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THE FUTURE OF CANADIAN STRATEGIC TANKERS

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1. Introduction

The CC150 Polaris Multi Role Tanker Transport (MRTT) is Canada's only strategic tanker asset. The first of the two modified CC150 is due to be in service in the summer of 2007. In Canada the only assets requiring air-to-air refueling were the CF-18s. Therefore the CC150 MRTTs were modified to have two probe-and-drogue pods fitted under the wings to support fighter operations. The arrival of the new strategic airlift, the C-17 Globemaster, has now brought on the second asset within Canadian inventory which may require strategic refueling. However, this asset is equipped with a boom receptacle versus the probe-and-drogue like the CF-18.

The Air Force Campaign Plan[1] forecast the replacement of the CF-18 to be in 2017. Currently, due to the large involvement of Canadian industry in the Joint Strike Fighter (JSF) development, the author will assume that the JSF will be a front-runner for this replacement.

This essay will examine Canada's future demands on strategic air-to-air tankers. It will examine the synergy that can be achieved between the requirements of the C-17 strategic airlift aircraft and the potential acquisition of the JSF. It will argue that future requirements would be best serve by retrofitting Canada's current CC150 MRTT with a ventral boom refueling system. However the author will argue that despite these retrofittings, at least one more CC150 MRTT or preferably two bigger Airbus A330 MRTTs, should be acquired to increase the strategic tanker fleet size. It must be

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[1] Department of National Defence. Airforce Strategy; The flight plan for Canadian Forces' aerospace power. Working draft V1.8, March 2007. p. 41.

understood that although a portion of this paper has been dedicated to the JSF cost analysis, the main focus is the strategic tankers. As well, the reader must keep in mind that all cost figures are not from "Commercial in Confidence" sources; therefore they are approximate and available from unclassified references.

To demonstrate the argument the author will look at:

a. The requirement for the C-17 to utilize its air refueling capability;

b. Factors that affects the capability and cost of different JSF variants, which Canada may wish to acquire; and

c. Factors that affect the number and type of required strategic tankers for Canada.

2. Current Strategic Airlift.

The C-17 Globemaster strategic airlift aircraft is the latest Canadian acquisition due to enter service in the summer of 2007. This platform is a departure from aircrafts equipped with and requiring probe-and-drogue refueling system. The C-17 utilizes the US Air Force's standard boom refueling system. Current and future Canadian mobility missions for the C-17 will be enhanced with the use of strategic tankers, equipped with such refueling system.

The USAF's mobility operational objectives demonstrate the synergy between their Airlift and Air Refueling assets. Figure 2.1: USAF Air Mobility Mission[2] shows

[2] AF Scientific Advisory Board ,University Center for Strategy and Technology. "New World Vistas: Air and Space Power for the 21st Century", http://csat.au.af.mil/studies.htm ; Internet access 23 December 2006. Chapter 2, p. 3.

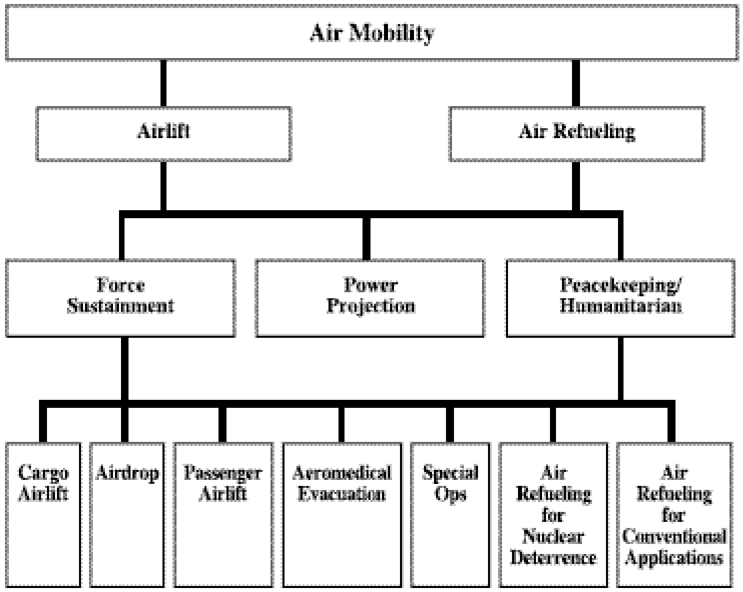

Figure 2.1: USAF Air Mobility Mission

that the operational objectives of air mobility are force sustainment, power projection and peacekeeping/humanitarian support. These objectives are similar to how the Canadian procurement project identifies the C-17's requirements within the strategic airlift's Statement of Operational Requirement's (SOR)[3]. In the SOR documentation it is also identified that:

> … The new Strategic Air Transport Weapon System (SAT WS) will provide the global reach and speed necessary to operate efficiently over long distances. It will be employed to deliver cargo directly into a theatre of operations ... Direct delivery will reduce the requirement to offload cargo and/or personnel at an intermediate staging base for onward delivery via a tactical aircraft… The reduction of the requirement to utilize an intermediate staging base for transfer of cargo and/or personnel will increase the CF's operational flexibility, response time, and efficiency …[4]

[3] Department of National Defence. Directorate of Aerospace Requirement. " Airlift Capability Project-Strategic-00001117", Statement of Operational Requirement. June 2006. p. A-10.

[4] *Ibid*., p. 2.

As well, the SOR lists the mandatory requirement that the strategic airlift aircraft must have provision for air-to-air refueling capability.[5]

In times of need, only strategic air refueling can enable a rapid force projection, force sustainment or humanitarian use of strategic airlift. This enabler allows a decrease in reliance in en route staging and host nations support while speeding airlifts into theaters of operation. In operation DESERT SHIELD and DESERT STORM it was acknowledged that "… the ability to air refuel [strategic airlift] was a force multiplier …"[6]

Future employment of Canada's C-17 will be enhanced with the use of strategic air tankers. This use will act as a force multiplier by decreasing the reliance on host nation support for en route staging, while increasing the rapidity of response into a theater of operation.

3. Future Fighter Replacement

Canada employs the CF-18 as its only fighter. The Estimated Life Expectancy for the CF-18 is currently placed at 2017[7]. The Air Force Campaign Plan[8] indicates that a new generation fighter capability, to replace the aging CF-18s, is planned for 2017. Although a thorough options analysis remains to be performed, it would seem likely that the Lockheed Martin's F-35 lightning II, or commonly known as JSF, would be a front-

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[5] *Ibid*., p. 7.

[6] AF Scientific Advisory Board ,University Center for Strategy and Technology. "New World Vistas: Air and Space Power for the 21st Century", http://csat.au.af.mil/studies.htm ; Internet access 23 December 2006. Chapter 2, p. 7.

[7] Department of National Defence. Airforce Strategy; The flight plan for Canadian Forces' aerospace power. Working draft V1.8, March 2007. p. 44.

[8] *Ibid*., p. 41.

runner. Canada is a partner in the development of the JSF and Canadian industry is heavily involved in aerospace contracts for the production of this aircraft.

As the JSF is likely to be the most capable and affordable 5th generation solution for Canada, the author will assume that the JSF will be the replacement for the CF-18s.

Within the JSF family there are three variants, which will be offered; the USAF Conventional Take Off and Landing (CTOL), the US Navy Carrier Version (CV) and the US Marine Short Take Off and Vertical Landing (STOVL) variant. All variants, although similar, offer different capabilities to their users. The object of this section is not to offer an option's analysis, but rather to look at a few key areas that affect the future of Strategic Air Tankers in Canada. The following key areas related to range and cost will be looked at: The commonality of parts between JSF variants; A comparison of range performance; The use of boom versus probe-and-drogue refueling systems; and the estimated procurement cost for the two most likely variants for Canada, the CTOL and CV.

Commonality of Parts of F-35 Variants

The primary measure of cost reduction for the JSF program is to ensure the maximum commonality of parts within the three variants. Affordability "… is achieved in large part through a very high level of common parts and systems across the three versions of the aircraft."[9]

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[9] F-35 Joint Strike Fighter Program Office, http://www.jsf.mil ; Internet; accessed 10 March 2007.

Figure 3.1: F-35 Technology Commonality[10], demonstrates the varied amounts of commonality between the three different variants. The program office defines the parts into three categories;

a. Common Parts: These are parts that are useable by all three variants. Maximizing this type of parts will minimize the manufacturing and spare replacement costs;

b. Cousin Parts: These are common parts, which require further modification to purpose fit the particular variant: and

c. Unique Parts: These are parts that are unique to the variant. They are not shared by other variants, therefore their manufacturing cost is inversely proportional to the number being manufactured and stored for future spares. Minimizing this type of parts will minimize the manufacturing and spare parts replacement cost.

