ANALYSIS OF OPTIONS TO SUSTAIN A CANADIAN FORCES FIGHTER CAPABILITY

TASK 2: CHIEF OF FORCE DEVELOPMENT MISSION NEEDS ANALYSIS

FINAL REPORT

Vice Chief of the Defence Staff

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Executive Summary
Chief of Force Development Mission Needs Report
Evaluation of Options to Sustain a CAF Fighter Capability

This report examines the overall mission needs that the CF188 replacement must be able to meet. The strategic planning methodology used is Capability Based Planning (CBP) which looks at the domestic and expeditionary mission needs of the Canadian Armed Forces (CAF) 5 to 30 years into the future to forecast the capabilities that will be needed against a range of possible threats. Through the lens of Defence policy, CBP assists in answering three important questions: what the CAF believes it needs to do in the future, how well it will do it with the capabilities currently available and programmed and what it might change to perform better. The key conclusions in the report are:

Canada will need a manned fighter aircraft well into the future, principally for its unique ability to protect Canadian airspace. No other platform or combination of platforms can meet this critical domestic mission need.

Manned fighter aircraft provide a multirole and visible option for Government contributions to expeditionary coalition operations. Their role is discretionary in that the government will not only choose whether or not to deploy aircraft but has the option of task-tailoring to the specific mission requirements and threat. The force development projection is that the Canadian fighter's contribution in a war fighting scenario would follow first strikes by Allies.

While the current capabilities of the CF188 are sufficient for the near-term, this 'capability baseline' is *relative* and will erode through the 2020s as technologies and the military capabilities of other nations and non-state threats improve. Beyond this timeframe, greater capability than the CF188 will be required or mission risks will increase.

Future threats are considered in terms of likely opponents' *capabilities* and *intent*; what do they have and how might they use it? In addition, what is the likelihood of *exposure* to this threat? Domestically, any CF188 replacement must defend Canada against the high-level military capabilities of foreign states, notably manned bombers; however, the malign intent to employ such capabilities against Canada is judged to be low. Future expeditionary missions will likely feature less-than-modern-state air defence sophistication but with significant killing potential and hostile intent.

Domestic Missions. The predominant role for the CF188 replacement will be domestic in nature. This mission is non-discretionary based on both the need to protect our sovereignty and bi-national North American Aerospace Defense (NORAD) treaty obligations. Not only is some 90% of the fighter's *historic use* related to domestic or continental missions, the projection is that, within that frame, about 80% of its capability output (or utility) relates to the Aerospace Control function, in particular Defensive Counter-Air (DCA) - the ability to protect airspace. Domestic DCA is also projected to remain, with high confidence, the fighter's most important role. No other CAF asset, alone or in combination, can substitute in the critical role of an airborne interceptor. Canada will need a manned fighter aircraft well into the future, principally for its unique

ability to protect Canadian airspace. The state of unmanned aircraft technology does not suggest a viable replacement to the CF188 in the near to mid-term.

Expeditionary Missions. Expeditionary operations are manifestly more discretionary. Not only does the Government of Canada have choice *in* participation, there is also choice in *how* it participates. Historically, Canada employs its fighter capability abroad once every decade. Moreover, a fighter element is among the fastest-deploying capabilities in the CAF when accompanied by air-to air refuellers.

Canadian fighter aircraft are projected to be used as a part of a larger coalition air package following the initial force intervention strikes aimed at degrading air defence and command and control systems. Here, the most sophisticated threats to fighter aircraft would be degraded yet still significant. Moreover, in many failing/failed state contexts, there are few airborne threats with which to contend. In these air supremacy situations, the fighter's output largely transitions to delivering effects to ground targets. In these cases, and where the situation allows for ground forces to be deployed, the CAF has other systems such as artillery that also do this (in certain circumstances) which means that a new fighter may be less critical to mission success abroad as compared to at home.

Capability is Relative. Without question, past findings reinforce the need for a manned fighter replacement. CFD assesses that the *relative levels* of present capability would suffice as an operational baseline moving ahead. Maintaining these relative levels into the future will demand a higher performing replacement fighter compared to the CF188. This is especially true considering the replacement fighter's estimated life expectancy measured in decades. Present day unmanned technologies are not assessed as sufficiently mature for consideration as a CF188 replacement in the 2020s leaving a manned fighter aircraft as the only viable near term option. While the current capabilities of the CF188 are sufficient for the near-term, this 'capability baseline' is *relative* and will erode through the 2020s as technologies and the military capabilities of other nations and non-state threats improve. Beyond this timeframe, greater capability will be required or mission risks will increase.

In summary, this report recommends that Canada replace the CF188 with another manned fighter aircraft.

CHIEF OF FORCE DEVELOPMENT MISSION NEEDS REPORT - EVALUATION OF OPTIONS TO SUSTAIN A CAF FIGHTER CAPABILITY

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OVERVIEW

Orientation

This report is written by Canadian Armed Forces (CAF) officers who serve in the CAF Chief of Force Development (CFD) organization; military practitioners from a range of backgrounds whose task is to provide advice to leaders on options in conceiving, designing and building future capabilities, from five to 30 years hence. Force Development is a combination of military art and science. It is military art because, like the application and management of violence itself, force planning has no precise outcomes templates nor can the future be predicted with certainty. However, rigor of analysis is possible when military experts a) work with Defence Science and Technology (S&T) experts, and b) are also informed by academic communities and allied experts. Force development advice is determined by informed assessments (the science) and judgments (the art) on future capability requirements.

Force developers offer evidence-based decision support to senior leadership in the difficult choices they face. This is now done using a widely accepted method called Capability Based Planning (CBP).[1] Capability Based Planning places the central focus of attention on capability, or the ability to achieve a desired end result. A capability is derived from combinations of individual platforms (a tank, a fighter, an air-to-air refueller, etc) employed by military practitioners in appropriate ways (depending on the desired objective and prevailing conditions) and which form a system of systems.

[1] Capability Based Planning's (CBP) predecessor was Threat-Based Planning (TBP). Instead of looking at a range of possible futures to inform capability choices as CBP does, TBP was more linear. In an era where bi-polarity existed, TBP identified opponent threat systems and developed platforms to match, defeat or overcome those systems. The Soviet Union's mass of T-72/80 tanks resulted in the development of Apache attack helicopters and the M1 Abrams main battle tank. The Canadian Forces used TBP for the better part of a century, shifting to CBP in 2000. CBP is at the point now of becoming fully internalized and understood within the military and defence enterprise.

