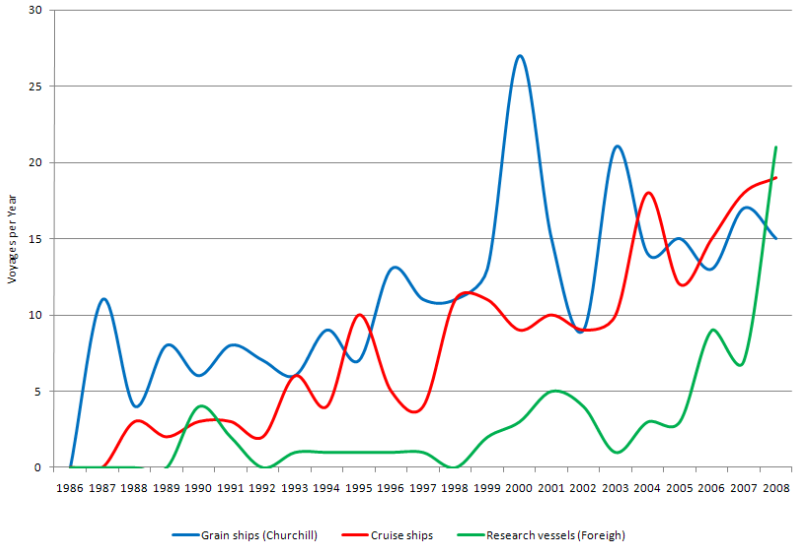

Figure 3.2 - Cruise, Research & Grain Traffic, 1986-2008[141]

This augmentation in traffic is concerning from a SAR perspective because it is happening in an area that is severely lacking mapping information required for safe maritime navigation. There is only around "10 per cent of the total Arctic has been charted and surveyed to a modern standard. Twenty-five to 35 percent of the main Arctic

[141] Brad Judson, "Trends in Canadian Arctic Shipping Traffic – Myths and Rumours," (Victoria: BMT Fleet Technology Limited, 2010), 3.

shipping routes are surveyed and charted to [southern] standard."[142] In comparison, 40 to 50 percent of waterways are charted in southern Canada, with 100 percent of the most critical channel covered.[143] The grounding of two ships in 2010 in the Arctic brought back this issue to the forefront. The cruise ship *Clipper Adventurer* ran aground in the Coronation Gulf, NU, after hitting an alleged uncharted rock shelf. Its crew was unable to dislodge the vessel and the Canadian Coast Guard had to rescue the 128 passengers onboard.[144] The rock shelf was discovered in 2007 but it was unknown to the *Clipper's* crew as they failed to consult the notice to shipping. The same year, the merchant vessel *Nanny* ran aground in the NWP, NU.[145] The tanker was carrying 9.5 million litres of diesel fuel when it hit a sandbar. The cause of the accident is unknown as the investigation is still in progress but both incidents highlight the potential disastrous consequences of the increasing maritime activities in the Canadian Arctic.

The Transportation Safety Board report regarding the *Clipper Adventurer* incident noted that:

> Until 1988, there were few passenger ships voyaging to the Arctic. In the 7 years 1980–1987, there were only 4 Arctic passenger voyages, and these were conducted by 1 passenger vessel. However, in the past 7 years [report written in 2010], there have been a total of 105 distinct voyages, conducted by 7 different passenger vessels. During this time, there has been an average of 9 passenger vessels per year conducting a total of 15 voyages per year. With approximately 105 passengers per voyage, there are at least 1575 passengers in the Arctic every year. Of the 118 vessels in the

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[142] Canadian Broadcasting Corporation (CBC) News, "How to Make Arctic Waters Safer for Ships," last updated 22 September 2012, http://www.cbc.ca/news/canada/story/2012/09/20/f-arctic-charting-navigation-channels.html.

[143] Senate, *Sovereignty & Security in Canada's Arctic, Interim Report*…, 17.

[144] Canadian Broadcasting Corporation (CBC) News, "Coast Guard Seeks Damages for Arctic Cruise Ship Accident. Clipper Adventurer Hit Uncharted Sand Bar in 2010," last updated 20 June 2012, http://www.cbc.ca/news/canada/north/story/2012/06/19/north-coast-guard-clipper-adventurer-damages.html.

[145] Canadian Broadcasting Corporation (CBC) News, "Grounded Arctic Tanker Tries to Lighten Load," last updated 13 September 2010, http://www.cbc.ca/news/canada/north/story/2010/09/13/nwpassage-tanker-refloat.html.

> Canadian Arctic that conducted 284 voyages in 2011, there were 15 tankers and 7 passenger vessels. Tankers are considered to be of high risk because an accident could have severe environmental consequences. Passenger vessels are also considered high risk since, among other consequences, an emergency in the Arctic could leave passengers and crew stranded for an extended period of time in a harsh environment.[146]

Given these facts and recent events, it would be logical to believe that the increasing maritime traffic has led to an increase in maritime incidents. However, this is not the case. Figure 3.3 shows the relationship between the augmentation of maritime traffic (all type of shipping combined) and the number of accidents and incidents in the Arctic.[147] The correlation between the two factors is surprisingly inversely proportional. As the number of ship augmented over the years, the actual number of maritime accidents and incidents decreased.

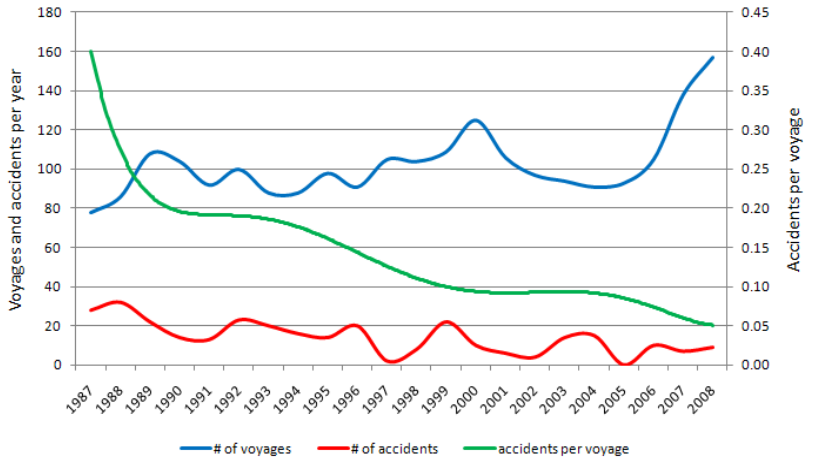

Figure 3.3 – Traffic & Casualty Trends, 1987-2008[148]

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[146] Transportation Safety Board of Canada, *Marine Investigation Report M10H0006, Grounding – Passenger Vessel Clipper Adventurer, Coronation Gulf, Nunavu, 27 August 2010,* Released 26 April 2012, http://www.tsb.gc.ca/eng/rapports-reports/marine/2010/m10h0006/m10h0006.pdf.

[147] In Figure 4.3, a reportable accident or incident includes occurrences such as: injury, death, sinking, collision, explosion, grounding, power failure, or marine spill.

[148] Judson, *Trends in Canadian Arctic Shipping Traffic*…, 4.

This paradox is due to many factors such as an increase in operational experience, the provision of better ice imagery and analysis data, the implementation of new regulations and enhanced ship design. Making the vessel Traffic Reporting Arctic Canada Traffic Zone (NORDREG) mandatory for certain classes of ship is only one example of regulatory initiative contributing to safety. [149] These risk mitigation measures have "contributed to a decreasing accident rate under variable year to year ice conditions in the Canadian Arctic." [150] As both the number of accidents and the rate of accidents have decreased over the last 20 years despite the increase in traffic, it is relevant to question whether or not a similar paradigm has been observed in aviation transportation.

Air Traffic

Similarly to the maritime domain, there has been an impressive augmentation of aviation activities in the polar region over the last few decades and this evolution might create significant additional pressure on the SAR system. Activities related to aviation in the Arctic could be divided in two groups: the cross polar commercial aviation activities and the local air traffic supporting northern communities. Commercial airlines have been flying over the Arctic since 1954 but the real growth in polar flights occurred in the late 1990s when the Russian government authorized a series of polar routes through its airspace. The first official polar route flight was conducted in 1998 and the number has augmented at a significant rate given the substantial time and fuel savings for commercial

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[149] Some vessels, pending on their gross tonnage and/or type of cargo, must submit reports prior to entering, while navigating within and upon exiting the NORDREG Zone which encompasses all Canadian Arctic waters. Transport Canada, "Government of Canada Takes Action to Protect Canadian Arctic Waters," last accessed 3 March 2013, http://www.tc.gc.ca/eng/mediaroom/releases-2010-h078e-6019.htm.

[150] Judson, *Trends in Canadian Arctic Shipping Traffic*…, 5.

airlines.[151] The annual polar flight growth in the Canadian AOR has been astonishing. It went from 800 polar flights recorded in 2003, to more than 12,500 flights in 2011.[152]

Northern communities rely heavily on air transportation as many of them do not have road access. Depending on the location, the community re-supply relies on air and seasonal sea lifts, temporary winter roads or air transportation only. Based on airports movement statistics, northerners travel twice more than Canadian located in the south.[153] To better visualize the situation, all the aircraft flight tracks north of 60°N latitude for the August 18, 2005 date are shown in Figure 3.4.

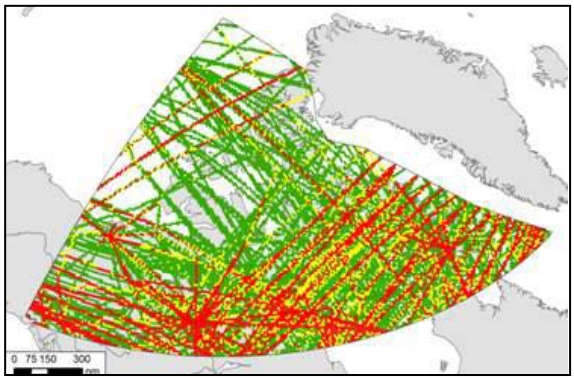

Figure 3.4 Flight Track North of 60°N – 18 August 2005[154]

These flights are supported through "48 certified airports, and 73 aerodromes, 20 of which receive Boeing 737 operations."[155] The resources exploitation described earlier also has a significant impact on aviation traffic as well in the north. In instance, the oil

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[151] Boeing Defence, Space and Security, "Polar Routes Offer New Opportunities," last accessed 3 March 2013, http://www.boeing.com/commercial/aeromagazine/aero_16/polar_route_opportunities.html.

[152] Nav Canada, *Nav Canada 2012 Annual report. A World in Motion* (Ottawa: Nav Canada Communications, 2013),11.

[153] Joseph Sparling, "Northern Aviation- A Strategy to Strengthen the Northern Economy," *Northern Air Transport Association* (4 March 2011), 2-3.

[154] Department of National Defence, *DRDC-CORA TM 2011-122, Optimal RSOM-Hub Locations for Northern Operations A MAJAID Scenario Analysis* (Ottawa: DND Canada, 2011). 16.

[155] Transport Canada, "Guest Editorial: North of Sixty," Last accessed 3 March 2013, http://www.tc.gc.ca/eng/civilaviation/publications/tp185-3-09-editorial-3947.htm.

sands industry's impact on the Fort McMurray airport, even though not quite meeting the definition of Arctic community (N56°39'), illustrates well the potentially rapid growth in air travel generated by resource exploitation. The annual traffic at this particular airport went from 102,000 passengers in 1999 to 775,000 in 2011.[156] This corresponds to a 760 percent increase in one decade. Similarly, the Yukon air market, in term of number of passenger, has grown by 65 percent from 2002-2010. Acknowledging that the north still represents less than one percent of the Canadian aviation market, these numbers are impressive and represent a significant upward trend in both categories of flying activities for this area.[157]

Once again, it would be logical to presume that the increased level in aviation activities would come with a proportionate rise in the number of accidents and SAR requirements.[158] But the actual numbers and facts are not substantiating an upward tendency:

> In 2011, Canada recorded the lowest total number of accidents (211) for Canadian registered aircraft excluding ultralights since 1976 when the Transportation Safety Board of Canada began recording such data…. Canada has one of the safest air transportation systems in the world. During the last decade, the rate of air transportation accidents has considerably declined from nearly eight accidents per 100,000 hours flown in 2000 to fewer than six in 2011—a drop of 25%. The total number of yearly accidents has also declined: the numbers reported in the last four years—211, 234, 231 and 234—are the lowest recorded figures in 15 years. In fact, that's more than 40 fewer accidents a year when compared to the previous 10-year average, an indicator of Canada's solid aviation safety record.[159]

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[156] Senate, Standing Senate Committee on Transport and Communications, *The Future of Canadian Air Travel: Toll Booth or Spark Plug? Report on the Future Growth and Global Competitiveness of Canada's Airports,* (June 2012), 6.

[157] Sparling, Northern Aviation- A Strategy to Strengthen the Northern Economy…, 3, 8.

[158] Department of Foreign Affairs and International Trade Canada, "The Northern Dimension of Canada's Foreign Policy," last accessed 3 March 2013, http://www.international.gc.ca/polar-polaire/ndfp-vnpe2.aspx?view=d.

[159] Transport Canada. TP 14816, *Transportation in Canada 2011, Comprehensive Review* (Ottawa: Minister of Public Works and Government Services, Canada, 2011), 33, 46.

These statistics demonstrate clearly that a direct correlation between increasing aviation activities and the number of related incidents/accidents is not necessarily proportionate. Indeed, the facts presented above suggest that this relationship has been inversely proportionate in Canadian aviation for several years, a very important factor to consider when assessing SAR demand and capabilities.

Interestingly enough, there were only two Canadian airline accidents in 2011 and they both occurred in the north. The first one was the Resolute Bay First Air Flight 6560 crash described earlier and the second one was the crash of Arctic Sunwest Charter in Yellowknife causing the death of both pilots on board.[160] This leads to question whether or not there is a different trend associated with northern aviation operation. Figure 3.5 shows number of accidents and fatal accidents in the north (NWT, NU and YK) from 2006-2011.