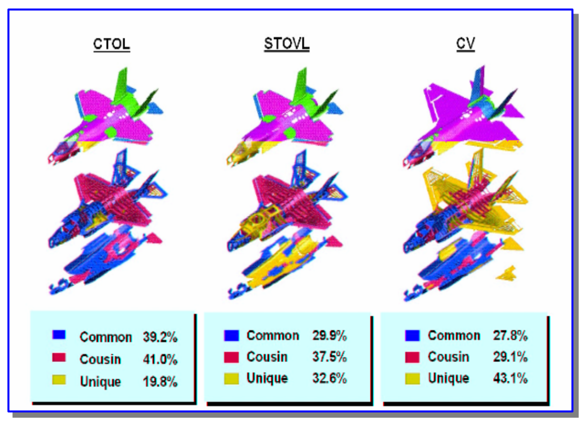

Figure 3.1: F-35 Technology Commonality

The CTOL variant is comprised of 39.2% common and 41.0% cousin parts, while only 19.8% of its parts are unique. The CV is the variant which have the least commonality in parts; only 27.8% common and 29.1% cousin with the highest percentage of unique parts at 43.1%.

As of 2005, the program is estimated to produce 2458 JSF; 1778 CTOLs for the USAF and 680 STOLs and CVs for the US Navy[11]. The US Navy has not identified the

[10] *Ibid.*

current mix ratio of STOLs and CVs. Even if, for argument, it is estimated that 340 STOLs and 340 CVs were produced this number is substantially less than the 1778 estimated to be procured by the USAF. The CTOL variant will have 79.2% of its parts manufacturing cost spread over the manufacturing of 2458 aircraft. The CV will have 43.1% of its parts manufacturing cost spread over the manufacturing of 340 (or a number less than 680) aircrafts.

Due to the smallest amount of common parts and the largest amount of unique parts, the US Navy version of the F-35 will be the most expensive variant for procurement. As well, it will be the most expensive variant to maintain throughout its expected life.

F-35 Range Performance Comparison

One of Canada's primary requirement for its next fighter aircraft will have to be its ability to have a large un-refueled range. This will facilitate its ability to perform sovereignty operations to and from remote locations within Canada or its assigned task within a coalition force.

The new Air Force Strategy document states that "…it must be noted that Canada has the second largest territory in the world…responding to any potential unwanted or unauthorized activity presents significant challenges."[12] When comparing the combat radius performance between the F-35 variants in Fig 3.2: Key Performance Parameter

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[11] United States Government Accountability Office. Report to Congressional Committees; Tactical Aircraft: Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisiton Strategy. GAO-05-271, March 2005.

[12] Department of National Defence. Airforce Strategy; The flight plan for Canadian Forces' aerospace power. Working draft V1.8, March 2007. p. 6.

Status[13], it can be seen that the CTOL as a maximum estimated combat radius un-refueled of 636 nautical miles (nm). While the STOL and CV respectively have 510 nm and 696 nm. The combat radius that these variants can achieve is, seemingly, proportional to the amount of internal fuel that they can carry; The CTOL can carry 18, 498 lbs of internal fuel while the STOL and CV carry 13, 326 lbs and 19, 624 lbs respectively.[14]

The CV variant carries more fuel than other variants due to its bigger size. The US Navy having the requirement to land on aircraft carriers needed bigger wings on the