Capability is defined as "…the combined effect of multiple inputs. It is not the sum…but the synergy…that determines the level of capability."[2] Force Developers using a CBP approach develop a rich understanding of what will need to be achieved in the future and the choices available to achieve that end. This involves analyzing policy to determine future capability delivery and, from there, working back to derive the changes required to adjust the force accordingly between now and that future. This offers a different perspective to that taken by those seeking to sustain or enhance current systems and the means to achieve the results required by Canadians.

Aim

The aim of this report is to assess the CF188 replacement mission needs in the context of probable mission requirements (threats, environmental factors and expected military outputs). To do this, the Chief of Force Development (CFD) leveraged a substantial body of CAF-wide force development analysis conducted from 2011 to 2012 in the strategic capability portfolio review. The mission needs will be analyzed through the lens of Force Development (FD) scenarios used in Capability Based Planning (CBP) which span the *Canada First* Defence Strategy's three roles and six missions.

Within CBP and through FD scenarios, a potential threat is considered from *capability*, *exposure* and *intent* aspects. Therefore, one considers what capability one might reasonably expect to encounter, the likelihood of exposure to this threat and, finally, the intent of potential adversaries. Capabilities can be understood using open-source and classified assessments. Exposure refers to the question 'if not domestic, will the CAF be required to operate there?' Intent is fundamentally important because, without higher order context, misleading conclusions can be arrived at concerning the depth and breadth of CAF capabilities required to safeguard Canada's interests moving forward. The basis for this context in assessing the CF188 replacement is the Chief of Defence Intelligence's assessment,[3] the CAF's Future Security Environment (FSE) publication[4] and supplementary Directorate of Capability Integration Futures Section material. An understanding of the threat, allied capabilities and the full range of other CAF capabilities defines the likely capability environment within which the CF188 replacement will operate. As the CAF's central FD authority, CFD is uniquely able to step away from single projects or platforms to see them in a broader setting; the value proposition of this report. It is important because of the sometimes overlapping effects that various platforms bring to operational missions. Expected military outputs relate to what is expected of the CF188 replacement.

The report is structured in five parts. First, the approach section describes the analytical methodology. The second section provides context in outlining the FSE, describing a scientific model of how past operations inform future likelihood, and arraying the scenarios across the spectrum of conflict. This section concludes with common allied trends and sets the overarching context for understanding mission needs. Section three summarizes the mission needs analysis and section four provides

[2] Dr Ben Taylor. *The Technical Cooperation Program (Australia, Canada, New Zealand, United Kingdom and United States of America): Analysis Support to Strategic Planning*. October 2012, 20.
[3] Chief of Defence Intelligence. *CF Fighter Capability Intelligence Assessment* (UNCLASSIFIED). 4 January 2013.
[4] Canadian Forces Publication. *The Future Security Environment 2008-30*, Chief of Force Development. (Unclassified) 27 January, 2009.

additional analysis on the factors of threat, balance, flexibility and risk. Section five concludes the paper.

This report thus assesses the CF188 replacement requirements (mission needs) at the strategic and operational levels in the context of future threats. The focus will be on operational level military requirements in a joint context – specifically, the applicability of a fighter capability to the *Canada First* Defence Strategy missions. Task 2's mission needs analysis will be informed by Capability Based Planning documents, Task 3's assessment of a fighter capability at the tactical level and Task 1's threat analysis emphasizing technological trends as well as geo-political and proliferation intents. In doing so, CFD does not comment on individual fighter platform options. Rather, CFD attempts to define what the fighter should be expected to achieve as part of the Canadian Armed Forces, both at home and abroad.

Section 1 – Analytical Methodology

Approach

Capability Based Planning is a systems-based analytical method that answers three simple questions:

- What do we think we will need to do?
- How well do we think we can do it with what we have now?
- What do we need to change to do it better?

To arrive at these answers, a three-step approach is used:

- Step One. Defines Canadian Armed Forces (CAF) capabilities from their largest building blocks down into progressively more detail to allow substantive deductions to emerge. This construct is known as the *CAF Capability Framework* (extract at Figure 1). It allows a systems approach when considering individual platforms. It begins at Tier 1, in this case "Capabilities in the Aerospace Environment" then considers in Tier 2 the different aerospace capabilities needed in the conduct of military operations (i.e. "Air Force Aerospace Control"). Lastly, Tier 3 further apportions different activities such as "Offensive Counter Air" which is the last useful level for strategic force developers to consider. Going into greater granularity enters into the domain of the environmental force development system; in this case, that of the Royal Canadian Air Force.

TIER I	TIER II	TIER III
Capabilities in the Aerospace Environment		
	Air Force Aerospace Control	
		Defensive Counter Air (DCA)
		Offensive Counter Air (OCA)
	Air Force Aerospace Force Application	
		Strategic Attack

Figure 1: The CAF Capability Framework (extract)

- Step Two. Applies the CAF Capability Framework as depicted at Figure 1 to force development scenarios that define the desired outcomes of any given mission. In other words, Chief of Force Development (CFD) uses this framework in the analysis of every CFDS mission. The force development scenarios provide *context* to the capability framework analysis and are fictional future operational constructs set in the real world. Each capability is then ranked into four broad groupings:

Mission Critical. A capability that delivers a direct effect as part of its primary function. This effect is evaluated as critical to mission success and will pose severe risk to mission success if it is not employed.

Mission Essential. A capability that is an essential enabler to Mission Critical capabilities; the lack of one or more Mission Essential capabilities will pose risk to mission success.

Mission Routine. A capability that is required for the mission but has either a routine supporting function or a very low likelihood of employment. Only in cases where multiple Mission Routine capabilities constitute a systems failure will any significant risk be posed to the mission.

Not Allocated. A capability that is evaluated as not required for the particular mission being considered in the context of the scenario.[5]

- Step Three. Assess the *current* CAF's ability to meet future capability requirements. It should be noted that, for the purpose of CBP, the current CAF portfolio includes what the CAF currently operates and what is in the Defence Services Programme to be acquired within the next 20 years. Accordingly, our assessment incorporates ships, vehicles, and aircraft we do not yet possess but for which Chief of Force Development (CFD) has mandatory capabilities; these form the basis of our projected assessments. This step requires that CFD assess capabilities as they would be employed in operational circumstances; not as an individual platforms or small units, but as part of a system of systems. This step also requires consideration of the three broad phases of mission employment, namely the shaping, surge and sustained operations phases.[6] Accordingly, force packages are created, such as a Canadian Joint Task Force in the case of Afghanistan circa 2009, with land and air forces. These are made of individual Force Elements such as an infantry company, a flight of fighters, a combat service support theatre activation element, etc. Using these building block organizational structures, Step 3 concludes with a diverse group of military defence analysts and science and technology experts assigning a colour coded system which defines each capability's assessed ability to meet the needs of future missions:

  Blue. A capability surplus to the mission requirement exists. This indicates areas of affluence that could potentially be scaled down to allow for investment opportunity elsewhere.[7]

[5] CFD used eight scenarios, approved by the Chief of the Defence Staff in 2008, for this analysis. Each scenario had several vignettes; sub-scenarios that served to add variations and depth to the scenario which provide a more fulsome examination of capabilities.