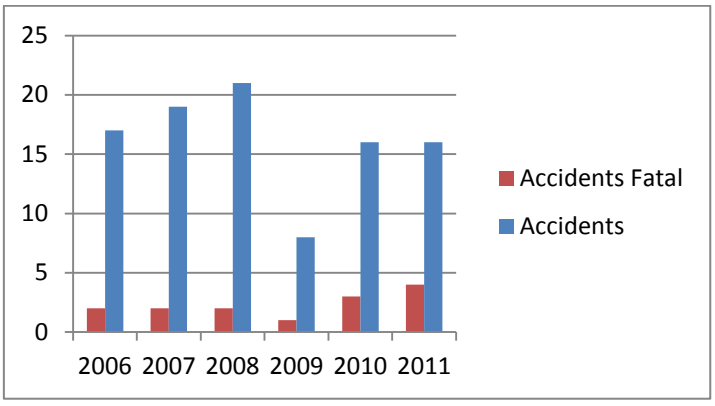

Figure 3.5 – Aviation Accidents in the North 2006-2011[161]

Once again, the figure does not indicate a clear upward trend which is consistent with the general tendency noted at the national level. The number of accidents has been steady or

[160] Transport Canada. TP 14816, *Transportation in Canada 2011, Comprehensive Review...*, 34.

[161] Data extracted from: Transport Canada. "TP 14816, *Transportation in Canada 2011, Statistical Addendum* (Ottawa: Minister of Public Works and Government Services, Canada, 2011), A98.

decreasing over the last few years and given the low numbers involved, the 2011 accident statistics should be considered as a spike versus a meaningful upward trend. The reasons for this paradigm are similar to the maritime domain. Many factors such as technological improvement, comprehensive operating procedures and regulatory initiatives have greatly enhanced aviation safety. These factors have combined and contributed to offset and mitigate the risk associated with increasing aeronautical operations.

SAR in the Arctic – Trend Analysis – 2007-2011

It has been made clear so far that even if the maritime and aviation traffic have been increasing, it has not translated in an increase of accidents or incidents. As mentioned before, SAR incidents requiring a response are not limited to the aviation and maritime domains. Therefore, it is important to perform a broader trend analysis and look at all actual northern distress cases dealt by the JRCCs. As mentioned earlier, CF aircraft or ships are tasked in about 1,100 cases of the 8,000 annual SAR incidents involving a response of the federal SAR system.[162] Using 2010 as a typical year, only 1,658 of all the cases for that year were categorized as distress incidents (category 1 and 2 incidents)[163] and 39 of them were located north of 60^{o}N latitude representing less than 3 percent of all the annual distress calls.[164] Of those 39 cases the CF is typically involved in 20-25 cases.

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[162] DND, "Backgrounder: Canada's Air Force: A Proud Partner…," last accessed 3 March 2013.

[163] SAR incidents are grouped as Aeronautical, Maritime, Humanitarian or Unknown incidents. Category 1 and 2 incidents, for each group, refer to distress and potential distress cases only. They exclude incidents resolved in the uncertainty phase, incident requiring assistance but where no distress exist, false alarms or hoaxes. For more detail, see National SAR manual, Annex 4C, 21-24.

[164] Canadian Forces Canada Command, Presentation by Maj. Jay Nelles, *Canadian Forces Search and Rescue.* Northern SAR Roundtable, 21 June 2011, last accessed 3 March 2013, http://www.nss.gc.ca/site/North-Nord/2011/CF%20SAR%20(DAR).pdf.

Figure 3.6 presents a fifteen year trend (1996-2011) of the number of SAR incidents north of 60°N that prompted a response by CF FW SAR aircraft.[165] From a CF point of view, there is an argument to be made that there is no need to increase the level of SAR support in the north. Based on a purely statistical approach, the argument is quite solid as no significant increase in the number of SAR cases has been noted in 15 years. It is also important to note that the number of SAR incidents north of 60°N represents less than 5% of all incidents prompting a CF aircraft response. It is a very small fraction of all the cases for which CF aircraft are involved.

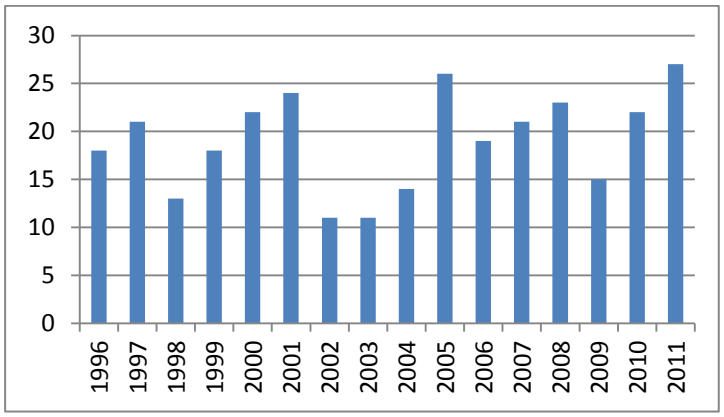

Figure 3.6 – Incidents North of 60°N Prompting a Response by CF FWSAR Aircraft.[166]

Another factor to consider regarding the trend analysis is the historical seasonal pattern of when SAR incidents occur. Figure 3.7 illustrates the seasonal trend of all the SAR incidents involving a response by the JRCCs. Figure 3.8 shows the seasonal trend for SAR incidents north of 60°N prompting a response by FW SAR aircraft. Whereas the

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[165] The data presented were extracted from a study relating to FWSAR aircraft only. Even though the numbers do not include RW aircraft, they remain extremely representative as FW aircraft are almost always tasked to support northern incident to provide the fastest response possible.

[166] The author was authorized, for the purpose of this study, to extract raw data from: Department of National Defence (DND), *DRDC-CORA File 3554-1, Preliminary Spatial Analysis of Historical Search and Rescue Incidents* (Ottawa: DND Canada, 12 April 2012), 10-11.

number presented in Figure 3.8 include only the CF FWSAR participation, it still supports the argument that most northern incidents occur during the summer months which is consistent with the national trend. It also draws the attention on the fact that there are only 5-10 cases annually that occur outside the summer/navigational season. This information is critical as it sets the stage to propose more tailored solutions to improve the overall effectiveness of the NSP in the Arctic.

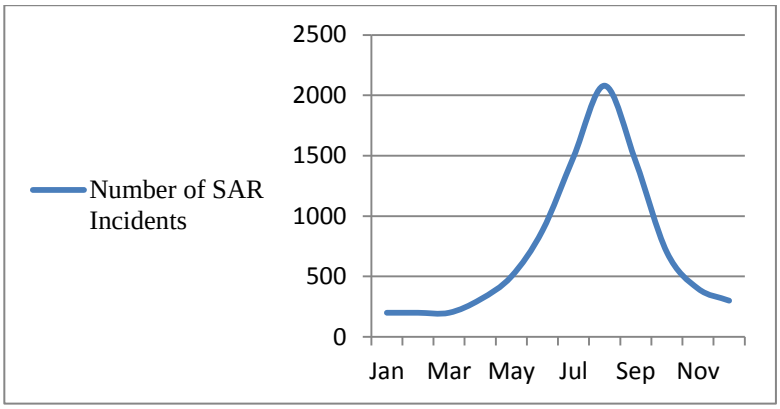

Figure 3.7 – National Seasonal Trend of all SAR Incidents[167]

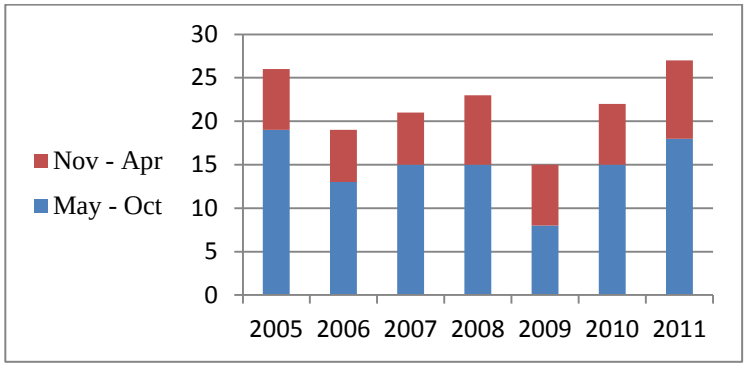

Figure 3.8 – Seasonal SAR Incidents Distribution North of 60°N Prompting a CF FWSAR Response.[168]

[167] *Ibid.*
[168] *Ibid.*

In an environment where resources are limited, the numbers presented lead to the conclusion that the current CF capabilities are appropriate to the current demand, assuming that the existing level of service is deemed acceptable. Some authors argue that the emerging activities in the north are re-shaping the future in term of SAR demand in the Arctic. Accordingly, as Colonel (retired) Pierre Leblanc notes, "it may not be wise or prudent to drive based solely on the rear view mirror. The [SAR capabilities] review should take into account the changes in activity which has occurred in the last few years and developing trends."[169] Similarly, Dr. Ron Wallace who has worked extensively throughout the circumpolar Arctic region, presented a policy update paper in 2009 suggesting that Canada will be "compelled to respond to uninvited, perhaps significant, challenges that may literally come to us out of the Arctic."[170] Three years later, he referred to the series of northern fatal air accidents that happened in 2011 and other factors to demonstrate an emerging Arctic SAR demand.[171] But the reality is much more blurry as all the trend analysis presented herein in terms of incidents, accidents and SAR demand are not indicating an upward tendency justifying a radical increase in northern SAR capabilities. The trend analysis rather suggests a measured and incremental approach to expand and improve northern SAR capabilities.

Summary

As this chapter has shown, there are no discernible trends indicating an augmentation of northern SAR incidents even if the level of activities in the north has been steadily increasing. One could argue that the increase of activities will inevitably

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[169] Leblanc, Canada Ducked an Arctic Bullet…, 23.

[170] Ron Wallace,"Why Canada Needs a Robust Arctic Air Rescue Capability: A Policy Update Paper," (Calgary: Canadian Defence and Foreign Affairs Institute, 2009), 2.

[171] Wallace, "Emerging Canadian Priorities and Capabilities…, 1-2.

lead to an increase of SAR incidents; this is true, but it would be too simplistic and erroneous to think that they are proportionally inter-related. Many factors have contributed to offset and mitigate the risk of incident over time. The collective impact and actions, in terms of new regulations, enhanced technology, new operating procedures and prevention programs of the various NSP stakeholders were responsible to prevent the direct correlation between the increasing level of activities and the actual number of SAR incidents. Of course, it would be unwise to blindly assume that technology, new regulations and new prevention programs will always be sufficient to offset the upward trend in activities, especially when considering the harshness of the Arctic environment. It is equally important to acknowledge the fact that regardless of the SAR system in place, it will never achieve a 100 percent success rate everywhere in Canada. Consequently, it comes down to the difficult task of attaining the proper balance between the SAR response capabilities, the actual demand and the implementation of mitigating programs and regulations aimed at avoiding the SAR incidents in the first place recognizing that the later has limitations.

Although the factual data presented in this chapter are not a driving factor for radical changes, the sample of missions presented in Chapter Two have clearly indicated room for improvement regarding the current SAR capability in the north. It is the aim of the next chapter to review current initiatives and projects and to offer suggestions to enhance the current SAR capabilities in the north, keeping in mind the particularly low demand. In the end, the proposed solutions need to be operationally and financially sound in order to be supported.

Chapter 4 – ARCTIC SAR: THE WAY AHEAD

Two paradoxes have been presented so far in this study. First, it has been demonstrated that the current SAR system provides the slowest response in an environment that requires the fastest intervention possible. Second, it has been also established that even if transportation and socio-economic development indicators and statistics denote an undeniable increase in activities in the Arctic, it has not translated in an augmentation of SAR incidents so far. In light of these paradoxes, there is a compelling argument for a credible and stronger northern SAR capability, but how to achieve it remains unclear given the particularly low demand. In this chapter, a balanced and holistic approach to improve the current Arctic SAR capabilities is suggested to mitigate the shortfalls and weaknesses of the current system. The discussion is focused on ongoing projects, initiatives and suggestions aimed at reducing the time required to extract the casualties form the environment as it has been identified as one of the major weaknesses of the current system when dealing with Arctic SAR.

CF RW SAR Capabilities in the Arctic

One of the major difficulties associated with Arctic SAR has always been the time required to remove the casualty from the elements. It constitutes the weak link in the system and this was quite apparent in the mini cases studies presented earlier. It is often associated with the absence of a CF primary SAR unit in the north, more precisely, the lack of RW assets. The case studies presented in Chapter Two showed that FW SAR assets are generally on scene within a reasonable period of time and are able to deliver some assistance while waiting for the extraction. The case studies also demonstrated that even with the progress made by the acquisition of more capable platform such as the

Cormorant helicopter, the time required to complete an extraction remains problematic in the Arctic.

This situation has been the subject of many critics and fuelled many debates leading to requests for establishing a CF primary SAR unit in the north. Colonel (Retired) Pierre Leblanc, Yukon Premier Dennis Fentie, and Micheal Byers, a political science professor and Arctic expert, have all publically requested the establishment of a permanent northern SAR unit.[172] Recent events such as the First Air 6560 tragedy and the grounding of two vessels in the Arctic have provided ammunition to their claim. However, given the rather small and stable northern SAR demand observed over the last decade, it is argued herein that the solution does not necessarily equate to the relocation or the establishment of a CF primary SAR unit in the north in the short-medium term. After all, the current capabilities are still coping successfully with the vast majority of northern SAR occurrences; albeit it is recognized that there is room for improvement.

In Canada, the Cormorant helicopter is the only RW aircraft dedicated to SAR. It was introduced in the CF in 2001 to replace the Labrador helicopter fleet and it is currently by far the most capable platform in the CF inventory to this task. It provides an all-weather (including substantial icing conditions), day-night RW asset with ample power, working space and numerous redundant communication and navigation systems. It also gives an exceptional long-range capability as it can fly for over 1,000 km without refueling.[173] These characteristic makes it an ideal candidate and often the only CF RW

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[172] Senate, *Sovereignty & Security in Canada's Arctic, Interim Report*…, 12. See also: Michael Byers, "Every Arctic Voyage is a Potential Disaster," *Ottawa Citizen*, 3 September 2010, http://byers.typepad.com/arctic/2010/09/every-arctic-voyage-is-a-potential-disaster.html.