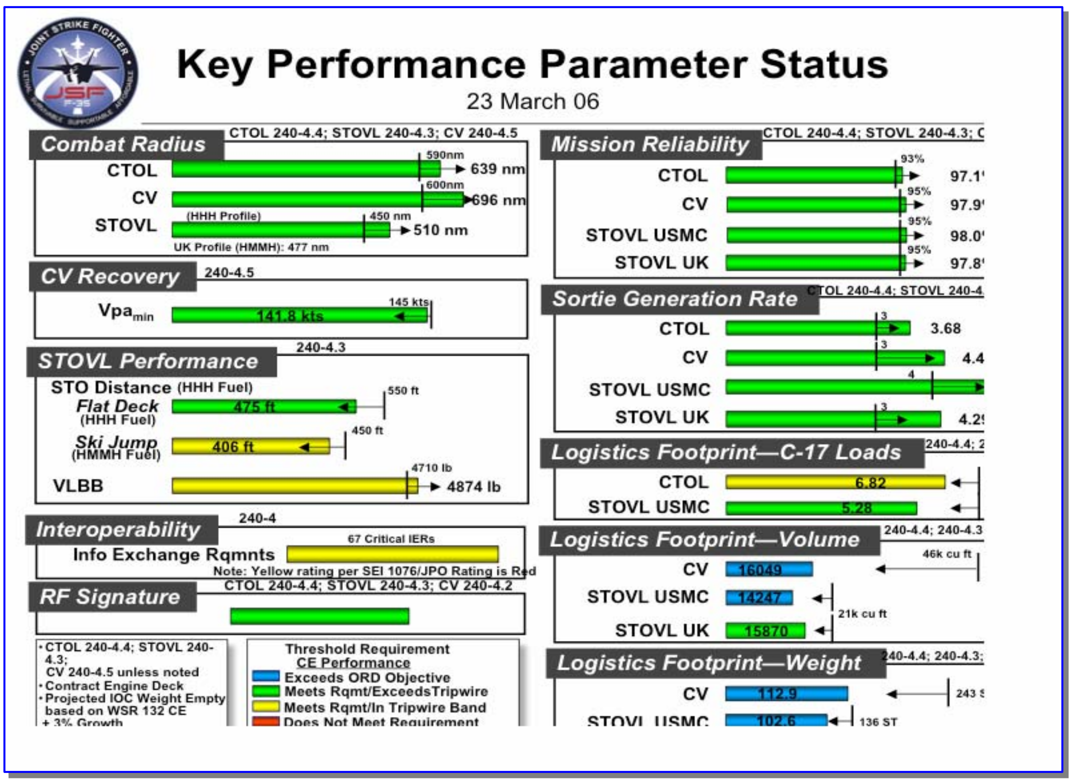

Figure 3.2: Key Performance Parameter Status

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[13] F-35 Joint Strike Fighter Program Office; "F-35 JSF ITF EXCOM 7"; program update briefings; 05 April 2006.

[14] F-35 Joint Strike Fighter Program Office, http://www.jsf.mil ; Internet; accessed 10 March 2007.

JSF to lower its approach speed to the required 145 kts (Fig 3.2). This approach speed is predicated on large amount of remaining internal fuel for recovery to shore, if carrier landings cannot be performed. Also the CV must have the ability to land on the carrier with unexpended heavy ordinance, such as the internally carried 2000 pounds bombs. This resulted in a heavier design with larger wings that allows more room for internal fuel. In a Canadian context, the differences in approach speeds are likely to be insignificant since Canadian fighters do not carry heavy ordnances during sovereignty missions in Northern Canada, where landing speeds are likely to be critical.

The JSF program office published the combat radius of the different variants measured against specified flight profiles; these profiles replicate typical combat missions where heavy bomb loads are carried and maximum power is used for defensive actions. It is to be noted that the USAF profile is more stringent and consumes more fuel than the US Navy profile. These profiles are classified and cannot be discussed within the scope of this paper. If a common nomenclature was used for measuring the maximum combat radius of the different variants, the CTOL would, at the very least be equal to the CV variant's estimated 696 nm.

Due to its smaller size the CTOL variant carries less fuel than the CV. Its smaller size allows it to be lighter, have a lower drag coefficient and be more aerodynamically efficient. This results in a fighter that burns less fuel for the same given range.

Boom vs Probe-and-Drogue Refueling System

The requirement for air-to-air refueling is different between the F-35 variants. The USAF CTOL variant is equipped to receive fuel from a tanker boom into a receptacle seated behind the canopy of the aircraft. The STOVL and CV variants use the

Probe-and-Drogue method with the use of a retractable probe situated on the forward right side of the aircraft. Although maximum commonality between the variants is a primary requirements, the USAF will not equip its' CTOL with a Probe-and-Drogue System.

Currently the USAF has the largest tanker fleet in the world: 59 KC-10s and 534 KC-135s.[15] All 593 strategic tankers use the centerline boom method. Of those, 20 of each type have been modified with wing air refueling pods for multipoint drogue refueling system. In 2005, 96% of the USAF's 3,227 aircraft were refueled by the boom system. The 96% is further subdivided with 669 bombers and surveillance aircraft and 2,419 fighters.[16] The CTOL JSF will replace 1763 of the fighters, but the remainder fighters, bombers and surveillance aircraft will still need to refuel via the boom system.

Although recognizing that the ability to refuel two JSF at the same time is an advantage, a US Government Accountability Office's 2005 JSF Refueling report stated that;

> …the boom method is less likely to damage the low observable feature of the JSF aircraft and, therefore, reduce its vulnerability to enemy air defenses… In contrast to a stable boom, air turbulences are more likely to move the drogue basket and strike the JSF aircraft, leaving it more vulnerable to enemy air defenses because its low observable feature has been degraded.[17]

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[15] Michael J. Sullivan. United States Government Accountability Office. Air Force Assessment of the Joint Strike Fighter's Aerial Refueling Method. GAO-05-316R, March 2005, p. 4.