[6] Shaping activities relate to DND's Global Engagement Strategy and the military activities that support positively influencing pre-crisis outcomes in various areas of the world. Whether through Military Attachés or the Military Training Assistance Program, shaping activities can occur long before any crisis occurs, if at all. Other shaping activities can include overt displays of military capability to signal national intent and resolve. The Surge phase relates to military intervention in a hostile, fragile, failing or failed state and denotes operations designed to achieve the conditions to either quell the political problem or for follow-on forces to arrive. The Sustained operations phase denotes longer duration operations, usually involving land forces, aimed at achieving a level of security and stability to allow local governance to take root.

[7] Chief of Force Development's strategic analysis and recommendations offer areas of *Investment*, *Sustainment* or *Divestment* for leadership to consider. An *Invest* area, from a CAF capability perspective, represents the creation of an entirely new capability or significant enhancement of an existing one. *Sustain* areas consist of Life-Cycle-Management, replacing like-with-like and a wide array of custodial functions required in keeping a capability fielded. The majority of CAF capabilities tend to fall in this category.

Green. No risk of failing to meet mission requirement exists.

Yellow. A moderate risk of failure to meet mission requirement exists. This is because of either a lack of output capacity or an ad-hoc formulation and delivery of a capability.

Red. A high risk of failure to meet mission requirement exists. This is due to a lack of the entire capability in the CAF inventory or a deficiency of capacity to meet the expected demand.

After examining the detailed layers of the Capability Framework in Steps 1, 2 and 3, the assessment is then rolled back upward to the Tier 1 level by rendering an assessment of how each Force Element, (in this case a flight of six fighter aircraft) viewed in a systems-based manner, contributes to each capability area. From there, further analysis allows for measuring how each Force Element impacts or contributes within a capability area. This is done by also looking at other Force Elements in the Canadian Armed Forces (CAF) portfolio that might perform a function to deliver an effect in lieu of the fighter (i.e. a missile fired from a ship against aircraft or land targets as opposed to a fighter engaging those targets). This aggregate system of systems analysis allows for a big picture contextual risk assessment to be made in relation to each mission, then to the CAF as a whole.

The analysis in this report is limited to the capability areas to which the CF188 replacement contributes. The following capability areas are relevant to analysis of a future fighter capability:

- Aerospace Control

  Defensive Counter Air (DCA). Includes all measures designed to nullify or reduce the effectiveness of hostile air action. Operations conducted to neutralize opposing aerospace forces that threaten friendly forces and/or installations through the missions of Combat Air Patrol (CAP), Escort (ESC) and Air Intercept (AI).[8]

  Offensive Counter Air. Operations mounted to destroy, disrupt or limit enemy air power as close to its source as possible. This includes tasks such as Surface Attack (SA), Suppression of Enemy Air Defences (SEAD) and Sweep (SWP).[9]

  Strategic Attack. Capabilities that aim to progressively destroy and disintegrate an adversary's capacity or will to wage war (as seen in the initial phases of both United States-led campaigns in Iraq). Such missions are normally conducted against the adversary's centre of gravity (i.e. those targets whose loss will have a disproportionate impact on the enemy, such as national command centres or communication facilities).

Divest areas are those assessed as either not required for the future or areas to consider if resources do not allow for sufficient investment, based on evolving capability needs into the future.

[8] *Out of the Sun: Aerospace Doctrine for the Canadian Forces*, 20 July 1997. CAP is defined as "to defend (point, barrier, lane or area) friendly surface-based forces against attack by opposing aerospace forces." ESC is "to defend airborne friendly forces against attack by opposing airborne forces" and AI is "to intercept opposing aerospace forces conducted from alert facilities, airborne CAP, or diverted from other missions."

[9] *Ibid.* SA targets the source of an adversary's aerospace power including warning and control facilities as well as aerospace base and launch facilities. SEAD targets an adversary's aerospace defence systems and SWP targets adversary aircraft or targets of opportunity in an allocated area of operations.

- Land Effects - Firepower

  Close Air Support (CAS). Air attacks against targets which are so close to friendly ground forces that detailed integration of each air mission with the fire and movement of those forces is required.[10]

  Land Strike. Counter-surface operations using aerospace power, in cooperation with friendly surface and sub-surface forces to deter, contain or defeat the enemy's land and maritime forces in the littoral.[11]

- Maritime Effects

  Tactical Air Support to Maritime Operations (TASMO). Using aircraft, not integral to the requesting unit, tasked to provide air support to maritime operations.[12]

- Intelligence, Surveillance and Reconnaissance (ISR). The activity that synchronizes and integrates the planning and operation of all collection capabilities, with exploitation and processing, to disseminate the resulting (i.e. decision-quality) information to the right person, at the right time, in the right format, in direct support of current and future operations.[13] Unmanned Aerial Vehicles (UAVs) often have ISR collection as their primary mission but fighters (as well as other aircraft) can collect, through sensors or the pilot, as a tertiary benefit to a primary mission. The line between fighter and ISR UAV continues to blur with the former mounting more formidable sensors and the latter being armed.

The CF188 replacement was assessed against all six CFDS missions using the following Force Development scenario sets as depicted.[14] They were as follows:

- CFDS Mission 1 - Conduct daily domestic and continental operations, including in the Arctic and through NORAD;
- CFDS Mission 2 - Support a major international event in Canada;
- CFDS Mission 3 - Respond to a major terrorist attack;
- CFDS Mission 4 - Support civilian authorities during a crisis in Canada such as a natural disaster. (This was analyzed together with CFDS Mission 2 understanding the fighter's role in this mission is generally minor);
- CFDS Mission 5 - Lead and/or conduct a major international operation for an extended period. This was analyzed through the following sub-mission scenarios:
  i. Mission 5a – Peace Support Operations – In peace support operations, a fighter capability was assessed as not applicable;
  ii. Mission 5b – Peace Enforcement Operations – The scenario used portrays CAF elements conducting a stabilization mission in a failed state in the Horn of Africa where the preponderance of threats are below the state level; and

[10] *Ibid.*
[11] *Ibid.*
[12] *Ibid.*
[13] Vice Chief of the Defence Staff. *Intelligence, Surveillance and Reconnaissance Operating Concept* (Final Draft 1.0), dated 26 September, 2012.
[14] Some of these missions (e.g. Mission 3) were analysed considering both domestic and overseas activities.

iii. Mission 5c – Regional Conflict Operations – This scenario involved state-on-state conflict erupting on the Korean Peninsula where the CAF participated as part of a coalition operation.