[173] Department of National Defence (DND), "Royal Canadian Air Force, CH-149 Cormorant Overview," last accessed 11 March 2013, http://www.rcaf-arc.forces.gc.ca/v2/equip/ch149/index-eng.asp.

aircraft able to handle the harsh conditions in the Arctic, leading some to request its permanent presence in the north or at least during the summer months.[174]

But there is an unfortunate and unexpected reality that came with the Cormorant that cannot be ignored. The aircraft came with a much lower serviceability rate than expected due to a more extensive maintenance program than predicted and lack of spare parts. Up to 2009, only 50% of the Cormorant fleet could be called upon for duty at any given time and this poor serviceability rate eventually led to the re-location of assets across the MOBs. [175] In order to maintain a sufficient number of serviceable Cormorants nationwide on a daily basis, the CF substituted the Cormorant by Griffon helicopters in Trenton in 2005. The Griffon was chosen for Trenton as the AOR was more appropriate for its capability and the 14 Cormorants left in the CF inventory were re-distributed on both Canadian coasts as they are better suited for the maritime SAR environment.[176]

A 2008 study determined that the Cormorant serviceability issues cannot theoretically be solved by addressing the spare part availability only. It showed that the Cormorant maintenance program needs to be reduced or the size of the fleet would need to be increased to meet the serviceability performance requirement.[177] The study, which

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[174] Tobi Cohen, "Canadian Rescue Capacity Questioned in Wake of Arctic Ship Grounding," *Postmedia News*, 29 August 2010, last accessed 11 March 3013, http://www.canada.com/news/Canadian+rescue+capacity+questioned+wake+Arctic+ship+grounding/3457291/story.html.

[175] Defence Industry Daily, "Readiness a Problem for Canada's Aircraft, June 2009," last accessed 11 March 2013, http://www.defenseindustrydaily.com/Readiness-a-Problem-for-Canadas-Aircraft-05486/.

[176] iPolitics, "Griffon Helicopters in Search and Rescue Deemed at 'Risk': Air Force Report," last accessed on 11 March 2013, http://www.ipolitics.ca/2011/02/22/griffon-helicopters-in-search-and-rescue-deemed-a-risk-air-force-report/; Originally, 15 Cormorants were distributed among four MOBs: Gander, Greenwood, Trenton and Comox. One crashed on 13 July 2006 during a training mission and was never replaced. For more on the substitution of Cormorant by Griffon helicopters in Trenton, see: iPolitics, "Return in service of Cormorants delayed to 2014: Documents," last accessed 23 March 2013, http://www.ipolitics.ca/2011/01/21/return-in-service-of-cormorants-delayed-to-2014-documents/.

assumed ideal sparing conditions, concluded that at "least 25 or 19 Cormorant aircraft are required if four or three bases are desired, respectively."[178] If there was a reduction of 25 percent in the duration of the maintenance inspections, these numbers would be 20 and 15, respectively. It is critical to acknowledge this reality as it highlight the fact that the CF currently does not have enough Cormorant helicopters to support its four primary RW SAR MOBs. Consequently, even with the recent progress made with the ongoing rationalization of the Cormorant maintenance program and the acquisition of VH-71 spare parts (an updated version of the Cormorant) from the U.S. in 2011,[179] it would be unrealistic to believe that creating an additional SAR MOB in the north with Cormorant would be possible under the current conditions. An additional unit would require the acquisition of more Cormorants or assigning other RW platforms to SAR duties in the south.

It is also imperative to acknowledge the expenditure associated with Cormorant operations. The aircraft was acquired for approximately $39 million per unit and the operating costs are estimated at $32,232 per hour.[180] It is currently one of the most expensive fleets operated by the CF; and in this context the creation of a northern unit

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[177] Department of National Defence (DND), *DRDC-CORA TM 2008-11, On the Availability of the CH149 Cormorant Fleet in an Ideal Sparing Situation* (Ottawa: DND Canada, 2008). The serviceability performance requirement is defined as at least one aircraft available 99-99.5 percent of the time at each unit to support SAR operations 24 hour, 7 day a week. Raman Pall, "On the Availability of the CH149 Cormorant Fleet" (Proceedings of the 2008 Winter Simulation Conference, 2008), 1186, 1189. This report is a modified open source of the DRDC-CORA 2008-11 which was written by the same author. It is available at: http://www.informs-sim.org/wsc08papers/142.pdf.

[178] *Ibid*., 1193.

[179] Murray Brewster, "Spare Parts for the Cormorant?" *The Chronicle Herald*, 29 September 2011, http://thechronicleherald.ca/canada/24272-spare-parts-cormorants.

[180] Department of National Defence (DND), *Review of the Canadian Search and Rescue Helicopter Acquisition Cormorant.* (Ottawa: Chief Review Services, 2007), 4; Gloria Galloway, "Peter MacKay's Vacation Ended with Search-and-Rescue Shuttle Service," *The Globe and Mail*, last updated 10 September 2012, http://m.theglobeandmail.com/news/politics/ottawa-notebook/defence-minister-peter-mackays-vacation-ended-with-search-and-rescue-shuttle-service/article2175679/?service=mobile.

would represent an enormous cost hardly justifiable given the low demand. Considering the factors presented above and the fact that the number of northern SAR incidents has been fairly low and stable over the years, there is a need to pursue more rational cost-benefit options.

Before looking at options, it is also necessary to expand on the Griffon employment as a primary SAR platform. The Griffon's suitability for usage in a primary SAR role in Trenton, let alone its capabilities for northern SAR operations, has been questioned since its introduction. It is a very reliable platform but it cannot operate in icing conditions, it offers limited range and power margin, has no emergency flotation system, no weather radar, and limited redundancy for communication and navigation in the northern domestic airspace. It is acceptable for most missions in the southern areas of the country but due to its operational limitations, its usage in an all year-round SAR role in the north does not constitute a sound and workable alternative. Its employment as primary SAR aircraft in Trenton was supposed to be temporary in nature to bridge the gap created by the low serviceability of the Cormorant fleet. But given the slow progress and current status of the Cormorant fleet, there are no indications that the Cormorant will return in Trenton in the short-medium term; another important consideration for the way ahead.[181]

New CF RW SAR Capabilities

There are ongoing procurement projects that will strengthen considerably the secondary CF RW SAR capabilities in the near future. First, the CF is acquiring 15

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[181] iPolitics, "Griffon Helicopters in Search and Rescue Deemed at 'Risk': Air Force Report," last accessed on 11 March 2013, http://www.ipolitics.ca/2011/02/22/griffon-helicopters-in-search-and-rescue-deemed-a-risk-air-force-report/.

Chinook helicopters which will be based in Petawawa, ON, with delivery starting in summer 2013. The Chinook will primarily support land forces, but also other Government departments in responding to humanitarian emergencies such as fire, floods, earthquakes and secondary SAR missions. It offers many unique characteristics such as a large cargo space, heavy lift capability and extended range that will make it "an ideal aircraft for operations in Canada's vast and harsh environment, particularly in the north."[182] It is unfortunate however that the Chinook project does not include an enhanced de-icing package or a hoist as these capabilities would have made it an even greater enabler for RW Arctic SAR. Nevertheless, it will still be a terrific addition to the overall CF RW capability.

Second, the maritime helicopter fleet is also in the process of being renewed. The Sea King helicopters currently operating on both coasts will be phased out and replaced by 28 Cyclone helicopters. The project has been plagued with delays and the 28 aircraft should have been delivered by the end of 2013 but only eight of them will be delivered on time.[183] Regardless of the delays, Cyclones will also be available in a relatively near future and will greatly enhance the SAR capabilities of its predecessor. Unlike the Sea King, the Cyclone will make extensive use of Night Vision Goggles (NVG), significantly broadening the SAR potential of maritime helicopters by making their employment possible for all types of SAR incidents, including cases over land at night.[184] The aircraft has a rescue hoist, is able to operate in icing conditions and is fitted with an integrated

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[182] Department of National Defence (DND), "Royal Canadian Air Force, Air Force News – New Chinook helicopters will be based in Petawawa, December 14, 2009," last accessed 11 March 2013, http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=9763.

[183] David Pugliese, "Delivery of Sea King Replacement Helicopters Delayed Once Again," *Ottawa Citizen*, 18 December 2012.

[184] Lesley Craig, "The Sea King's not Done Yet," *The Maple Leaf* 13, no. 11 (March 2010): 4.

multi-sensor EO/IR system.[185] Excluding size and range, its characteristics are comparable to the Cormorant helicopter.

As the Cyclone will constitute a real alternative to support SAR operations, its incorporation in the RCAF fleet will generate greater opportunities. First, having the Cyclone undertaking the primary SAR mandate for pre-planned periods of time in the south will offer possibilities for Cormorant units to deploy and exercise in the Arctic. This could potentially mitigate and extend significantly the CF RW presence in the Arctic outside the navigational season pending on availability of the Cyclone and supporting northern infrastructures.

Second, the ongoing project also provides a window of opportunity for a much more profound restructuring of the RCAF SAR unit's roles and responsibilities. Assuming that the current maritime helicopter project encompasses the bare minimum of airframe required to fulfill its mandate with the Royal Canadian Navy, adding 2-3 Cyclones to the existing plan would convey many more possibilities. One can envision having these additional airframes stationed at Canadian Forces Base (CFB) Shearwater (NS), taking over the primary RW SAR mandate instead of the Cormorants currently stationed in Greenwood. The coexistence of those additional aircraft with the other Cyclones used in their maritime roles would potentially be cost effective and most likely beneficial from a personnel standpoint. This would permit the relocation of Cormorants back in Trenton and result in a better suited capability in central Canada to support Arctic SAR operations. Of course, the whole concept requires detailed research and analysis to

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[185] Frank Colucci, "Cyclone Search: The Canadian Forces CH148 Cyclone Integrated Mission System Manages Powerful Maritime Surveillance Sensors Installed on a Networked Multi-mission Helicopter," *Aviation Magazine*, May 2010, 23.

make sure it is operationally and financially sound and would not jeopardize the support to the Royal Canadian Navy. The point made herein is that an occasion is presenting itself to significantly improve the CF RW SAR capabilities at relatively low cost. As a minimum, there is a benefit in conducting a detailed study to assess the feasibility and determine if it is a viable option.

The significance of these two RW acquisitions cannot be underestimated. Even if they are not intended to be used in a primary SAR role, they will provide further depth and redundancy to the overall CF SAR response. Both aircraft fleet will provide robust options to handle the harsh conditions associated with the Arctic and will help in increasing the CF RW footprint in the north.

Increasing the CF RW presence in the North

One way to improve the current CF RW presence in the north is to augment, stagger and compel helicopter participation in northern exercises. The benefits of having RW in the area more frequently was underscored by the quick response provided by Griffon and Sea King helicopters during the FA 6560 crash in Resolute Bay during Operation Nanook 2011. The CF conducts three annual major operations in the north: Operations Nanook (3-4 weeks in August), Nunalivut (2-3 weeks in April) and Nunakput (June to September). The exercises have different purposes, size, duration and location vary from year to year but they all result in a substantial CF presence in the Arctic. Operation Nevus, dedicated to preventive and corrective maintenance on the High Arctic Data Communications System (HADCS) on Ellesmere Island, NU, is another recurrent operation normally involving CF RW assets in the Arctic.[186]

[186] Department of National Defence (DND), "Canadian Joint Operations Command: Recurring Operations," last accessed 12 March 2013, http://www.cjoc.forces.gc.ca/cont/rec-eng.asp, Op Nevus.

A deliberate approach should be taken to ensure minimum helicopter participation to these operations to augment the CF RW footprint in the Arctic. Whereas it is true that these assets do not typically have a specialized SAR capability and specific standby posture, their methodically planned and staggered presence would still increase their potential employment as secondary SAR assets. It would reduce their coincidental presence and potentially help diminish the traditional seasonal pressure on the primary SAR units. Once again, this also implies the availability of a minimum amount of infrastructure to support operations.

Infrastructures to Support SAR operations in the North

Aircraft breakdowns during SAR missions can have dramatic outcomes and require immediate attention to be able to complete the mission in time. It is true that some aircraft types are more reliable than others but regardless of the fleet, it is a well-known fact that any piece of machinery operating in the cold is much more susceptible to mechanical failures. Acknowledging that breakdowns are more probable in a cold environment, there is a compelling need for proper northern infrastructure to support operations as the harsh weather often slow, prevent or even lead to injuries when performing outdoor maintenance actions. The lack of hangar space in the north is a widespread problem given the limited capacity of northern airports, as it is required for maintenance, repair and overnight shelter. This is especially true for helicopter operations as the storage of the aircraft minimize the risk of unserviceability associated with cold weather start.[187]

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[187] AviationPros.com. "Cold Climate Helicopter Operations," last accessed 23 March 2013, http://www.aviationpros.com/article/10577530/airframe-technology-cold-climate-helicopter-operations.

The CF already has four Forward Operating Locations (FOLs) to support CF-18 operations in the Arctic. They are located in Inuvik (NWT), Yellowknife (NWT), Rankin Inlet (NU) and Iqaluit (NU).[188] They were not designed or intended to support SAR operations in the first place. However, in a framework where resources are scarce and where their anticipated usage for SAR operations is very limited, these installations could represent a sound alternative to strengthen Arctic SAR infrastructures. CFS Alert also offers limited support for SAR operations and new military installations are planned to be constructed in Nanisivik (NU) and Resolute Bay (NU).[189] The new installations and modifications to existing infrastructures could provide a network of dual purpose facilities for the CF to facilitate current and future SAR operations. These facilities could provide a mixture of support ranging from hangar space, re-fuelling capability, quarters, to basic communication facilities, based on what is currently available.