[16] Congressional Research Service, "Air Force Aerial Refueling Methods: Flying Boom Versus Hose-and-Drogue". CRS Report for Congress; Received through the CRS Web; Code RL32910; 5 June 2006. p. 4.

[17] Michael J. Sullivan. United States Government Accountability Office. Air Force Assessment of the Joint Strike Fighter's Aerial Refueling Method. GAO-05-316R, March 2005, p. 5.

The report concluded that the saving to the JSF Program by equipping the CTOL with a probe would be US$180 Million. The cost for modifying an adequate number of tankers to service the JSF would be US$2.5-US$3.5 Billions[18].

Therefore the additional risk of damaging the low observable features of the JSF and the additional cost to modify existing USAF Tanker fleet greatly outweighed the cost savings to the JSF program.

Procurement Cost Difference Between JSF Variants

The F-35 CV will be the most expensive JSF variant for any nation to own. This section will look at the cost breakdown between the CTOL and CV variants.

There are three main areas of cost to look at when purchasing an aircraft; 1) the cost associated with the research and development in designing the aircraft, called development cost, 2) the cost of producing the aircraft or procurement cost, and 3) the total estimated cost to own the aircraft over its life cycle, or program acquisition cost. The program acquisition cost is the number that goes forward to the Treasury Board for project approval. In determining the US program acquisition spending, the Government Accountability Office multiplied the cost of procurement by a Life Cycle Cost (LCC) factor, determined to be 2.4 for the overall program.[19] This in itself is generous to the more expensive CV since it has the least amount of common parts thus users would incur higher ownership cost over the years for servicing and replacing the unique parts. To

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[18] *Ibid.*, p. 2.

[19] United States Government Accountability Office. Report to Congressional Committees; Joint Strike Fighter: DOD Plans to Enter Production Before Testing Demonstrates Acceptable Performance . GAO-06-356, March 2006. p. 31.

reflect the difference in LCC between the variants a slightly lowered LCC factor was assumed in table 3.1.

Since the beginning of the program, the commonality amongst variants has decreased with an increase in the cost of producing the aircraft.[21] Each variant's procurement cost has increased over the years and with a reduced procurement quantity

has left the JSF program to buy fewer numbers of aircraft at a higher cost. From the original 2,988 JSF to be procured by US forces alone, only 2,458 now remain. The US Navy accounts for the greatest reduction of 409, or 38%, from its original plans to aircraft for a total program cost of US$8.9 Billions, you could purchase 60 CTOL variants plus an additional 27 CTOLs. Or, the program could save US$2.7 Billions.

Further investigation with respect to the effects of the landing speeds differences, if any, between the CTOL and CV would be required to assess the JSF's ability to operate from Northern Canadian forward deployed locations. What has been demonstrated is, that the CV variants will be the most expensive variant of the JSF, with no added range capability, offered to Canada. For any given fleet size of JSF, required to replace the CF-18, a substantial savings can be achieved by selecting the CTOL variant.

4. Strategic Air Tanker

This section will look at the future demand that might be placed on Canada's strategic tankers. The Canadian strategic needs will be assessed against the available and historical fuel off-loads, as well, as the costs associated with an increase in capability.

Future Demand on Canadian Tankers

Historically Canadian strategic tankers have perceived their employment to be solely in support of fighter operations.[23] The future employment for Canadian tankers will span the refueling of:

1. Strategic airlift;
2. Continental fighter deployments, with cargo and personnel;
3. Strategic fighter deployments with cargo and personnel;
4. Continuation training for strategic airlift crews and fighters; and

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[23] Department of National Defence. Directorate of Aerospace Requirement. "Strategic Air-to-Air Refuelling-00002657", Statement of Operational Requirement. May 2001. p. 7.

5. Integral part of Canadian participation in coalition exercises or missions.

Looking at some of the statistics from the US forces we can understand why their tanker force is aging rapidly. Over more than 300 tankers were used in Golf war of 1991. In 1999 during the peak of the Kosovo campaign 40% of the Air Force's tankers and 80% of their crews were used. Since 9/11, tankers are on continuous alert postures to respond to national emergencies. In Operation Enduring Freedom tankers refueled fighters, B-2 bombers for attack missions and, simultaneously, refueling C-17 strategic airlift aircraft for immediate humanitarian relief supplies.[24]