- CFDS Mission 6 - Deploy forces in response to crises elsewhere in the world for shorter periods.

Section 2 - Context

The Future Security Environment

The aim of the Future Security Environment (FSE) is to identify the challenges Canada might face as opposed to what Canada will need to be able to do in the future. The FSE describes a future operating environment inherently challenging to military forces.[15] Analysis of the trends likely to affect the FSE indicates the period up to 2030 and beyond will be one of transition characterised by both high levels of instability in many regions of the world and an increased presence of non-state actors. Canadian Armed Forces (CAF) capabilities should be contemplated within that overarching paradigm (which is significantly different than that of the Cold War era) when planning against a single well defined and well understood threat prevailed. The variables facing force developers today and tomorrow are more numerous and challenging in their disparity than was the case during the Cold War.

International stability could be threatened by many factors; the most significant include poor or weak governance, global economic disparity, rapid population growth, increased resource scarcity, extremism, the proliferation of advanced weaponry (potentially including Weapons of Mass Destruction), criminal organizations and the unpredictable future effects of climate change. Concurrently, the international environment will continue to adjust to a rebalancing of geostrategic power as the world is likely to move away from a uni-polar world dominated by the United States (US) to a multi-polar world. The application of all instruments of national power (Diplomatic, Information, Military and Economic) will remain critical to providing the ultimate guarantee of a nation's security. Given Canada's position as an international actor with national interests, it is almost certain that the CAF could be required to deploy around the globe, often to unstable areas of the world, to contribute to the achievement of Canadian strategic and foreign policy aims. To be able to project effects, the CAF will require global capabilities such as global C4ISR, access to basing and strategic lift. The US will most likely remain the pre-eminent military power in the coming decades capable of projecting power into every region of the globe and the CAF will likely continue to conduct expeditionary operations predominately in a coalition context. Economic constraints will require careful evaluation of scope and scale of core capabilities. In an expeditionary context, it is impossible to foresee with certainty the geographic regions and environments within which the CAF will be required to operate. However, the CAF must be capable of operating within the complete range of environments present within Canadian territory.

Domestically, the direct conventional threat to Canada is assessed to remain low.[16] The CAF will continue to be called upon to support civilian authorities in response to natural disasters, terrorist attacks, outbreaks of infectious disease or to help provide security for high profile international events. The CAF's domestic tasks, such as North American Aerospace Defense (NORAD) commitments and Search and

[15] *The Future Security Environment 2008-30*, Chief of Force Development. 27 January, 2009. Updated analysis was used to inform the 2011/12 round of CBP which incorporated Allied analysis and additional sources published since 2009. The updated version included in the CBP final report dated June 2012 was endorsed by the Chief of the Defence Staff on 20 June 2012.
[16] Chief of Defence Intelligence. *CF Fighter Capability Intelligence Assessment (*UNCLASSIFIED). 4 January 2013, 5.

Rescue operations will continue to be non-discretionary. Canada and the US will continue to have an intertwined continental defence and security partnership. Within a continental context, the CAF must maintain interoperability with the US armed forces to fulfil the NORAD mandate. Moreover, in order to achieve efficient continental defence, this interoperability must not be centred on a specific service but across all environments and domains (e.g. Air Force, Navy, Cyber, Space, etc). Canada must ensure that future CAF force development, while fulfilling NORAD requirements, maintains the ability to enforce and ensure Canadian sovereignty without an enduring dependency upon US capabilities. As well, the changing environment in the Arctic is likely to lead to increasing economic activity and international interest in the region, especially on the part of other Arctic nations. This will grow the requirement for measures to ensure that Canadian sovereignty and rule of law in the Arctic are both demonstrated and maintained.[17] The convergence of transnational criminal and terrorist activities could further influence the need for military specific support to the civil authorities as such activities could provide a diverse range of threats.[18]

What the Past says about Potential Future CAF engagements. The Future Security Environment (FSE) analysis suggests that events which could elicit future Government of Canada decisions to employ instruments of national power, especially the military, are on the rise in terms of frequency. Historical analysis also provides a powerful and relevant tool to inform assessments of possible future CAF employment.

To provide an estimate of how often and for how long the forces are likely to be used, Canadian Armed Forces (CAF) operations from 1945-2011 were examined. This is because the breadth of those missions spanned what the CAF considers today as the *Canada First* Defence Strategy's (CFDS') three roles and six missions. The operations were assessed for size, scope, purpose of force employment, and timeline. Over 600 individual CAF operations were found. The list was filtered down to 333 significant operations[19] that were then categorized according to the six CFDS missions.

To provide meaningful metrics, the annual frequency of occurrence for each scenario was computed by dividing the number of occurrences of associated past CAF operations observed by 67 years (1945-2011, inclusive). For the duration of each scenario, the minimum and maximum durations were recorded.

These representative scenarios were then modeled in Tyche, a stochastic[20] scheduling model in which CAF deployments are generated randomly over a five year time period based on provided data on likelihood and duration. Tyche randomly generated 1,000 five-year simulations using scenario frequencies and expected duration derived from historical data of past CAF missions between the years 1945-2011. Sensitivity analysis was subsequently done on just the data from the post-Cold War era, 1990-2011. The operational schedules produced by the model allow the

[17] *Ibid,* 4.
[18] *Ibid,* 5.
[19] A "significant operation" was defined as one that had assigned to it, overall; 20 or more CAF personnel or a major CAF platform (naval vessel, aircraft or a land vehicle).
[20] A stochastic model is one in which a degree of randomness is introduced to how some part of a system will perform. By analysing multiple runs of such a model, statistical data on the likelihood of certain occurrences, such as a disaster relief operation occurring while Canada hosts a major international event, can be obtained.

calculation of the percentage of time spent on different types of operations and of the probability of one or more events occurring at the same time. The analysis results provided through this Tyche study[21] provide insight as how much demand would be placed on the CAF in the future given that trends can be relied upon, to some degree, as indicators of future likelihoods. Tyche suggests domestic missions will occur frequently; every year or two. From an expeditionary perspective, Tyche results suggest that Canadian involvement in future state-on-state conflicts will be exceptionally unlikely (no occurrences in the modeling).[22] What are far more likely are military engagements in the space on the spectrum of conflict in between clearly defined state-on-state warfare and humanitarian assistance missions. These occurred once every 1.7 to 2 years in the model with escalating regional conflicts with small nations occurring every decade. It can be argued that expeditionary operations are more discretionary than not but, for the purposes of this report, the assumption is that the CAF must stand ready to credibly serve Canada's interests internationally. The Chief of Force Development remains silent on the matter of policy choice. Tyche analysis reinforces FSE trend assessments that military capabilities will likely be required more often, both domestically and internationally; the latter being predominantly within a coalition context.