The importance of planning for northern infrastructure was recently highlighted by the U.S. Coast Guard experience in Barrow, Alaska. The FOL Barrow was established during Arctic Shield 2012, a U.S. exercise focused on operations, outreach and capability assessment to respond above the Arctic Circle.[190] The concept involved pre-positioning two MH-60 Jayhawk helicopters in Barrow to provide a faster response to emergencies in the Arctic during the summer months. When they deployed in Barrow in 2012, the only hangar available was rented for $60,000 per month, "a price that made Coast Guard

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[188] The purpose of these installations is to sustain CF-18 operations in support of the North American Aerospace Defence Command (NORAD) mandate. DND, *Royal Canadian Air Force in the North*…, last accessed 22 February 2013, http://www.rcaf-arc.forces.gc.ca/v2/page-eng.asp?id=1512.

[189] Department of Aboriginal Affairs and Northern Development Canada, *Canada's Northern Strategy. Our North, Our Heritage, Our Future* (Ottawa: Minister of Public Works and Government Services, 2009), 10.

[190] Department of Homeland Security. United States Coast Guard, "News Release: Coast Guard Rescues Father, Son South of Barrow," last accessed 12 March 2013, http://www.uscgnews.com/go/doc/4007/1546227/Coast-Guard-rescues-father-son-south-of-Barrow.

leaders gasp."[191] The U.S. Coast Guard experience in Barrow stresses the importance and benefits of planning and developing northern infrastructure well in advance. Northern installations are extremely costly and creating, expending or upgrading existing facilities could reduce substantially the cost and average response time to conduct a wide range of operations in the Arctic.[192]

Canadian Coast Guard Helicopter Project

One of the greatest strengths of the NSP is its integrated and multi-departmental dimension. In that respect, the requirement of expediting and finding solution to a faster extraction time does not rely solely on the CF and therefore, the quest for potential solutions should be sought and better coordinated among the different NSP stakeholders. For instance, the Canadian Coast Guard is also in the process of renewing its helicopter fleet. Their project aims to procure 24 new helicopters (likely of two distinct types) with deliveries anticipated within 5 years.[193] This project represents another opportunity to greatly enhance the Arctic SAR capability as two of the "new helicopters are to be earmarked for work aboard the polar icebreaker John G. Diefenbaker."[194] The final choice, especially for the two ship born helicopters, should aim at providing an all-weather SAR platform able to respond to all types of SAR events. The inclusion of

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[191] Kirk Johnson, "For Coast Guard Patrol North of Alaska, Much to Learn in a Remote New Place," *The New York Times,* 21 July 2012.

[192] TheStar.com, "Star exclusive: Canada looking at building military bases in Arctic." Last accessed 23 March 2013, http://www.thestar.com/news/canada/2011/07/14/star_exclusive_canada_looking_at_building_military_bases_in_arctic.html.

[193] Canadian American Strategic Review. "Background: Canadian Coast Guard Replacement Helicopter Project Candidates: Light-Lift and Medium-Lift Helicopter Type Possibilities for the CCG," last accessed 12 March 2013, http://www.casr.ca/bg-ccg-helicopter-project-candidates.htm.

[194] Canadian Broadcasting Corporation (CBC) News, "Feds Plan Purchase of 24 New Coast Guard Choppers," last modified 20 August 2012, http://www.cbc.ca/news/politics/story/2012/08/20/nl-coast-guard-choppers-820.html.

hoisting capabilities with trained paramedics would greatly enhance the overall capacity of the NSP at a relatively low cost.

Civilian Partnership

There are also other alternatives worth deliberating to mitigate the lack of federal RW assets in the Arctic. A partnership with the civilian industry should be seriously considered for the provision of SAR services in certain areas of the Arctic. Few countries have already taken this approach for the provision of surveillance and SAR services. The U.S., the U.K., Australia and Greenland have all engaged in various form of partnership with the civilian industry with success. Greenland is engaged in a partnership for the whole area whereas the U.K. and the U.S. have only contracted a portion of their AOR so far. The U.S. has established a successful cooperative effort in northern Alaska with a civilian operator, North Slope Borough SAR, which operates two FW and two RW aircraft.[195] Despite their difficulties in operating their two Bell 412 (civilian version of the Griffon) helicopters in a northern environment, North Slope Borough SAR has still been successful in complementing the U.S. Arctic SAR effort.[196] At the other end of the spectrum, the whole SAR services in Greenland are provided through Air Greenland. The company is a partnership between public Governments and private industry and operates 34 aircraft and helicopters with a fraction of them providing SAR services.[197]

There are significant advantages in considering civilian partnership in Canada. As the socio-economic developments flourish in the north, the civilian helicopter footprint

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[195] North Slope Borough, "Search and Rescue Department," last accessed 12 March 2013, http://www.north-slope.org/departments/sar/.

[196] Rotor and Wing, "North to Alaska," last accessed 12 March 2013, http://www.aviationtoday.com/rw/products/toolsequip/North-to-Alaska_35379.html.

[197] Air Greenland, "Air Greenland Charter," last accessed on 12 March 2013, http://www.airgreenland.com/charter/.

will increase and provide more opportunities for SAR collaboration. From a government standpoint, the SAR services are provided at a better cost as there is no need for maintenance and infrastructure to support underused military aviation operations. This approach in the Canadian Arctic could potentially be quite advantageous for the taxpayer as the actual demand for northern SAR is fairly low compared to other parts of the country. There is also an obvious advantage for the private/civilian industry as some of the operating costs are absorbed and offset by the provision of SAR services. It is not about creating a double standard SAR system; it is about having a dual purpose aviation operation to minimize costs so it becomes possible to provide an economically sound and better service. Even in a scenario where the contracted services would be reduced to a 2 hour standby posture at all times to minimize the number crews required and minimize the costs, it would still result in a faster SAR response as the transit time would be significantly reduced.

One could argue that as the CF does not control the level of proficiency or the basic survival training and equipment of private and corporate aircrew, their employment could lead to different standards and even more reliability if the mission goes awry. While the argument is sound, there is a significant difference between what is suggested herein and the current concept of operations. In the current framework, services are contracted on an opportunity basis which does not include standards and performance monitoring. There is no cohesive relationship allowing the development of a sound partnership. The proposed partnership concept herein would not be sporadic in nature. It would be a contracted service where minimum training standards, capabilities, response time, equipment, etc. could be negotiated and enforced. The civilian industry has demonstrated its capacity to undertake the task in many countries, including Canada. One

just needs to look at Cougar Helicopters, which has been providing SAR services since 1991 to the oil and gas industry in Canada and across the world. They use the civilian variant of the Cyclone, the S-92, providing an all-weather SAR capability.[198] With that in mind and considering the experience of other countries, it is very hard to argue that a partnership would not be possible.

A similar approach could also be considered for FWSAR in the Arctic.[199] In any cases, the question whether or not it would be more advantageous for the Government of Canada to contract part of the SAR services needs more research and goes beyond the scope of this study. Nonetheless, exploring this option would definitely be worthwhile, especially for the Arctic, as it has great potential, among other initiatives, to enhance the NSPs.

Other Initiatives

Many other initiatives exist to facilitate Arctic SAR, including some aimed at reducing the search time. One difficulty associated with Arctic air operations arises from the lack of airports and the increased distance between facilities. This causes numerous challenges as weather alternate options are extremely limited and the time on scene, especially for RW assets, is considerably reduced due to the distance between re-fuelling locations. Understanding that eliminating the search time during SAR operations is important for every mission regardless of the location, the distance between airports in the

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[198] Past and present bases include St. John's, NL; Halifax, NS; Tuktoyaktuk, NWT; Galliano, Louisiana; Barrow, Alaska; Nuuk and Ilulissat, Greenland. See: Cougar. A VIH Aviation Group Company, "Search and Rescue," last accessed 12 March 2013, http://www.cougar.ca/services/SAR/.

[199] In fact, rumours started last spring suggesting that the Government might be looking at an alternate service delivery type of contract for the FWSAR project. However, it is important to note that there has been no official confirmation of this claim by politicians and there is no supporting information on the Public Works and Government Services Canada website at this time. Murray Brewster, "Search-and-Rescue Plane Purchase Put off until 2013," *The Chronicle Herald*, 9 March 2012, http://thechronicleherald.ca/canada/71544-search-and-rescue-plane-purchase-put-until-2013.

Arctic makes it even more critical. Fortunately, technology development over time has led to a significant reduction or the complete elimination of the search requirements for many SAR incidents. In fact, many of the cases presented in Chapter Two did not involve search operations during the rescue phase as the exact position of the incidents was known by the responders. Introduction and easier access to technology such as the 406 beacon, satellite communication, handheld GPS, affordable personal emergency beacon such as the Satellite Personal Tracker (SPOT) device have largely contributed in the reduction or elimination of the search requirement in many cases. [200] Unfortunately, even with these improvements, the search requirements will never be eliminated completely and steps should be taken and initiatives pursued to reduce or eliminate it as much as possible; especially in the Arctic as the survivability chances are lessened due to the environment.

Aircraft mounted sensors have been available and used for a long time to support military operations across the world. Sensors include EO/IR and various radar applications to name a few. They are potentially great enablers in reducing the search time, especially in low visibility/night circumstances. In the Arctic, where darkness is permanent for a significant part of the year, their advantage becomes unquestionable. Yet, interestingly enough, none of the CF primary SAR aircraft is currently equipped with EO/IR sensors. The incoming Cyclone and Chinook helicopters and potentially the FWSAR replacement aircraft will have integrated sensors. In fact, the 2010 National Research Council review of the FWSAR SOR recommended making the integration of

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[200] For more details, see: National Search and Rescue Secretariat. "Arctic SAR," *SAR Scene* 18, no. 3 (Winter 2009), 16-18, last accessed 12 March 2013, http://www.nss.gc.ca/site/ss/magazine/vol18_3/Vol18-3_E.pdf.

EO/IR sensors and NVG capabilities mandatory in the FWSAR SOR. It is much more beneficial to integrate these sensors from the outset as their addition and integration on existing fleet as proven to be very difficult.[201] Therefore, it is arguably necessary to pursue the acquisition of these sensors on the incoming new platform and consider fitting the Cormorant with similar devices.

Space based sensors could also have important implication for Arctic SAR operations as they could potentially help detecting an incident site and eliminate the search requirements. The Government of Canada recently confirmed its intent to go ahead with the RADARSAT constellation project and this will greatly enhance the surveillance capabilities of the Canadian Arctic.[202] The CF Polar Epsilon project uses the data "to provide all-weather day/night surveillance capabilities utilizing imagery through the Canadian-based RADARSAT-2 satellite constellation."[203] It provides near real-time processing of images and will help the CF and other federal departments maintaining a better situational awareness in the Arctic, which should result in a more appropriate and tailored response to the situation. [204] The integration of this capability in support to SAR operations remains to be proven, but the potential benefits for Arctic SAR operations undoubtedly exist.

CASARA has always been a key player in reducing the search time. They provide a valuable and affordable partnership that contributes to a timely response, quicker

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[201] NRC, *Review of the Statement of Operational Requirement for the Fixed Wing SAR…,* 39.

[202] John Ivison, "Canadian Politics: Stephen Harper Steps in to Save Radarsat Upgrade after Budget Cutbacks Threatened Satellite Program's Future," *The National Post,* 19 December 2012, http://news.nationalpost.com/2012/12/19/stephen-harper-steps-in-to-save-radarsat-upgrade-after-budget-cutbacks-threatened-satellite-programs-future/.

[203] Bond, Levon. "JUSTAS and Project Epsilon: Integrated Intelligence, Surveillance, and Reconnaissance of the Canadian Arctic." *Canadian Military Journal* 11, no. 4 (Autumn 2011): 25.

[204] Fortin, Steve. "A New Step for the Polar Epsilon Project." *The Maple Leaf* 13, no. 24 (21 July 2010): 16.

resolution and, potentially, the elimination of the search requirements for CF aircraft. In 2007/2008, "CASARA responded to approximately 25 percent of all aeronautical incidents in Canada."[205] The association makes up for about 25 percent of the country's air search capability. Advantages in using CASARA include local knowledge, proximity, enduring presence and they are an excellent enabler to saturate the search area as early as possible. Unfortunately, CASARA's footprint in the north is very limited despite recent calls and additional funding from the military. In 2009, there were only 10 pilots out of 209 members in the Arctic regions.[206] The framework used in the north is called the CASARA North initiative. It is an initiative between the RCAF, Northern Air Transportation (NATA) and CASARA to provide a quick initial first response to SAR incidents in the north. The intent is to have local charter airlines (NATA members) and CASARA northern zone members entering into agreements to deliver trained aviation search assets. A similar model has been used in NU in the past with success, and the intent is to expand the initiative as much as possible to maximize the aviation resources already in place to reduce or eliminate the search requirement for the CF aircraft.[207]

The Maritime Domain

The discussion has been focused on the RW aspect and aviation operations so far. But initiatives expediting the recovery of person involved in a SAR incident are not

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[205] Department of National Defence (DND), *Summative Evaluation of the Contribution to the Civil Air Search and Rescue Association-CASARA* (Ottawa: Chief Review Services, 2009), 3.

[206]CTV News, "Military Seeks Volunteers for Arctic Search and Rescue," last accessed 12 March 2013, http://www.ctvnews.ca/military-seeks-volunteers-for-arctic-search-and-rescue-1.727794; Canadian Broadcasting Corporation (CBC) News, "Military Seeks Civilian Aid for Arctic Search and Rescue," last updated 20 November 2011, http://www.cbc.ca/news/canada/north/story/2011/11/19/north-civilian-search-rescue.html; DND, *Summative Evaluation of the Contribution…,* 16.

[207] National Search and Rescue Secretariat, "CASARA Presentation," last accessed 12 March 2013, http://www.nss.gc.ca/site/North-Nord/2012/CASARA%20Presentation%20CASARA%20North%20Jan%202012.pdf.

limited to air assets. The Government of Canada should also pursue aggressively its current plan of constructing the Nanisivik Naval Facility and its intention to acquire six to eight new Arctic/Offshore Patrol Ships.[208] Both projects are part of the Canadian First Defence and Northern Strategies which "will help Canada exert a sustained naval presence in Arctic waters during the navigable season."[209] The combination of these initiatives would be a definite and tangible improvement to the overall CF SAR capabilities in the north during the navigable season. They would also provide additional infrastructure and extra ice breaking capable resources, on top of the Canadian Coast Guard capabilities, to respond to maritime incidents.[210]

Many northern communities also have some degree of marine emergency response capabilities through the employment of Fast Rescue Craft (FRCs). FRCs are especially useful when somebody is not in distress but stranded on an ice floe, a fairly common SAR scenario in the Arctic. In such cases, FRCs provide an adequate SAR response at a much lower cost than using RW assets assuming the weather conditions permit. This capability could be expanded across northern communities lacking such resources through the Canadian Rangers.