In 2005, a Congressional Research Service concluded that the need of the US Air Force for strategic tankers would grow "…beyond the 600 tankers envisioned…"[25] Moreover, the US Air Force Air Mobility Command expects that due to the increase in global missions dependent on strategic tankers, the requirement for aerial refueling will increase beyond the year 2010.[26]

Canada's MRTT class strategic tankers are capable of carrying cargo with passengers while performing air-to-air refueling operations. This is very beneficial since currently most fighter deployments within North America, involves multiple legs for aircraft, thus increasing the chances of un-serviceabilities en route. The squadron's materials are frequently deployed via ground transport and the squadron's personnel are being deployed via commercial means. The MRTT will not be replacing the C-17, but will complement its' use. General Norton Schwartz, Commander in Chief, United States

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[24] Dr. R. Grant and Dr. L. Thompson, "Modernizing the Aerial Refueling Fleet", Lexington Institute. September 2006. p. 4.

[25] *Ibid*., p. 6.

[26] *Ibid*., p. 4.

Transportation Command stated, "If I had… [MRTT]…I could return the C-17 either to moving cargo or reduce the [operating] tempo,"[27]

The reduction of fighter squadrons within Canada, and the strategic vision to reduce the number of Operational fighters to 36[28] will necessitate greater deployment flexibility for NORAD assets. The distances within Canada are so great that tactical tankers would have difficulty supporting four fighters from CFB Bagotville in an immediate deployment to the northwestern regions of Canada while holding fuel for alternates. Those distances are relatively close to crossing of the Atlantic for a European deployment.

With the purchase of the C-17 Strategic Airlift Aircraft, an increase in NORAD tasking for fighters, and continuing Canada's participation in overseas deployment and humanitarian aid missions, the demand for Canadian Strategic MRTT will increase. This demand will come from not only our own use, but also from the use of our allies which may require our strategic tanker capability to supplement their own. How much fuel our tankers will be required to off-load and an understanding of Canada's strategic needs will be assessed in the next section.

Tanker Off-Load Capabilities

The off-load capacity of a tanker is very important since it is what determines how many strategic tankers will be required to support continental missions, major theater war or multiple immediate humanitarian relief missions.

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[27] *Ibid*., p. 12.

[28] Department of National Defence. Airforce Strategy; The flight plan for Canadian Forces' aerospace power. Working draft V1.8, March 2007. p. B-5.

The study of historical fuel off-loads is an important step in determining what will be the probable off-loads that strategic tankers will be required to provide. Rarely does a tanker give all of his fuel to multiple receivers during a mission. If Canada's tankers will be expected to not only refuel their own, but also other coalition aircrafts, knowing how much of an off-load should be required is essential.

In Operation Desert Storm, the average off-load of all-type of tankers (including coalition) was 47,500 lbs. per sortie. In Operation Allied Force, in Kosovo, it was 48,700 lbs. per sortie. During Operation Enduring Freedom the rates climbed to 75,400 lbs. The second Gulf War saw the average rates of 60,800 lbs per sortie. Stability operations in Iraq and Afghanistan have shown average sortie rate of 62,400 lbs. It must be noted that during special occasions, such as the Iraqi election in 2005, the average off-load rate spiked at 89,000 lbs. of fuel.[29]

Criteria	A310	A330
Max. Fuel Carried (1000 lbs)	171	245
Max. Cargo (in 1000 lbs.)/Passengers	68/60	96/113
Max. Range (nm) with 66,000 lbs cargo	4000	6500
Range (nm) with 6 fighter in trail	NA	2100
Range (nm) with 4 fighter in trail	2100	2800
Range (nm) with 3 fighter in trail	NA	3100
Range (nm) with 2 fighter in trail	2600	3600
Max. off-load (1000 lbs) with 2 hr loiter @1000nm	99	143

Table 4.1: Strategic Tanker Typical Off-Load Comparison

Knowing what Canada's strategic tankers may be task to do help in determining if they will be performing to the average historical off-loads while employed within a coalition force. Table 4.1: Strategic Tanker Off-Load Comparison[30], indicates that the CC150 MRTT's typical off-load when loitering for two hours at 1000 nautical miles (nm)

[29] Dr. R. Grant and Dr. L. Thompson, "Modernizing the Aerial Refueling Fleet", Lexington Institute. September 2006. p. 8.

[30] Global Security, "Airbus A310 Multi Role Transport Tanker(MRTT)" http://www.globalsecurity.org/military/world/europe/mrtt.htm; Internet; accessed 20 January 2007.

from his base is 99,000 lbs. This number is well within the average and surge averages which have been historically studied for theatre operations. This, in a Canadian context translates into a continental use for continuous NORAD operations or special tasking such as the 2010 Olympics in Vancouver.