The Force Development Scenarios. Scenarios are used to render capability assessments within Capability Based Planning. Those used in support of ongoing force development activities and this report are a set of eight approved by the Chief of the Defence Staff in 2008 (Figure 2). The scenarios are situated within what military practitioners refer to as the 'spectrum of conflict'. This is not to suggest baseline domestic missions occur within a conflict; they do not. But the use of a continuum is useful in visualizing the disparate range of activities the CAF may be called upon to execute on behalf of the Government of Canada and Canadians.

[21] Defence Research and Development Canada. *Scenario Frequency and Concurrency Analysis Report*. (In support of Chief of Force Development's Capability Based Planning Spiral 1 Activities 2011/12). dated 16 May, 2012.
[22] *Ibid.*

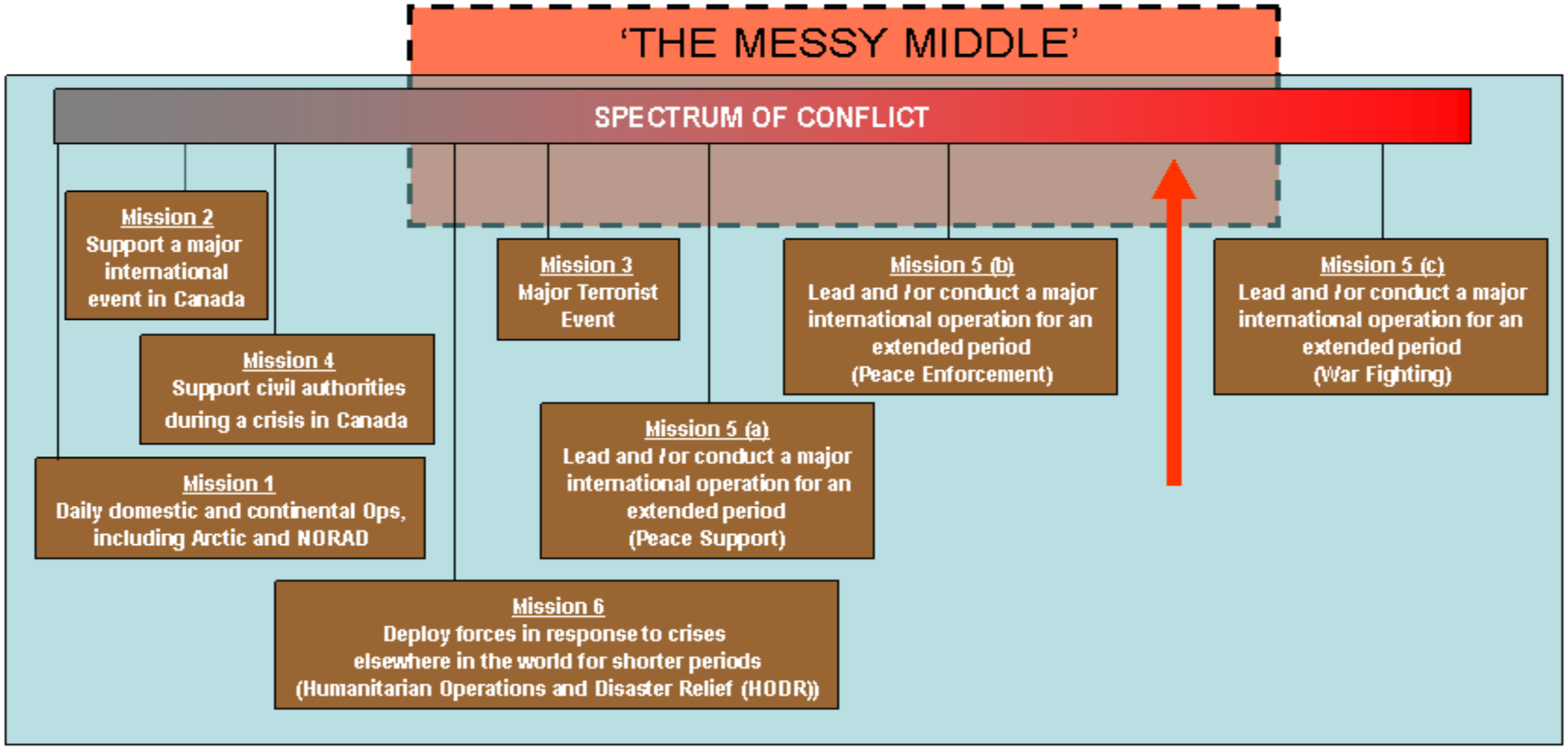


Figure 2: Force Development Scenarios on the Spectrum of Conflict

The scenarios provide a number of realistic, plausible and challenging operational problem sets to assess Canadian Armed Forces (CAF) performance over a number of time horizons.[23] Conceptually, each scenario is positioned along the spectrum of conflict continuum, ranging from peacetime day-to-day operations in Canada to near peer State-on-State war fighting operations, in order to replicate the full array of challenges in which the CAF must be able to succeed. It should be noted that the extant scenario set features no expeditionary exclusive-to-fighter scenario or vignette (i.e. enforcement of a no-fly zone). That said, the defence of Canada mission undertaken by the fighter is an informative surrogate for the purposes of this analysis.