There are approximately 5,000 Canadian Rangers in 178 communities across Canada. Joint Task Force North is home to 1st Canadian Ranger Patrol Group (1 CRPG) which encompasses NU, YK, NWT, and some in BC. 1 CRPG has already over 1,500 Rangers in 56 patrols located numerous 56 communities.[211] The Rangers are the only

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[208] DND, *Backgrounder: The Canadian Forces in the North*…, last accessed 15 February 2013, http://www.emeraldsiberians.com/nr-sp/bg-do/12.003-north-nord-eng.asp.

[209] *Ibid*.

[210] Lackenbauer, *From Polar Race to Polar Saga*…, 26.

organized group in many isolated communities and they are singularly equipped to assist SAR specialists. Equipping the Canadian Rangers in the bigger communities with FRCs could greatly enhance their SAR capability with a dual purpose objective in mind.[212] FRCs could be used by the Canadian Rangers primarily for security patrols but they would also provide an alternative to support specific SAR incidents not requiring specialized skills. This idea is not new and it has been shared and supported by various actors but no tangible progress has been made so far. Of course, this would require investments and the establishment of a framework to ensure proper training and skills are maintained and to make sure no unrealistic expectations are placed on the Canadian Rangers.[213] It would add one more layer to the system at relatively low cost that could prevent wasting numerous flying hours for benign events not requiring specialized skills set.

Other maritime mitigation measures taken by the various NSP stakeholders should pursue other initiatives in terms of prevention and regulation as it could reduce the risk and eliminate SAR incidents from happening in the first place. Increasing the funding for the hydrographic services to map the main Arctic waters is a good example of initiatives that would make Arctic navigation safer. The current strategy has been to map the narrow corridor of the NWP but the focus must also "be on main shipping corridors, approached

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[211] Department of National Defence (DND), "Canadian Rangers, 1 Canadian Ranger Patrol Group/Joint Task Force North (JTFN)," last accessed 12 March 2013, http://www.cfna.forces.ca/units/1crpg-eng.asp.

[212] P. Whitney Lackenbauer, "The Canadian Rangers: A 'Postmodern' Militia That Works," *Canadian Military Journal* 6, no. 4 (Winter 2005–2006): 52; Pierre Leblanc, "North West Passage Unguarded: Thinking Outside the Igloo?" F*rontline Defence*, issue 3 (2011), 59.

[213] Senate, *Sovereignty & Security in Canada's Arctic, Interim Report*…, 8; Lackenbauer, *From Polar Race to Polar Saga*…, 24.

to communities, and areas where ships will sail in the future."[214] As the traffic increases in the NWP, considerations should be made to create an Arctic Pilotage program. Canadian vessel pilots have played a central role in ensuring safe marine transportation for centuries and there is a compelling "argument for extending Canada's pilotage system to the country's northern waters."[215] New regulations also have a significant role in reducing the number of incidents. The NORDREG mandatory compliance for maritime traffic in the Arctic as of 2010 is a good example. It is argued that the regulation and prevention programs could be tightened even more to minimize the risk of incident in Arctic waters given the limited SAR assets the area. Making the NORDREG compliance to all vessels sailing in Arctic waters mandatory is a possibility worth to be considered. Having cruise ships sailing in pairs or within a specified distance, so that they could provide mutual assistance in case of problem, is another option for mitigating the risk associated with Arctic cruise ship operations.[216] It might seem extreme as proposal but the fact is that given the size and the increasing capacity of the cruise ships, it often requires nothing less than another cruise ship to rescue one.

Managing Expectations

Many projects, initiatives and proposals have been reviewed and suggested so far in this chapter. They would all, to various degrees, contribute to improve the current NSP for Arctic SAR. However, it should be noted that even if most of them would be endorsed and implemented, there would be still periods of time during the year when only limited SAR assets would be available in the north. Most proposed measures coincide with the

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[214] Senate, *Sovereignty & Security in Canada's Arctic, Interim Report*…, 17.

[215] Canadian Marine Pilots' Association, "Overcoming Challenges in Arctic Waters," *The Canadian Military Pilot* 2, no. 2 (Fall 2010): 6.

[216] Congressional Research Service Report for Congress, *Changes in the Arctic: Background and Issues for Congress* (Washington, DC: Congressional Research Service, August 1, 2012), 37.

maritime navigational season which corresponds to the SAR demand seasonal peak. Little has been provided to cover the winter season when the activity level in the Arctic slows down. Unless some form of dual purpose civilian contracted services could be established, there is not really a financially and operationally sound solution to this problem.

The Arctic winter season favours the usage of the Cormorant helicopter for the extraction to deal with the severe weather conditions and the permanent darkness. Based on the data presented in the last chapter, the yearly average number of northern SAR incidents prompting a CF aircraft response is estimated at 7 during that period when considering the last few years. Given the operating cost of such equipment, in a situation where only a handful of SAR incidents happen yearly during that period, the best course of action might be to better manage expectations after all. The notion is to be as upfront as possible with the Canadian population by making it clear that the SAR response in the Arctic during that period of time will be slower. In all likelihood, based on the case studies presented earlier, the typical response will have a FW aircraft on scene between 5-10 hours but the recovery, if RW assets are required, will happen more likely within 12-24 hours. Consequently, education and prevention programs from the various NSP stakeholders, such as the Adventure Smart program, should accentuate the need for self-rescue and enhanced survival skills and equipment for individuals operating in the Arctic environment during that timeframe.[217]

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[217] The NSS provides support for the delivery of the AdventureSmart prevention program. For more on the program, see: AdventureSmart. "Home," last accessed 31 March 2013, http://www.adventuresmart.ca/index.php.

Summary

This Chapter centered on finding workable solutions to improve the current Arctic SAR capabilities. The creation of a permanent northern SAR unit, as suggested by many actors, might not be the best course of action given the associated cost versus the current demand. A holistic approach that includes a variety of possibilities to bridge and mitigate the currents shortfalls and weaknesses of the actual program is much more favourable. Expediting the extraction time remains problematic despite improvement made over the years. The numerous options explored would all contribute, to various degrees, to improve the current situation. It is unlikely that only one of these options would make a significant difference; it is rather a combination of them that would result in a tangible effect.

The solutions proposed in this chapter also underline the need to capitalize on one of the major strengths of the NSP. The integrated aspect of the NSP encourages a comprehensive approach among the various stakeholders for the betterment of the current system. Therefore, the answer does not rely exclusively in enhancing the rescue capabilities, but also the inclusion of regulatory initiatives, enhanced prevention programs and also a better management of expectations.

CONCLUSION

The importance of the Arctic for Canada has never been greater. The climate changes and melting of Arctic sea ice have largely contributed to this renewed interest for the region. The general public, and more importantly, the Government of Canada, have re-focused their attention on the north as exemplified by the development of Canada's Northern Strategy. This renewed interest also led many Canadians and experts to question Canada's capabilities to react to various crises in the Arctic, including SAR events.

The Canadian SAR system is remarkably consistent with the whole-of-government approach taken in Canada's Northern Strategy. The NSP's integrated and multi-departmental roles and responsibilities merge highly specialized equipment and skills to deliver the SAR service across the country. While the role of the CF has been predominant in the program since the beginning, it is primordial to remember that it is fundamentally the collective actions of all the stakeholders and volunteer organizations that make the Canadian SAR system successful. The NSP is also strengthened by numerous international treaties and agreements that clearly define responsibilities and facilitate coordination among neighboring countries. International cooperation is extremely beneficial in areas such as the Arctic where the environment poses a distinctive challenge for all parties involved.

Canada has the largest and one of the most challenging SAR AOR in the world characterized by extremes in climate, topography and weather conditions. Not surprisingly, the Canadian SAR system faced particular circumstances and this is especially predominant in the Arctic. Critics have long questioned the Arctic SAR capabilities in Canada. It has been often done with an emotional twist which ignored the real issues and the complexity of Arctic SAR. Unfortunately, it leaves the impression that

Canada lags behind or even worse, makes one believe that Arctic SAR is a myth rather than a reality. When looking at the NSP, one must avoid taking a single event in isolation to judge the overall program and consider the whole task at hand to better appreciate Canada's achievements in that domain. Canada's Arctic SAR capabilities are substantial, tangible and successful in the vast majority of occurrences. Arctic SAR missions include the highest degree of risk and have been a stellar testimony of the incredible courage and determination of the crews involved. Given the level of difficulty under which most Arctic missions are undertaken, the positive outcome of almost all missions should be praised, albeit there is room to improve the current program.

The status quo is not an acceptable course of action as the need for improving the current Arctic SAR capabilities has been made abundantly clear. This study has argued that resource scarcity and constraints hinder depth and flexibility making the whole system rather fragile and arguably already working at its maximum capacity in a northern context. Humanitarian cases, not the core responsibility of the CF, represent about 75 percent of the missions north of 60^{o}N latitude involving CF aircraft. The lack of residual capacity in the current setting makes it even harder to respond to this added pressure. However, the Canadian geography and population distribution makes it unrealistic to establish a SAR system that would provide the same level of responsiveness everywhere in the country, predominantly in the high Arctic. Comparing Arctic SAR to the southern capability reflects a poor understanding of the problem. It does not account for the disparity of demand, the particularly demanding time and space Arctic environment, and the cost associated to SAR operations in a resource constrained framework. Even with the undeniable increasing level of activities in the Arctic, the Arctic SAR demand has

remained constant and very low over the last two decades and consequently, solutions must be tailored to this reality.

Since most primary SAR assets are logically located to the South to respond to the majority of incidents, it results in having the slowest response time in the Arctic where the fastest response is actually sought after due to the extreme environmental conditions. This paradox is one of the biggest challenges for the Canadian SAR system. Accordingly, the core argument of this study called for a more robust casualty extraction capability in the north. The creation of a permanent northern CF RW unit offers limited benefits and does not constitute a practical and sound solution given the current low demand and resource constraints. Instead, this study has advocated a holistic approach to augment and improve the northern SAR capabilities. Many initiatives and proposals were reviewed and suggested to improve the current northern SAR capabilities. The acquisition of new RW platforms in the CF inventory will be a critical step in deepening the overall CF SAR RW capabilities. It will provide more options and augment tremendously the flexibility to respond to long northern SAR cases while still preserving a residual capacity in the south. The intensification and deliberate staggering of CF northern exercise involving RW assets, the Canadian Coast Guard RW replacement project and civilian partnerships are also other opportunities to increase the RW SAR footprint in the north.

While the discussion had a prevalent RW emphasis, it was also expanded to other domains. Reducing the search time through EO/IR and space sensors, expanding CASARA presence in the north, bolstering the Royal Canadian Navy's northern resources, equipping the Canadian Rangers with FRCs and strengthening and developing new regulations are all contributing measures to a stronger northern SAR capability and a

safer Arctic. The bottom line is that it is essential to capitalize on the integrated and multi-agency aspect of the NSP as it is one of the major strengths of the system. The answer does not rely exclusively in enhancing the rescue capabilities, but also the inclusion of regulatory initiatives and enhanced prevention programs aimed at eliminating the SAR occurrence in the first place.

In the end, there is no perfect solution in the short term given the actual and factual demand. Not a single initiative will make a dramatic change on the existing Arctic SAR capabilities. It is rather their combined effect that will make a tangible difference and enhance the overall NSP in the north. It is also crucial to better manage expectations and acknowledge the fact that there will be still periods of time when the SAR response in the Arctic will be slower; mainly in the winter. Therefore, the NSP stakeholders, shouldered by provincial/territorial authorities, should accentuate the need for self-rescue and enhanced survival skills and equipment for individuals operating in the Arctic environment outside the navigational season. This would greatly increase chances of survival and also bring the level of expectations to a realistic degree.

BIBLIOGRAPHY

Air Greenland. "Air Greenland Charter." Last accessed on 12 March 2013. http://www.airgreenland.com/charter/.

Arctic Council. "Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic." Last accessed 15 February 2013. http://www.arctic-council.org/~arctikar/index.php/en/about/documents/category/20-.

Arctic Council. "Search and Rescue." Last accessed on 24 February 2013. http://www.arctic-council.org/index.php/en/oceans/search-and-rescue.

Arctic Monitoring and Assessment Programme. *AMAP 2009- Update on Selected Climate Issues of Concern. Observations, Short-lived Climate Forcers, Arctic Carbon Cycle, and Predictive Capability*. Oslo, Norway, 2009. http://library.arcticportal.org/1220/.

Arsenault, Daniel, and Josh Christianson. "Punching Above its Weight: The CP140 Aurora Experience within Task Force Libeccio and Operation Mobile." *The Royal Canadian Air Force Journal* 1, no. 3 (Summer 2012): 26-37. http://www.rcaf-arc.forces.gc.ca/CFAWC/eLibrary/Journal/2012-Vol1/Iss3-Summer/Sections/05-Punching_Above_its_Weight_The_CP140_Aurora_Experience_Within_Task_Force_Libeccio_and_Operation_MOBILE_e.pdf.

Attariwala, Joetey. "CH-148 Cyclone: Set to Join the Fleet." *Canadian Defence Review*, (February 2011): 52-57. http://www.gdcanada.com/documents/CDR%20Cyclone%20Article%20Feb%202011_web.pdf.

Australia. Australian National Search and Rescue Council. *National Land Search Operations Manual version 6*, Australian Federal Police, 2010. http://natsar.amsa.gov.au/Manuals/Land_Search_Operations_Manual/documents/MicrosoftWord-NatLandSARMan6.pdf.