The Air Force Strategy's[31], Strategic Vectors defines Canada's expeditionary role within Canada and abroad. In this document it is stated that:

> The future security and operating environment will place an even higher premium on a rapid and robust CF response to crises and emergencies in Canada and internationally. The Air Force must be capable of deploying, sustaining operations and re-deploying from locations…across the length and breadth of Canada and around the globe…The distances between wings and bases within Canada, and the designation of North America as an operational theatre…place a premium on the Air Force's expeditionary capability.[32]

Table 4.2, lists the type and numbers of MRTT required to travel to a destination with fighters in tow. It is assumed, at this point, that it is beneficial for a CC150 MRTT

Departure	Destination	Distance(nm)	2 Fghtrs	4 Fgtrs	6 Fghtrs
Cold Lake, Ab	**Bagotville, PQ**	1649	1 x A310	1 x A310	2xA310 or 1xA330
Cold Lake, Ab	**Tyndall AFB, Fla**	1792	1 x A310	1 x A310	2xA310 or 1xA330
Bagotville, PQ	**Yellowknife, NWT**	1728	1 x A310	1 x A310	2xA310 or 1xA330
Bagotville, PQ	**Vancouver, BC**	2052	1 x A310	2xA310 or 1 A330	2xA310 or 1xA330
Bagotville, PQ	**UK, Scotland**	2474	1 x A310	2xA310 or 1 A330	2xA330
Bagotville, PQ	**Moron AFB, Spain**	2877	2xA310 (only 1 at dest.) or 1xA330	2xA310 (only 1 at dest.) or 2xA330	2xA330
Bagotville, PQ	**Kabul, Afgh.**	5490	2xA330 sequential	2xA330 sequential	3x330 sequential

Table 4.2: Strategic Tanker Required for Transit with Fighters in Trail

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[31] Department of National Defence. Airforce Strategy; The flight plan for Canadian Forces' aerospace power. Working draft V1.8, March 2007.

[32] *Ibid.,* p. 18.

to depart from the fighter's location with cargo and personnel aboard required for the deployment. Table 4.2 lists the ranges that Canadian fighters have to operate with. It can be concluded that the current plans for Canada to have 2 CC150 MRTT (A310) will really only help in the deployment within the North American continent. Further, if 6 fighters were needed for rapid deployment within North America, it would require that both CC150 MRTT be used, and serviceable. Moving towards the expeditionary "6-pack"[33] as per the Air Force Strategy, a single Airbus A330 MRTT would be required for continental use, two would be required to move 6 fighters with cargo and personnel for an expeditionary deployment overseas. Refueling for the C-17 for rapid deployment of cargo or humanitarian supplies would require the preposition of the tankers en route and are therefore not looked at in Table 4.2.

The use of the CC150 MRTT for refueling within a theatre of operation will be more than adequate when compared to the, historical daily average tanker off-loads. The off-load capacity of the CC150 MRTT will also be sufficient for most deployment within North America, although in some instances, it will require 100% employment of the fleet with no margins for un-serviceability. For a true expeditionary capability of deploying up to a 6-pack with cargo and personnel outside of North America a slightly larger MRTT, such as the Airbus A330 would be required.

Cost Analysis of Multi Role Tanker Transport and Air Hospital

Cost of selecting a ventral boom system equipped MRTT tanker is low compared to the cost of specifically selecting a probe-and-drogue equipped replacement fighter.

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[33] *Ibid.,* p. B-5.

The Royal Australian Air Force has ordered five A330 MRTTs. These will be equipped with two probe-and-drogue pods on the wings and one ventral boom system for a total project cost of US$1.6 Billions or individual production cost of US$160 Millions. Their tankers will have the ability to refuel their current F-18A, their newly acquired F-18F, F-111(boom) and their planned acquisition of the JSF CTOL (boom) variant. The boom refueling system on the A330 was designed by EADS CASA, which used the A310 MRTT as the test vehicle for the arm.[34] The approximate cost for two A330 MRTTs is US$320 Millions or total project cost of US$640 Millions.

Canada modified two CC-150s to the MRTT tanker version for a total project cost of US$116 Millions, or US$58 Millions per aircraft. The actual production cost of the modifications, were approximately US$29 Millions per aircraft. This modification included strengthening of the airframe, additional fuel cells and a refueling operator's control station.[35] Although EADS CASA has not disclosed the price for a boom system retrofit, it is fair to assume that such a retrofit would be less than the original US$29 for the Canadian MRTT modification. As stated earlier this modification has been performed by EADS CASA as the technology demonstrator for the RAAF contract for the A330 MRTT. Therefore the cost to retrofit two CC150 MRTTs with a boom refueling system would be approximately less than US$20 Million per aircraft or total project cost of less than US$80 Millions for two CC150 MRTTs.