The *Messy Middle* indicated on the graphic at Figure 2 is an area that lies at the centre of the spectrum of armed conflict where there are challenging military missions that can be difficult to characterize. The development of the concept reflects Future Security Environment analysis that conventional conflicts seeking the decisive defeat of a near peer state have largely given way to punctual or protracted engagements involving non-state opponents who are difficult to identify and even harder to fix in time and space. Such operations feature relatively opaque military end states with success often more definable in host nation governance and self-sufficiency terms. Evolving global trends point to a security environment where a Hybrid Warfare[24] type conflict will persist as the dominant form of military employment. Such environments call for tightly-coupled military effects. It follows that force development staff officers strive to define the best CAF capability and structure balance within the context of a *jointly-enabled*[25] force to succeed in the most challenging portion of the *Messy Middle* (as indicated by the red arrow on Figure 2). This approach is different to one that contemplates future capabilities and structures optimized for success in Full Spectrum Operations war fighting (i.e. State on State industrial warfare in a classical sense). Put simply, a force designed to win in a regional conflagration involving peer or superior forces is subtly but significantly different than one optimized for an Afghanistan or Libya Messy-Middle type operations. The latter are so complex that the long-held axiom of "training for war and scaling back for operations less than war" no longer holds. To be successful in the Messy Middle, a force must have a Hybrid Warfare type conflict as its developmental reference point. This does not imply the force cannot perform in full spectrum war fighting but it does accept to manage certain risks in that very low probability space. It must be noted that the primacy of success of the domestic mission-set remains intact.

While the likelihood of having to conduct five or six dissimilar major *Canada First* Defence Strategy (CFDS) missions concurrently is extremely unlikely, the CAF must be able to participate in multiple missions (potentially the same type) at the same time.[26] This suggests that force developers remain mindful to offer carefully calibrated force

[23] Horizon 1: 0-5 years, Horizon 2: 5-15 years and Horizon 3: 15-30 years.
[24] For the purposes of this report, the term 'Hybrid Warfare' is used to illustrate the blending of conventional and irregular (or asymmetric) approaches across the full spectrum of conflict. According to current Western military thought, the overarching implication is that Hybrid Warfare is not new, but that Western militaries traditionally equipped and trained for bespoke conventional state-on-state conflict must become more flexible and adaptable if they are to achieve mission success in the future operating environment.
[25] The Jointly-enabled Force or Joint Force refers to military outputs that call on more than single Service (Navy, Army or Air Force) outputs. *Joint* therefore refers to seamlessly delivering and accepting military effects across Service lines and this requires high levels of inter-Service integration. Any reference to *Combined* operations refers to the same notion but across different militaries (i.e. the CAF and US military). The term 'coalition' explicitly refers to the ability to conduct combined operations.
[26] Government of Canada. "*Canada First* Defence Strategy". June 2008, 3.

capability and design recommendations that respect the primacy of domestic missions while recognizing the need for capability choice for expeditionary engagements which are important Canadian contributions on the world stage.

Allies. Canada is not alone in undertaking efforts to determine the appropriate balance of military capability to respond to future demand. Key Allied trends and trajectories distilled from issued national strategic guidance provide significant similarities concerning future capability requirements. The similarities of trends and trajectories align in a number of areas; the need to ensure affordability moving forward, the requirement to retain a qualitative capability edge in light of future forecast military threats, the need for flexible and adaptable capabilities and structures, an emphasis on developing an improved joint force capability, and the desire for burden sharing between nations. Within this context (as well as within wider national political and industry requirements), each nation continues to reassess the role of its fighter aircraft within its capability portfolio based largely on budgetary pressures and the requirement to replace, in a timely manner, current fleets that will themselves operate for decades.

Section 3 – Mission Needs Analysis Summary

It is important to understand the Canadian Armed Forces (CAF) capability portfolio as a broad system of systems that defence seeks to align, in relative symmetry, to an affordable level of CAF capability ambition. In some cases, this implies investment into new capability frontiers such as cyber and Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR). In others, it means modernizing that which we already have. The Capability Based Planning assessment conducted in 2011-2012 has been revisited to draw out lessons specific to the CF188 replacement.[27] This section presents the key messages distilled from that assessment against the *Canada First* Defence Strategy's (CFDS') three roles and six missions.

CAF Fighter Aircraft As An Overall Capability Requirement

The Capability Based Planning analyses make it clear that Canada and the CAF require a fighter aircraft as a key component of the CAF's system of systems that will deliver effects in future missions. It is irrefutable that a Canadian fighter is inherently critical to the protection of Canada's sovereignty and to bi-national treaty obligations under North American Aerospace Defense Command (NORAD). No other platform can accomplish this task in the near to mid-term.

Manned or Unmanned. Unmanned Aerial Vehicle (UAV) technology has advanced in recent years and they have demonstrated their value in a variety of operations. They have been used by Canada, for example, to conduct Intelligence, Surveillance and Reconnaissance missions both domestically and internationally and our Allies have deployed UAVs to carry out precision strikes against ground targets in a limited range of tactical environments. The UAV technology is such that they can be controlled remotely or be programmed to carry out specific tasks.

Our Allies continue to invest in UAV technology, research their potential use and we continue to track their development as we believe that this technology shows great promise for the future.

For the foreseeable future, however, UAVs do not have all of the capabilities required to replace a manned fighter aircraft and are not a viable solution to replace the CF188. It cannot, for example, operate in an air-to-air combat situation. Even though it can be remotely controlled, it lacks the speed, range, agility and defensive systems to be effective in that role and would be highly vulnerable in a combat aerospace environment. In most military environments, the UAVs' ability to attack specific targets is also limited. Their software systems are not yet sufficiently reliable to accurately identify a target; decide whether to engage a target; assess the situation following an attack; or make tactical decisions in a combat environment. In short, UAVs are not advanced enough to provide the same level of flexibility of manned aircraft in combat environments.

[27] The CBP assessment covered the entire CAF capability portfolio; 11 Tier One capabilities, 39 Tier Two capabilities and 101 Tier Three capabilities. This 2011/12 assessment did not look at the fighter more than any other bespoke platform. In producing this report, all assessment phase material was re-examined pulling out fighter-specific data and, more importantly, fighter-specific trends in a broader context.

Technology cannot substitute a pilot's real-time on-board ability to be aware of rapidly evolving situations. Humans are better placed to make rapid, real-time judgments. They remain critical to carrying out domestic and continental Defensive Counter-Air (DCA) missions as well as reliably delivering Offensive Counter-Air (OCA) or air-to-ground kinetic effects in a demanding expeditionary high-threat war fighting environment.

Given this, an unmanned capability could not meet, out to at least 2030 and likely well beyond, the mission critical tasks required of the replacement for the CF188. Therefore, it is assessed that the CF188 replacement must be manned to meet the critical demands of domestic sovereignty and continental defence obligations and to provide an adaptable expeditionary air power option.