Balasevicius, Tony. "Toward a Canadian Forces Arctic Operating Concept." *Canadian Military Journal* 11, no. 2 (Spring 2011): 21-31. http://www.journal.forces.gc.ca/vo11/no2/doc/05-balasevicius-eng.pdf.

Bergh, Kristofer. "Sipri Insights on Peace and Security: The Arctic Policies of Canada and the United States: Domestic Motives and International Context." *Stockholm*

International peace Research Institute, no. 2012/1 (July 2012): 1-19. http://books.sipri.org/files/insight/SIPRIInsight1201.pdf.

Boeing Defence, Space and Security. "Backgrounder: C-17 Globemaster III." Last accessed 24 February 2013. http://www.boeing.com/defense-space/military/c17/docs/c17_overview.pdf.

Boeing Defence, Space and Security. "Polar Routes Offer New Opportunities." Last accessed 3 March 2013. http://www.boeing.com/commercial/aeromagazine/aero_16/polar_route_opportunities.html.

Boeing Defence, Space and Security. "Statistical Summary of Commercial Jet Airplane Accident, Worldwide Operations, 1959-2011." Last accessed 9 March 2013. http://www.boeing.com/news/techissues/pdf/statsum.pdf.

Bond, Levon. "JUSTAS and Project Epsilon: Integrated Intelligence, Surveillance, and Reconnaissance of the Canadian Arctic." *Canadian Military Journal* 11, no. 4 (Autumn 2011): 24-29. http://www.journal.forces.gc.ca/vo11/no4/doc/Page%2024%20Bond%20Article%20English.pdf.

Borgerson, Scott. "Arctic Meltdown: The Economic and Security Implications of Global Warming." *Foreign Affairs* 87, iss.2 (March/April 2008): 63-77. http://www.foreignaffairs.com/articles/63222/scott-g-borgerson/arctic-meltdown.

Brewster, Murray. "Search-and-Rescue Plane Purchase Put off until 2013." *The Chronicle Herald*, 9 March 2012. http://thechronicleherald.ca/canada/71544-search-and-rescue-plane-purchase-put-until-2013.

Brewster, Murray. "Spare Parts for the Cormorant?" *The Chronicle Herald*, 29 September 2011. http://thechronicleherald.ca/canada/24272-spare-parts-cormorants.

Byers, Michael, and Steward Webb. "For Search and Rescue, Canadian-made Planes are Better, Cheaper." *The Tyee.ca*, 19 Jun 2012. Last accessed 8 March 2013. http://thetyee.ca/Opinion/2012/06/19/Canadian-Search-and-Rescue-Planes/.

Byers, Michael, and Steward Webb. "Search and Replace. The Case for a Made-in-Canada Fixed-Wing Search and Rescue Fleet." *Canadian Centre for Policy Alternative.* Ottawa: Rideau Institute, 2012.

http://www.policyalternatives.ca/sites/default/files/uploads/publications/National%20Office/2012/06/Search_and_Replace.pdf.

Byers, Michael. "Every Arctic Voyage is a Potential Disaster." *Ottawa Citizen*, 3 September 2010. http://byers.typepad.com/arctic/2010/09/every-arctic-voyage-is-a-potential-disaster.html.

Canada. Department of Aboriginal Affairs and Northern Development Canada. "Oil and Gas in Canada's North – Active Exploration and New Development." Last accessed 3 March 2013. http://www.aadnc-aandc.gc.ca/eng/1100100037301/1100100037302.

Canada. Department of Aboriginal Affairs and Northern Development Canada. *Canada's Northern Strategy. Our North, Our Heritage, Our Future.* Ottawa: Minister of Public Works and Government Services, 2009. http://www.northernstrategy.gc.ca/cns/cns.pdf.

Canada. Department of Fisheries and Oceans. Canadian Coast Guard. *SAR Seamanship Reference Manual*. Ottawa: Minister of Public Works and Government Services, 2000. http://www.ccg-gcc.gc.ca/folios/00027/docs/chap_3-eng.pdf.

Canada. Department of Fisheries and Oceans. "Canadian Coast Guard: Search and Rescue." Last Accessed on 24 February 2013. http://www.ccg-gcc.gc.ca/eng/CCG/SAR_About_Sar.

Canada. Department of Fisheries and Oceans. Canadian Coast Guard. *Search and Rescue Needs Analysis, 2007*. Ottawa: Canadian Coast Guard, 2007. http://www.ccg-gcc.gc.ca/e0003782#_Toc204749656.

Canada. Department of Foreign Affairs and International Trade Canada. "The Northern Dimension of Canada's Foreign Policy." Last accessed 3 March 2013. http://www.international.gc.ca/polar-polaire/ndfp-vnpe2.aspx?view=d.

Canada. Department of National Defence. *1 Canadian Air Division (1 CAD) Orders: Volume 2, Flying Orders*. Winnipeg: November 30, 1999.

Canada. Department of National Defence. *1 Canadian Air Division (1 CAD) Orders: Volume 3, Operations*. Winnipeg: November 30, 1999.

Canada. Department of National Defence. *1 Canadian Air Division (1 CAD) Orders: Volume 5, Training and Standards*. Winnipeg: November 30, 1999.

Canada. Department of National Defence. *1 Canadian Air Division: Searchmaster Handbook.* Winnipeg: DND, 2002.

Canada. Department of National Defence. "Backgrounder: Canada's Air Force: A Proud Partner in the National Search and Rescue Program, CAS BG-11.0001, February 17, 2011." Last accessed 15 February 2013. http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=11505.

Canada. Department of National Defence. "Backgrounder: Canadian Fixed-Wing Search and Rescue (FWSAR), BG-10.005, August 16, 2011." Last accessed 15 February 2013. http://www.forces.gc.ca/site/news-nouvelles/news-nouvelles-eng.asp?id=3304.

Canada. Department of National Defence. "Backgrounder: Maritime Helicopter Project, July 26, 2010." Last accessed 15 February 2013. Last accessed 15 February 2013. http://www.forces.gc.ca/site/news-nouvelles/news-nouvelles-eng.asp?id=3486.

Canada. Department of National Defence. "Backgrounder: The Canadian Forces in the Arctic, BG-12.001, April 13, 2012." Last accessed 15 February 2013. http://www.forces.gc.ca/site/news-nouvelles/news-nouvelles-eng.asp?id=4150.

Canada. Department of National Defence. "Backgrounder: The Canadian Forces in the North, February 28, 2012." Last accessed 15 February 2013. http://www.emeraldsiberians.com/nr-sp/bg-do/12.003-north-nord-eng.asp.

Canada. Department of National Defence. "Backgrounder: The Role and Capabilities of the Chinook Model, CAS BG-10.003, December 13, 2010." Last accessed 15 February 2013. http://www.forces.gc.ca/site/news-nouvelles/news-nouvelles-eng.asp?id=3678.

Canada. Department of National Defence. B-GA-404-000/FP-001, *Canadian Forces Aerospace Move Doctrine.* Winnipeg: Canadian Forces Aerospace Warfare Centre, 2011.

Canada. Department of National Defence. *Canada First Defence Strategy*. Ottawa: Government of Canada, 2008.

Canada. Department of National Defence. Campbell, L.C. *Canadian Forces Search and Rescue Level of Service and Roles and Responsibilities, letter from Chief of Air*

Staff to the National Search and Rescue secretariat, 21 August 2002. Ottawa: DND Chief of Air Staff.

Canada. Department of National Defence. *Canada Command CONPLAN 10250/10 MAIJAID – CF Response to a Major Air Disaster*. Ottawa: Commander Canada Command, 2010.

Canada. Department of National Defence/Canadian Coast Guard. B-GA-005-000/FP-004 – DFO 2204-23-4, *International Aeronautical and Maritime Search and Rescue Manual (IAMSAR) Volume IV - Canadian Supplement*. Ottawa: DND Canada, 2007. http://loki.cgc.gc.ca/cansarp/sarmanuals/IAMSAR.pdf.

Canada. Department of National Defence/Canadian Coast Guard. B–GA–209–001/FP–001 – DFO 5449, *National Search and Rescue Manual*. Ottawa: DND/CCG, Revised May 2000. http://loki.cgc.gc.ca/cansarp/sarmanuals/nsm.pdf.

Canada. Department of National Defence/Canadian Forces Canada Command. Presentation by Major Jay Nelles, *CF Overview of SAR in Canada-Airline Post Brief*, Northern SAR Roundtable, 31 January 2012. http://www.nss.gc.ca/site/North-Nord/2012/CF%20Overview%20of%20SAR.pdf.

Canada. Department of National Defence/Canadian Forces Canada Command. Presentation, *Search and Rescue (SAR) Overview*. Arctic Caucus Meeting, 17-19 August 2011. http://www.pnwer.org/Portals/18/Arctic%20Caucus%20SAR%20Overview%20Presentation.pdf.

Canada. Department of National Defence. *Canadian Forces Search and Rescue: 50 Years of Service to Canadians*. Ottawa: Art Direction CFSU(O) Creative Services, 1997.

Canada. Department of National Defence. "Canadian Joint Operations Command: Recurring Operations." Last accessed 12 March 2013. http://www.cjoc.forces.gc.ca/cont/rec-eng.asp.

Canada. Department of National Defence. "Canadian Joint Operations Command: Search and Rescue in Canada." Last accessed 24 February 2013. http://www.cjoc-coic.forces.gc.ca/cont/search-recherche/index-eng.asp.

Canada. Department of National Defence. "Canadian Rangers." Last accessed 15 February 2013. http://www.army.forces.gc.ca/land-terre/cr-rc/index-eng.asp.

Canada. Department of National Defence. Director Air Force Readiness. Presentation by Colonel Paul Drover, *Canadian Forces Search and Rescue,* Offshore Helicopter Safety Inquiry, 27 January 2010. Last accessed 31 March 2013. http://www.oshsi.nl.ca/userfiles/files/ExhibitP00154PowerPointPresentationbyColonelPaulDroverDNDCanadianForcesSAR201001.pdf.

Canada. Department of National Defence. *DRDC-CORA File 3554-1, Preliminary Spatial Analysis of Historical Search and Rescue Incidents*. Ottawa: DND Canada, 12 April 2012.

Canada. Department of National Defence. *DRDC-CORA TM 2008-11, On the Availability of the CH149 Cormorant Fleet in an Ideal Sparing Situation*. Ottawa: DND Canada, 2008.

Canada. Department of National Defence. *DRDC-CORA TM2010-193, The Arctic: The Physical Environment*. Ottawa: DND Canada, 2010.

Canada. Department of National Defence. *DRDC-CORA TM 2011-122,* Optimal RSOM-Hub Locations for Northern Operations *A MAJAID Scenario Analysis*. Ottawa: DND Canada, 2011.

Canada. Department of National Defence. *DRDC-ORD Technical Report TR 2005/15, Support to Air Transformation (Search and Rescue)*. Ottawa: DND Canada, 2005.

Canada. Department of National Defence, *Evaluation of the CF/DND Component of the National Search and Rescue Program.* Ottawa: Chief Review Services, 2008. http://www.crs-csex.forces.gc.ca/reports-rapports/2008/135P0785-eng.aspx.

Canada. Department of National Defence. "From the Investigator." *Flight Comment*, issue 1 (2012): 36. http://www.rcaf-arc.forces.gc.ca/vital/dfs-dsv/pub/nr-sp/docs/2010-2014/2012-01-eng.pdf.

Canada. Department of National Defence. *Review of the Canadian Search and Rescue Helicopter Acquisition (Cormorant).* Ottawa: Chief Review Services, 2007. http://www.crs-csex.forces.gc.ca/reports-rapports/pdf/2007/P0583-eng.pdf.

Canada. Department of National Defence. "Royal Canadian Air Force, Air Force News – 444 Squadron Rescues British Adventurer in Arctic, March 8, 2008." Last accessed 15 February 2013. http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=5779.

Canada. Department of National Defence. "Royal Canadian Air Force, Air Force News – New Chinook helicopters will be based in Petawawa, December 14, 2009." Last accessed 11 March 2013. http://www.rcaf-arc.forces.gc.ca/v2/nr-sp/index-eng.asp?id=9763.

Canada. Department of National Defence. "Royal Canadian Air Force, Articles: RCAF delivers fuel to Canada's most northerly post, May 2, 2012." Last accessed 23 March 2013. http://www.rcaf-arc.forces.gc.ca/8w-8e/nr-sp/index-eng.asp?id=12810.

Canada. Department of National Defence. "Royal Canadian Air Force: CH-149 Cormorant Overview." Last accessed 11 March 2013. http://www.rcaf-arc.forces.gc.ca/v2/equip/ch149/index-eng.asp.

Canada. Department of National Defence. "Royal Canadian Air Force in the North." Last accessed 22 February 2013. http://www.rcaf-arc.forces.gc.ca/v2/page-eng.asp?id=1512.

Canada. Department of National Defence. Royal Canadian Air Force. "New Releases: Man Stranded on Ice Floe Rescued by 413 Squadron in the Arctic, Jan. 28, 2010." Last accessed 02 March 2013. http://www.rcaf-arc.forces.gc.ca/14w-14e/nr-sp/index-eng.asp?id=10010.

Canada. Department of National Defence. "SAR Techs Receive International Award for Bravery at Sea." *The Maple Leaf* 15, no. 11 (December 2012): 7. http://www.forces.gc.ca/site/tml/_pdf/2012/12-eng.pdf.

Canada. Department of National Defence. SMM 60-130-2605, *Standard Manoeuvre Manual CC130(E/H) Search and Rescue Operations.* Winnipeg: 1 Canadian Air Division, 2010.

Canada. Department of National Defence, *Summative Evaluation of the Contribution to the Civil Air Search and Rescue Association (CASARA)*. Ottawa: Chief Review Services, 2009. http://www.crs-csex.forces.gc.ca/reports-rapports/2009/124P0864-eng.aspx.

Canada. Department of Public Works and Government Services Canada. "Fixed-Wing Search and Rescue (FWSAR) Aircraft Replacement Project." Last accessed 12 March 13. http://www.tpsgc-pwgsc.gc.ca/app-acq/stamgp-lamsmp/svtvn-rscfw-eng.html.