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[34] European Aeronautic Defence and Space Company, "EADS CASA Air Refuelling Boom System (ARBS)," http://www.eads.com; Internet; accessed 20 December 2006.

[35] Pedro Martinez-Cerbu, CC150 Deputy Aircraft Engineer Officer. Telephone conversation with author, 2 April 2007.

Simply modifying two current CC150 MRTT may, as demonstrated in table 4.2, not achieve the Canadian strategic views of deploying a 6-pack of fighters as an expeditionary force anywhere in North America or overseas. A more feasible solution of augmenting our current CC-150 with at least one more modified CC150 MRTT would be required. This third CC150 MRTT could be modified for a tanker role and make use of the available air hospital configuration for casualty evacuation role.

A air hospital role was identified within the strategic airlift requirement for a capability to "… aero medical evacuation (including the ability to accommodate and operate onboard medical equipment)"[36] In an air hospital role the CC150 MRTT can take up to six intensive care units and 56 stretchers[37] while having an extended range of operation due to the added fuel cells that are usually used for air refueling. Similarly, the A330 MRTT can be configured to an air hospital role with a larger capacity for intensive care units and stretchers.

The modification of one more CC150 would approximate a total project cost of less than US$98 Millions ($58M for conversion plus $40M for boom). The total approximate project cost of retrofitting two current CC150 with a boom systems and modifying a further CC150 to an MRTT air hospital role would be US$178 Millions.

Alternatively, Canada could obtain two A330 MRTT and retrofit two CC150 MRTT to boom system, at a total project cost of US$760 Millions. In this case, either an A330 or a CC150 could be modified to the available standard air hospital configuration.

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[36] Department of National Defence. Directorate of Aerospace Requirement. " Airlift Capability Project-Strategic-00001117", Statement of Operational Requirement. June 2006. p. 7.

[37] Airforce-technology, "A310 MRTT Mutli-Role Tanker Transport, Europe," http://www.airforce-technology.com/projects/mrtt.htm; Internet; accessed 20 February 2007.

The future demands for Canadian strategic tankers will be increasing. The current CC150 MRTTs that Canada own will be sufficient for in theatre operations when one looks at the required historical off-loads. For expeditionary deployment the current two CC150 MRTT may not be enough and should be augmented by modifying a further minimum of one CC150 to MRTT status or invest in two new A330 MRTT.

5. Conclusion

Canada's acquisition of the C-17 strategic transport will necessitate a potential requirement to acquire a boom refueling system for Canadian strategic tankers. This new capability will allow a rapid response capability for power projection and humanitarian relief needs in theatre while decreasing the reliance on host nations for en route staging or coalition support.

The availability of multiple variants of the JSF allows Canada the possibility to explore air refueling synergies between the strategic airlift aircraft and the possible replacement fighter for the CF-18. Although factors relating to the minimal runway length requirements between different variants for the JSF need to be further examine, the cost difference between the Navy and USAF variants are significant. The replacement of the CF-18 fleet by 40 to 80 JSF CTOL will yield an approximate total program savings of US$1.8 Billions to US$3.6 Billions over the CV variant.

Cost savings in choosing the CTOL variant of the JSF will allow the modification of the current CC150 MRTT fleet to a ventral boom refueling system. Further modification to minimally one more CC150 to MRTT/Air Hospital configuration will allow flexibility in strategic refueling employment and gain a long range air hospital asset for casualty evacuation from theatres of operation. The cost of these modifications would be approximately US$178 Millions, or less than 6.5% of savings on a fleet size of 60 JSF CTOL.

Modifications of current CC150 would increase Canadian's capability within North America, but due to the distances required for the rapid deployment of a 6-pack of fighters into an oversea theatre, it may be insufficient. The acquisition of two A330 MRTT and the modification of the current two CC150 MRTT to a boom refueling system will give Canada the most flexible combination. For an approximate total project cost of US$720 Millions Canada would have two CC150 MRTT for deployment needs within North America and two A330 MRTT for force projection and casualty evacuation needs for overseas theatre of operations. This total project cost, represents 25% of the US$2.7 billions of potential savings by selecting a fleet of 60 USAF CTOL variant of the JSF vice the Navy CV variant.

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