> Canada must possess a manned fighter

The Capability Challenge. These observations establish that a future Canadian Armed Forces (CAF) fighter aircraft force element will be an important requirement in a future CAF. Capability Based Planning (CBP) suggests it will be used often and, when it is employed, it will be in capabilities that are critical to mission success.[28] It is assessed with a very high level of confidence that the CAF will require a fighter force element in the future (2020-2030+), driven by the sovereignty and NORAD missions but also germane in an expeditionary context. It is unrealistic to conceive acquiring a new fighter aircraft that will be in service for over three decades and not seek a platform that is capable beyond the CF188 on the date of purchase; the salient question being, "by how much and in what areas?" While recognizing that CF188 is clearly approaching its Estimated Life Expectancy, this suggests a balanced approach to the nature of investments in the replacement aircraft.

> Through the 2020s, the CAF fighter will need increased capabilities to maintain relative capability against future threats

Observations on Employment

To visualize the fighter's employment, Force Development staff use a qualitative system of measurement criteria called Measures of Capability (MoCs).[29] It is the

[28] The predominant role for the CF188 replacement will be domestic in nature. Not only is some 90% of its *historic use* since 1990 related to domestic or continental missions, CBP suggests that, within that frame, about 80% of its capability output (or utility) relates to the Aerospace Control function, in particular Defensive Counter-Air (the ability to protect Canadian sovereign airspace). Domestic Defensive Counter-Air is also projected to remain, with high confidence, the CAF Fighter's most critical role making it a *mission-critical* unit within the CAF.

[29] Chief Force Development. *Capability Based Planning Handbook*. v6.3, 15 January 2011, Art 943.

balance of these individual characteristics that determine the usefulness of the Force Element within a system of systems to produce capability. Force development analysis favours Force Elements that are both effective and efficient. A *best-fit* is a Force Element that can meet the MoC requirement (is *effective*) without being under or over-engineered (e*fficient*). Achieving this balance in the realm of military affairs, where liabilities potentially translate into lost lives, is inherently challenging and requires a careful blend of professional military judgement (art) and modelling (science). For the CAF Fighter Force Element, the following criteria are considered:

- Lethality. The ability of the Force Element to detect, target, engage and destroy threats. With respect to the Capability Based Planning (CBP) process, this is considered in conjunction with threat types and the levels of precision/low-yield weaponry required to minimize collateral damage when required;
- Survivability. The ability to sustain operations within the mission operational area. This considers opponent's threat capability and environmental threats to a Force Element as well as its ability to withstand them;
- Reach. The ability of a Force Element to operate autonomously at distance;
- Persistence. The operational endurance of a Force Element. With respect to the Canadian Armed Forces (CAF) fighter platform, this MoC is in relation to the aircraft's ability to endure while airborne;
- Responsiveness. The ability to be effective when and where required. This includes the agility of the Force Element to change tasks (tempo) and re-orientate in mid-operation (synchronization);
- Interoperability. This describes a Force Element's ability to operate and share information. In the context of a mission, this could include other CAF Force Elements (i.e. air-to-air refuellers) and headquarters, other governmental departments and allied forces (principally the United States in a NORAD context but also for coalition operations); and
- Awareness. The ability to gather, fuse and display information. This addresses the 'sense' ability of an aircraft where a myriad of sensors gather information across different domains. Within the context of the mission, this information could be military-specific information or environmental type data.

This report cannot precisely ascribe Measure of Capability (MoC) weighting based on CBP results alone. It can be done, however, with the MoC weighting of individual contender aircraft at Task 3. These MoCs, as they relate to specific CFDS missions, will then be applied as a metric to any CF188 replacement options using a mission-by-mission weighting system.[30] It is this MoC analysis work that will fuse, rationalize and align the tactical and operational mission needs. For the purposes of this analysis, the use of the CAF Fighter Force Element can be broken into two broad areas; domestic and expeditionary.

[30] For example, Defensive Counter Air (DCA) in a CFDS Mission 5, Coalition Full Spectrum Operations State-on-State War fighting context, would receive a very high rating for Lethality. The same DCA mission in support of CFDS Mission 2, support to a major international event such as the Olympics, would assign a lower Lethality weighting.

Domestic Employment. There exists a useful difference of perspective between tactical employers of fighter aircraft and strategic joint force developers on the question of risks to domestic sovereignty. This healthy tension is normal and, indeed, desirable. The Chief of Force Development (CFD)'s challenge function allows tactical employers and strategic joint force developers to compare and contrast their particular risk assessments, allowing both to test their assumptions and seek out common ground. With respect to the domestic mission, the common ground centres on the fact that the protection of Canadian sovereignty is non-discretionary and, hence, the first order driver for the aerospace defence capability. Figure 3 below illustrates, in a representational way, the decision space facing developers of the aerospace defence capability. From the top left to right, three possible future contexts for the employment of the capability are set out, labelled *Sovereignty Pressured*, *Sovereignty Challenged* and *Sovereignty Attacked.* The lower part of the Figure comprises three small graphs that characterise these contexts in terms of hostile capability and intent. The left-most graph describes a context where those who have intent to challenge Canadian security have little or no capability to do so. The middle graph shows intent and capability as more balanced while still acknowledging that states with the highest capability sophistication and mass have minimal malign intent to attack Canada. The right-most graph shows a different context where a combination of military capability to attack is combined with the intent to do so.

The left-most context, *Sovereignty Pressured*, depicts the generally accepted Chief of Defence Intelligence and Future Security Environment posture of the future – where periodic fighter Force Element effects are needed to enforce sovereignty. This is where, historically, CFDS missions 1 and 2 have all occurred.[31] This context is assessed as the most likely future on which to base force development decisions. The middle context, *Sovereignty Challenged,* represents the trade space where some additional level of aerospace defence capability beyond the current levels needs to be developed as a hedge against the generally unlikely, but not impossible, eventuality of a sophisticated threat emerging. The shaded area in the bottom middle graph illustrates trade-space beyond the CF188's capabilities accounting for additional capability flexibility, changes within the Arctic, qualitative advances in opponent technology, shifts in geo-political intent, attainment of certain 'state-like' capabilities by non-state actors, etc. The *Sovereignty Attacked* context, where an aggressor can (and likely would) send significant numbers of sophisticated platforms against Canada, represents a context so far beyond the assumptions of *Canada First* Defence Strategy (CFDS) as to not be a credible basis for force development. Such a future challenge would bring about a complete shift in Canadian and United States defence planning.

[31] It can be argued that the events of 9-11 in the United States moved into the "Sovereignty Attacked" realm. While it is recognized that the CAF fighter response to those events under the aegis of NORAD placed the strategic condition in this country into the "Sovereignty Challenged" space, it does not detract from CFD's assertion that the dominant and most likely domestic future will remain "Sovereignty Pressured".