Canada. Emergency Prevention, Preparedness and Response Working Group. *Final Report*. Whitehorse: EPPR Working Group, June 15-16, 2011. http://www.arctic-council.org/eppr/wp-content/uploads/2011/09/EPPR-Working-Group-Meeting-Final-Report%209-10-11.pdf.

Canada. House of Commons. *House of Commons Debates. Official Report (HANSARD)* 146, no. 113, Monday, April 30, 2012, 11:30. http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=5532242&Mode=1#TOC-TS-1130.

Canada. House of Commons. *House of Commons Debates. Official Report (HANSARD)* 146, no. 138, Monday, June 11, 2012, 11:05. http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=5667054.

Canada. House of Commons. Standing Committee on National Defence. *Minutes of Proceedings and Evidences*, no. 59, Thursday, November 29, 2012, 16:30. http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=5903533&Language=E.

Canada. National Research Council Canada. CR-FRL-2010-0025, *Review of the Statement of Operational Requirement for the Fixed Wing Search and Rescue Aircraft – Final Report*. Ottawa: NRCC, 2010. http://www.forces.gc.ca/site/pri/2/pro/9/2010/10/report-rapport/Final_Report_EN.pdf.

Canada. National Search and Rescue Secretariat. "Arctic SAR," *SAR Scene* 18, no. 3 (Winter 2009): 1-24. http://www.nss.gc.ca/site/ss/magazine/vol18_3/Vol18-3_E.pdf.

Canada. National Search and Rescue Secretariat. "Who we Are." Last Accessed 22 February 2013. http://www.nss.gc.ca/site/whoWeAre/nssorg_e.asp.

Canada. Royal Canadian Mounted Police. "RCMP Search and Rescue." Last Accessed 24 February 2013. http://www.rcmp-grc.gc.ca/ccaps-spcca/rs-eng.htm.

Canada. Senate. Standing Senate Committee on National Security and Defence. *Sovereignty & Security in Canada's Arctic, Interim Report.* Ottawa: Senate Committees Directorate, 2011. http://www.parl.gc.ca/Content/SEN/Committee/403/defe/rep/rep07mar11-e.pdf.

Canada. Senate. Standing Senate Committee on Transport and Communications. *The Future of Canadian Air Travel: Toll Booth or Spark Plug? Report on the Future Growth and Global Competitiveness of Canada's Airports*. June 2012. http://www.parl.gc.ca/Content/SEN/Committee/411/trcm/rep/rep05jun12-e.pdf.

Canada. Statistic Canada. "Population and dwelling counts, for Canada, provinces and territories, 2011 and 2006 censuses." Last accessed 25 February 2013. http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/hlt-fst/pd-pl/Table-Tableau.cfm?LANG=Eng&TABID=1&T=101&SR=1&RPP=25&S=10&O=A&CMA=0&PR=0#C2.

Canada. Statistic Canada. "Shipping in Canada, 2011." Last accessed 8 March 2013. http://www.statcan.gc.ca/pub/54-205-x/54-205-x2011000-eng.pdf.

Canada. Transportation Safety Board of Canada. "Investigation Progress Update: First Air Flight 6560, Boeing 737 Accident, 20 August 2011, Resolute Bay (A11H0002)." Last accessed 02 March 2013. http://bst-tsb.gc.ca/eng/medias-media/progres-update/aviation/2012/a11h0002/a11h0002-20120105.asp.

Canada. Transportation Safety Board of Canada. *Marine Investigation Report M10H0006, Grounding – Passenger Vessel Clipper Adventurer, Coronation Gulf, Nunavu, 27 August 2010.* Released 26 April 2012. http://www.tsb.gc.ca/eng/rapports-reports/marine/2010/m10h0006/m10h0006.pdf.

Canada. Transport Canada. "Government of Canada Takes Action to Protect Canadian Arctic Waters." Last accessed 3 March 2013. http://www.tc.gc.ca/eng/mediaroom/releases-2010-h078e-6019.htm.

Canada. Transport Canada. "Guest Editorial: North of Sixty." Last accessed 3 March 2013. http://www.tc.gc.ca/eng/civilaviation/publications/tp185-3-09-editorial-3947.htm.

Canada. Transport Canada. *TP 14816, Transportation in Canada 2011, Comprehensive Review.* Ottawa: Minister of Public Works and Government Services, Canada, 2011. http://www.tc.gc.ca/media/documents/policy/Transportation_in_Canada_2011.pdf

Canada. Transport Canada. *TP 14816, Transportation in Canada 2011, Statistical Addendum.* Ottawa: Minister of Public Works and Government Services, Canada, 2011. http://www.tc.gc.ca/media/documents/policy/Stats-Addend-2011-eng.pdf.

Canadian American Strategic Review. "Aerial SAR – From Prestige Purchase to *Hangar Queens,* US Presidential VH-71 Helicopters Shipped North as CH-149 *Cormorant* Spares, February 2012." Last accessed 22 February 2013. http://www.casr.ca/doc-news-vh71-cormorant-delivery.htm.

Canadian American Strategic Review. "Arctic SAR - *Griffon*s and Arctic SAR FOLs — Step 1 in an Incremental Approach to Satisfying Canada's Arctic Search-and-Rescue Responsibilities, June 2011." Last accessed 22 February 2013. http://www.casr.ca/mp-arctic-rw-sar-daly.htm.

Canadian American Strategic Review. "Arctic Rescue - SAR Techs Shine in Ice Floe Rescue but Questions also Raised, November 2009." Last accessed 22 February 2013. http://www.casr.ca/doc-dnd-ice-floe-rescue.htm.

Canadian American Strategic Review. "Arctic Sovereignty - Arctic Search-and-Rescue: First Air Crash at Resolute Bay was within Sight of CF SAR Personnel preparing for a 'Major Air Disaster', August 2011." Last accessed 22 February 2013. http://www.casr.ca/id-arctic-sar-first-air.htm.

Canadian American Strategic Review. "Arctic Sovereignty - Keeping a Comparative Eye on the Neighbors — Air Greenland Shops For Replacement Helicopters for Arctic Aerial Search-and-Rescue Role, July/September 2011." Last accessed 22 February 2013. http://www.casr.ca/id-arctic-sar-greenlandair.htm.

Canadian American Strategic Review. "Canadian Sovereignty - A Reality Check: Can Canada Really use a C-17 Transport to Airlift SAR Helicopters to the Arctic to Perform Aerial Search & Rescue Missions? May 2011." Last accessed 22 February 2013. http://www.casr.ca/id-arctic-sar-transport.htm.

Canadian American Strategic Review. "Future New Fixed-Wing Search & Rescue - Canadian Forces Fixed-Wing Search and Rescue (FWSAR) Project, November 2012." Last accessed 22 February 2013. http://www.casr.ca/bg-af-fwsar-project.htm.

Canadian American Strategic Review. "Future New Fixed-Wing Search & Rescue – A Canadian Forces Fixed-Wing Search and Rescue Timeline, November 2012." Last accessed 22 February 2013. http://www.casr.ca/id-fwsar-project-timeline.htm.

Canadian American Strategic Review. "Future New Fixed-Wing Search & Rescue - 'FWSAR Plus': an expanded scope provides comprehensive solutions to satisfying multiple operational requirements with Canadian, April 2012." Last accessed 22 February 2013. http://www.casr.ca/ft-fwsar-dorschner.htm.

Canadian American Strategic Review. "New Helicopters for the CCG - Canadian Coast Guard Replacement 'Helicopter Project' – Options, September 2012." Last accessed 22 February 2013. http://www.casr.ca/ft-ccg-helicopters-dorschner.htm.

Canadian Broadcasting Corporation (CBC) News. "Coast Guard Seeks Damages for Arctic Cruise Ship Accident." Last updated 20 June 2012. http://www.cbc.ca/news/canada/north/story/2012/06/19/north-coast-guard-clipper-adventurer-damages.html.

Canadian Broadcasting Corporation (CBC) News. "DND Backtracks on Arctic Naval Facility." Last updated 22 March 2012. http://www.cbc.ca/news/canada/north/story/2012/03/22/north-nanisivik-plans-change.html.

Canadian Broadcasting Corporation (CBC) News. "Feds Plan Purchase of 24 New Coast Guard Choppers." Last modified 20 August 2012. http://www.cbc.ca/news/politics/story/2012/08/20/nl-coast-guard-choppers-820.html.

Canadian Broadcasting Corporation (CBC) News. "French Skier rescued from Baffin Crevasse." Last modified 21 April 2011. http://www.cbc.ca/news/canada/north/story/2011/04/21/glacier-auyuittuq-rescue-hintermeier.html.

Canadian Broadcasting Corporation (CBC) News. "Grounded Arctic Tanker Tries to Lighten Load." Last updated 13 September 2010. http://www.cbc.ca/news/canada/north/story/2010/09/13/nwpassage-tanker-refloat.html.

Canadian Broadcasting Corporation (CBC) News. "How to Make Arctic Waters Safer for Ships." Last updated 22 September 2012. http://www.cbc.ca/news/canada/story/2012/09/20/f-arctic-charting-navigation-channels.html.

Canadian Broadcasting Corporation (CBC) News. "Military Seeks Civilian Aid for Arctic Search and Rescue." Last updated 20 November 2011. http://www.cbc.ca/news/canada/north/story/2011/11/19/north-civilian-search-rescue.html.

Canadian Broadcasting Corporation (CBC) News. "Pilot in Failed Arviat Rescue has Years of Arctic Experience." Last updated 13 January 2013. http://www.cbc.ca/news/canada/north/story/2013/01/13/north-pilot-experience-arviat-rescue.html.

Canadian Broadcasting Corporation (CBC) – The Fifth Estate. "Mayday." Broadcasted 30 September 2011. Last accessed 24 February 2013. http://www.cbc.ca/fifth/2011-2012/mayday/.

Canadian Coast Guard Auxiliary. "Volunteer Marine Search and Rescue." Last accessed 13 March 2013. http://ccga-gcac.ca/.

Canadian Forces Canada Command. Presentation by Maj. Jay Nelles, *Canadian Forces Search and Rescue.* Northern SAR Roundtable, 21 June 2011. http://www.nss.gc.ca/site/North-Nord/2011/CF%20SAR%20(DAR).pdf.

Canadian Forces Canada Command. Presentation by Major Jay Nelles, *CASARA North.* Northern SAR Roundtable, 2 February 2012. http://www.nss.gc.ca/site/North-Nord/2012/CASARA%20North%20(Feb%202012).pdf.

Canadian Marine Pilots' Association. "Overcoming Challenges in Arctic Waters." *The Canadian Military Pilot* 2, no. 2 (Fall 2010): 5-6. http://www.marinepilots.ca/newsletter/CMPA_V2N2_Eng.pdf.

Charron, Andrea. "The Northwest Passage in Context." *Canadian Military Journal* 6, no. 4 (Winter 2005–2006): 41-47. http://www.journal.forces.gc.ca/vo6/no4/doc/north-nord-02-eng.pdf.

Civil Air Search and Rescue Association. "About CASARA." Last Accessed on 24 February 2013. http://www.casara.ca/about-casara/.

Cohen, Tobi. "Canadian Rescue Capacity Questioned in Wake of Arctic Ship Grounding." *Postmedia News*, 29 August 2010. Last accessed 8 March 2013. http://www.canada.com/news/Canadian+rescue+capacity+questioned+wake+Arctic+ship+grounding/3457291/story.html.

Colucci, Frank. "Cyclone Search: The Canadian Forces CH148 Cyclone Integrated Mission System Manages Powerful Maritime Surveillance Sensors Installed on a Networked Multi-mission Helicopter." *Aviation Magazine*, May 2010, 22-24. http://jproc.ca/rrp/rrp3/ch148_cyclone_avionics_may_2010.pdf.

Conley, Heather A., Terry Toland, Jamie Kraut and Andreas Osthagen. *A New Security Architecture for the Arctic: An American Perspective.* Washington, D.C.: Center for Strategic and International Studies, 2012. http://csis.org/files/publication/120117_Conley_ArcticSecurity_Web.pdf.

COSPAS/SARSAT. "About Cospas-Sarsat." Last Accessed on 24 February 2013. http://www.cospas-sarsat.org/en/about-cospas-sarsat/about-the-programme-g/international-cospas-sarsat-programme.

Cougar. A VIH Aviation Group Company. "Search and Rescue." Last accessed 8 March 2013. http://www.cougar.ca/services/SAR/.

Craig, Lesley. "The Sea King's not Done Yet." *The Maple Leaf* 13, no. 11 (March 2010): 4. http://www.forces.gc.ca/site/Commun/ml-fe/vol_13/vol13_11/1311_full.pdf.

CTV News. "Experts say Boeing Crash Shows Need for Arctic Capability." Last modified 19 May 2012. http://www.ctvnews.ca/experts-say-boeing-crash-shows-need-for-arctic-capability-1.686250.

CTV News. "Military Seeks Volunteers for Arctic Search and Rescue." Last accessed 12 March 2013. http://www.ctvnews.ca/military-seeks-volunteers-for-arctic-search-and-rescue-1.727794.

Defence Industry Daily. "Australia's Coastwatch: A Public-Private Model for Coast Guards and CBP." Last accessed 8 March 2013. http://www.defenseindustrydaily.com/cobham-catches-a-1b-australian-coastwatch-contract-01695/.

Defence Industry Daily. "Britain's Next Search-and-Rescue Helicopters: Civilian Contractors." Last accessed 8 March 2013. http://www.defenseindustrydaily.com/british-searchandrescue-a-billion-pound-partnership-02271/#more-2271.

Defence Industry Daily. "Readiness a Problem for Canada's Aircraft, June 2009." Last accessed 22 February 2013. http://www.defenseindustrydaily.com/Readiness-a-Problem-for-Canadas-Aircraft-05486/.

Dorschner, Jim. "FWSAR Plus: A Way Forward." *Canadian Military Journal* 12, no. 4 (Autumn 2012): 58-64. http://www.journal.forces.gc.ca/vol12/no4/doc/Dorschner-pages5864.pdf.

Fortin, Steve. "A New Step for the Polar Epsilon Project." *The Maple Leaf* 13, no. 24 (21 July 2010): 16. http://www.forces.gc.ca/site/commun/ml-fe/vol_13/vol13_24/1324_full.pdf.

Galloway, Gloria. "Peter MacKay's Vacation Ended with Search-and-Rescue Shuttle Service." *The Globe and Mail*, last updated 10 September 2012. http://m.theglobeandmail.com/news/politics/ottawa-notebook/defence-minister-peter-mackays-vacation-ended-with-search-and-rescue-shuttle-service/article2175679/?service=mobile.

Harper, Stephen. Speech, Prime Minister Stephen Harper Announces New Arctic Offshore Patrol Ships, Esquimalt, British Colombia, July 9, 2007. http://www.pm.gc.ca/eng/media.asp?id=1741.

Huebert, Rob. "Renaissance in Canadian Arctic Security?" *Canadian Military Journal* 6, no. 4 (Winter 2005–2006): 17-29. http://www.journal.forces.gc.ca/vo6/no4/doc/north-nord-eng.pdf.

Huebert, Rob. "The Newly Emerging Arctic Security Environment." Calgary: Canadian Defence and Foreign Affairs Institute, 2010. http://www.cdfai.org/PDF/The%20Newly%20Emerging%20Arctic%20Security%20Environment.pdf.

Hughes, David. "The Rescue of BoxTop 22. The Crash of a C-130 Pits a Massive3 Rescue Force against the Deadly Arctic Night." *Popular Mechanics* (June 1992): 50-52, 116-117.

iPolitics. "Griffon Helicopters in Search and Rescue Deemed at 'Risk': Air Force Report." Last accessed on 11 March 2013. http://www.ipolitics.ca/2011/02/22/griffon-helicopters-in-search-and-rescue-deemed-a-risk-air-force-report/.

iPolitics. "Return in service of Cormorants delayed to 2014: Documents." Last accessed 23 March 2013. http://www.ipolitics.ca/2011/01/21/return-in-service-of-cormorants-delayed-to-2014-documents/.

International Civil Aviation Organization (ICAO). "ICAP in Brief." Last accessed 24 February 2013. http://www.icao.int/Pages/icao-in-brief.aspx.

International Maritime Organization (IMO)/International Civil Aviation Organization (ICAO). *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual. Volumes I-III*. London: IMO/ICAO, 2003.

Ivison, John. "Canadian Politics: Stephen Harper Steps in to Save Radarsat Upgrade after Budget Cutbacks Threatened Satellite Program's Future." *The National Post,* 19 December 2012. http://news.nationalpost.com/2012/12/19/stephen-harper-steps-in-to-save-radarsat-upgrade-after-budget-cutbacks-threatened-satellite-programs-future/.

Johnson, Kirk. "For Coast Guard Patrol North of Alaska, Much to Learn in a Remote New Place." *The New York Times,* 21 July 2012. http://www.nytimes.com/2012/07/22/us/coast-guard-strengthens-presence-north-of-alaska.html?_r=2&.

Jordan, Pav. "Baffinland Sees Silver Lining in Scaling Back Mary River Project." *Globe and Mail*, 25 January 2013. http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/baffinland-sees-silver-lining-in-scaling-back-mary-river-project/article7849338/.

Judson, Brad. "Trends in Canadian Arctic Shipping Traffic – Myths and Rumours." Victoria: BMT Fleet Technology Limited, 2010. http://www.google.ca/url?sa=t&rct=j&q=Judson%2C+Brad.+%E2%80%9CTrend

s+in+Canadian+Arctic+Shipping+Traffic+%E2%80%93+Myths+and+Rumours&source=web&cd=1&cad=rja&ved=0CDQQFjAA&url=http%3A%2F%2Fmembers.shaw.ca%2Fcjudson%2Farctictraffic.doc&ei=RZYzUZ7xC6GZ0QH87o.

Kelowna.com. "Rescue Underway for Hunter Trapped on Northern Ice Floe." Last accessed 2 March 2013. http://www.kelowna.com/forums/topic/rescue-underway-for-hunter-trapped-on-northern-ice-floe.

King Ruel, Geneviève. "The (Arctic) Show Must Go On: Natural Resource Craze and National Identity in Arctic Politics." *International Journal* 66, no. 4 (Autumn 2011): 825-833.

Lackenbauer, P. Whitney, and W.A March, editors. *Sic Itur Ad Astra: Canadian Aerospace Power Studies Volume 4: De-Icing Required! The Historical Dimension of the Canadian Air Force's Experience in the Arctic*. Ottawa: Her Majesty the Queen as represented by the Minister of National Defence, 2012.

Lackenbauer, P. Whitney. "From Polar Race to Polar Saga: An Integrated Strategy for Canada and the Circumpolar World." Foreign Policy for Canada's Tomorrow, no.3. Toronto: Canadian International Council, 2009. http://opencanada.org/wp-content/uploads/2011/05/From-Polar-Race-to-Polar-Saga-Whitney-Lackenbauer1.pdf.

Lackenbauer, P. Whitney. "The Canadian Rangers: A 'Postmodern' Militia That Works." *Canadian Military Journal* 6, no. 4 (Winter 2005–2006): 49-60. http://www.journal.forces.gc.ca/vo6/no4/doc/north-nord-03-eng.pdf.

Lacroix, Matthew. "BOXTOP 22 Survivor Remembers Fatal Crash." *The Maple Leaf* 11, no 26 (Summer 2008): 6. http://www.forces.gc.ca/site/commun/ml-fe/vol_11/vol11_26/1126_full.pdf.

Lajeunesse, Adam, Will Russel, and A.E. Johnson. *Canadian Arctic Shipping: Issues and Perspectives*. International Centre for Northern Governance and Development: University of Saskatchewan, 2011. http://artsandscience.usask.ca/icngd/Occasional%20Paper%2011-01.pdf.

Lasserre, Frédéric. "Arctic Shipping Routes. From the Panama Myth to Reality." *International Journal* (Autumn 2011): 793-808.

Leblanc, Pierre. "Canada Ducked an Arctic Bullet." *The Hill Times*, 3 October 2011.

Leblanc, Pierre. "North West Passage Unguarded: Thinking Outside the Igloo?" *Frontline Defence*, issue 3 (2011), 58-59. http://www.frontline-global.com/downloads/11_DEF3_OutsidetheIgloo_PierreLeblanc.pdf.

Lee, Robert Mason. *Death and Deliverance: The Haunting True Story of the Hercules Crash at the North Pole*. Toronto: MacFarlane Walter and Ross, 1992.

Leslie, Andrew, Peter Gizewski, and Michael Rostek. "Developing a Comprehensive Approach to Canadian Forces Operations." *Canadian Military Journal* 9, no. 1 (Fall 2008): 11-20. http://www.journal.forces.gc.ca/vo9/no1/doc/04-leslie-eng.pdf.

Macauley, J.A. *That Others May Live, 50 Years of Para Rescue in Canada, 1944-1994*. Astra: The Para Rescue Association of Canada, 1994.

Matthews, Carolyn. *True Stories of Rescue and Survival - Canada's Unknown Heroes*. Toronto: Dundurn Press, 2008.

Melady, John. *Search and Rescue: When Disaster Strikes*. Markham: Scholastic Canada Limited., 1999.

Mifflin, Michael. "Arctic Sovereignty: A View from the North." *Policy Opinions* (May 2007): 55-58. http://www.irpp.org/po/archive/may07/mifflin.pdf.

Murray, Jean. "SAR Challenges. Despite Immense Challenges, Canada's Search and Rescue System has become one of the Best in the World." *www.Frontline-Canada.com* (September/October 2005), 6. http://www.frontline-canada.com/Defence/pdfs/05_5_Murray.pdf.

Nav Canada. *Nav Canada 2012 Annual report. A World in Motion*. Ottawa: Nav Canada Communications, 2013. http://www.navcanada.ca/ContentDefinitionFiles/Publications/CorpPublications/AnnualReports/AnnualReport_2012_en.pdf.

Northern News Services Online. "French Hiker Rescued after Falling in Crevasse." Last accessed 2 March 2013. http://www.nnsl.com/frames/newspapers/2011-05/may2_11fh.html.

North Slope Borough. "Search and Rescue Department." Last accessed 12 March 2013. http://www.north-slope.org/departments/sar/ .

Nunatsiaq Online. "Armed Forces Suspends Mock Disaster Response after Crash in Resolute Bay." Last modified 21 August 2011. http://www.nunatsiaqonline.ca/stories/article/65674military_was_ready_to_respond_to_aug._20_crash_in_resolute/.

Organization for Economic Co-operation and Development. *Whole of Government Approaches to Fragile States*. Paris: OECD Publishing, 2006. http://www.oecd.org/development/incaf/37826256.pdf.

Origin. "Canada Population 2012." Last accessed 25 February 2013. http://worldpopulationreview.com/canada-population/.

Orr, John. "Making Waves: CH-148 Cyclone Encounters Head Winds." *Canadian Naval Review* 4, no 2 (Summer 2008): 31-32.

Pall, Raman. "On the Availability of the CH149 Cormorant Fleet." Proceedings of the 2008 Winter Simulation Conference, 2008. http://www.informs-sim.org/wsc08papers/142.pdf.

Polar Pilots. "Helicopter Goes Down during Arviat, Nunavut Rescue." Last accessed on 12 March 2013. http://polarpilots.ca/index.php/whats-new/59-newadds/188-helicopter-goes-down-during-arviat-nunavut-rescue.

Pugliese, David. "Delivery of Sea King Replacement Helicopters Delayed Once Again." *Ottawa Citizen*, 18 December 2012. http://www.ottawacitizen.com/news/Delivery+King+replacement+helicopters+delayed+once+again/7717268/story.html.

Rotor and Wing. "North to Alaska." Last accessed 12 March 2013. http://www.aviationtoday.com/rw/products/toolsequip/North-to-Alaska_35379.html.

Search and Rescue Volunteer Association of Canada. "Welcome." Last accessed 13 March 2013. http://www.sarvac.ca/.

Shadwick, Martin. "Rescuing Search and Rescue." *Canadian Military Journal* 11, no. 3 (Summer 2011): 65-67. http://www.journal.forces.gc.ca/vo11/no3/doc/11-shadwick-eng.pdf.

Shadwick, Martin. "Search and Rescue Redux." *Canadian Military Journal* 9, no. 1 (Spring 2008): 102-104. http://www.journal.forces.gc.ca/vo9/no1/doc/15-shadwick-eng.pdf.

Sparling, Joseph. "Northern Air Carriers: An Integral Component in the Northern Economy and Canada's Air Transportation Network." Air North, Yukon's Airline, March 2012. http://www.flyairnorth.com/pdf/Northern_Air_Carriers.pdf.

Sparling, Joseph. "Northern Aviation- A Strategy to Strengthen the Northern Economy." *Northern Air Transport Association,* 4 March 2011.

Sutherland, Jonathan, and Diane Canwell. *The RAF Air Sea Rescue Service 1918-1986*. Barnsley: Pen and Sword Aviation, 2005.

Russel, William. "A Proposed Arctic Search and Rescue Strategy for Canada," Master's thesis, Dalhousie University, 2011. http://dalspace.library.dal.ca/bitstream/handle/10222/14285/Russell_2011_MMM.pdf.

Teeple, Nancy. "A Brief History of Intrusions into the Canadian Arctic." *Canadian Army Journal* 12, no. 3 (Winter 2010): 45-68.

The Economist, "Special Report, The Arctic: The Melting North." *The Economist,* 16 June 2012. http://www.economist.com/node/21556798.

The Mariport Group Limited. *Canadian Arctic Shipping Assessment - Main report for Transport Canada*. Digby: The Mariport Group Ltd, 2007. http://www.jointsecretariat.ca/pdf/CASA%20Complete%20Final%20Report%20and%20Annexes.pdf.

TheStar.com. "Insight: How Did Search-and-Rescue Mission to Igloolik Go Wrong?" Last accessed 8 March 2013. http://www.thestar.com/news/insight/2012/04/20/how_did_searchandrescue_mission_to_igloolik_go_wrong.html.

TheStar.com. "Star exclusive: Canada looking at building military bases in Arctic." Last accessed 23 March 2013. http://www.thestar.com/news/canada/2011/07/14/star_exclusive_canada_looking_at_building_military_bases_in_arctic.html.

United States. Congressional Research Service Report for Congress. *Changes in the Arctic: Background and Issues for Congress*. Washington, DC: Congressional Research Service, August 1, 2012. http://www.fas.org/sgp/crs/misc/R41153.pdf.

United States. Department of Commerce. United States Census Bureau. "State and Country QuickFacts." Last accessed 25 February 2013. http://quickfacts.census.gov/qfd/states/02000.html.

United States. Department of Homeland Security. United States Coast Guard. "News Release: Coast Guard Rescues Father, Son South of Barrow." Last accessed 12 March 2013. http://www.uscgnews.com/go/doc/4007/1546227/Coast-Guard-rescues-father-son-south-of-Barrow.

United States. Department of Homeland Security. United States Coast Guard. "SAR Program Information," Last accessed 25 February 2013. http://www.uscg.mil/hq/cg5/cg534/SAR_Program_Info.asp.

United States. Department of the Interior U.S. Geological Survey (USGS). *Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle*. Fact Sheet 2008-3049, 2008. http://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf.

United States. National Snow and Ice Center. "Arctic Sea Ice News and Analysis." Last accessed 3 March 2013. http://nsidc.org/arcticseaicenews/.

Wallace, Ron. "Emerging Canadian Priorities and Capabilities for Arctic Search and Rescue: A Policy Update Paper." Calgary: Canadian Defence and Foreign Affairs Institute, 2012. http://www.cdfai.org/PDF/Emerging%20Canadian%20Priorities%20and%20Capabilities%20for%20Arctic%20Search%20and%20Rescue.pdf.

Wallace, Ron. "Why Canada Needs a Robust Arctic Air Rescue Capability: A Policy Update Paper." Calgary: Canadian Defence and Foreign Affairs Institute, 2009. http://www.cdfai.org/PDF/Why%20Canada%20Needs%20a%20Robust%20Arctic%20Air%20Rescue.pdf.