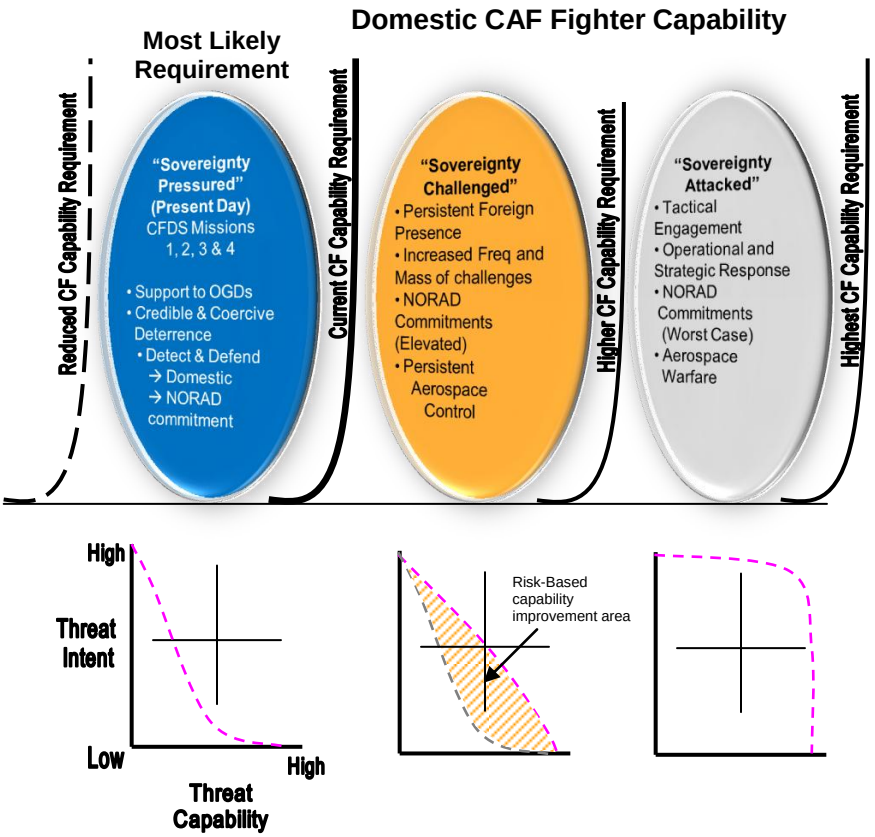


Figure 3: Domestic Threat and Capability Mapped to Operating Environments

Chief of Force Development's perspective is that 'Sovereignty Pressured' will remain Canada's dominant strategic environment for the coming decades and the CF188's capabilities are assessed as suitable to fulfil that mandate going forward. But time will negatively encroach on this assessment of capability suitability. Further technological developments, combined with an inability to confidently predict future geo-strategic conditions, imply the need to carefully consider capability enhancements to the CF188 replacement issue. This is graphically portrayed in the shaded area in the bottom centre graphic at Figure 3. Moving beyond that area of capability improvement into capabilities congruent with a 'Sovereignty Attacked' environment induces several issues. First, the cost of moving to a significantly higher level of capability requirement would have major consequences for all the enabling components of the aerospace control system of systems with the attendant diversion of resources from elsewhere in the capability portfolio. While national sovereignty is a *prima facie* capability concern, Canada is uniquely placed to consider assuming *some* risk against a higher level domestic challenge because of our bi-national collective defence posture for continental defence. The consequence of focussing on the most-demanding/most-dangerous tactical scenario is that it could lead to disproportionate investment into a tactical solution that does not meet the full breadth of the operational/strategic challenges faced in the assessed most likely environment and places pressures on other Canadian Armed Forces (CAF) high priority capabilities. Like all strategic decisions, it is informed by accepting risks on a balance-of-probability basis. An asymmetric approach to force development privileging bespoke platforms risks justifying a tactical capability that

strategic and operational capabilities are unable to support in the larger context of the future operating environment.

Domestically, the CF188 replacement's role is, without question, fundamental to Canada's non-discretionary sovereignty mission. Capability Based Planning (CBP) identified the need for an interceptor-like aircraft with range, speed and endurance in plentiful supply to answer the military speed, time and distance problem when confronting moving threats. No combination of other Force Elements can be substituted to answer the role of an interceptor. But this must be viewed in the context of an airpower concept of operations that has distributed forward basing (basing across southern Canada and Forward Operating Locations in Canada's North[32]) to allow the fighter to conduct cued deployment more proximate to a perceived threat. To address domestic threats in layman's terms, the fighter needs to get to an area of interest, be on station, detect the threat and act. And that area of interest could include major cities near the 49th parallel or the far reaches of Canada's Western, Eastern or Northern approaches.

Operating at home or abroad,
no other CAF asset, alone or in combination,
can substitute in the role of
an airborne interceptor

It has been assessed that a less capable aircraft would impose significant risks and more advanced aircraft should be assessed on their performance relative to the CF188 to answer the question "how much more capability is good enough and how much is too much?" Several inter-dependent capability areas must also be considered in relation to the CF188 replacement. The delivery of highly precise kinetic effects in order to be a credible coercive force is also fundamentally important in this calculus. Moreover, air-to-air refuelling, ground control intercept and forward basing compatibility with a replacement fighter remain mission critical aspects of the DCA capability; mission critical in that we need direct access to those capabilities organically because we would use them frequently. In sum, a fighter is limited not only by its own characteristics but also by the availability of key enablers that allow it to fulfil its core task.[33] To this end, broad Canadian Armed Forces (CAF) capability symmetry is crucial. Shortfalls in any of these areas would compromise the CF188 replacement's ability to conduct tactical

[32] In support of the NORAD mission, the Royal Canadian Air Force maintains five Forward Operating Locations (FOLs) where it can deploy fighter aircraft to respond more rapidly to, or act in anticipation of, increased air activity. The FOLs are located in Inuvik, N.W.T.; Yellowknife, N.W.T.; Rankin Inlet, Nunavut; Iqaluit, Nunavut; and 5 Wing Goose Bay, Newfoundland and Labrador. Ref: http://www.rcaf-arc.forces.gc.ca/v2/page-eng.asp?id=1512 (accessed 25 January 2013).

[33] Air-to-air refuelling is separate but not separable from the question of the next fighter platform. Denying the ability to extend a fighter's reach in-flight in the context of Canada's vast landmass increases the time, speed and distance problem of the Defensive Counter Air mission.

response and pose elevated operational and strategic risks to the CAF and North American Aerospace Defense Command missions and Canada's national interests.

> The current CF188's relative capability level vis-à-vis the perceived threat remains sufficient into the 2020s

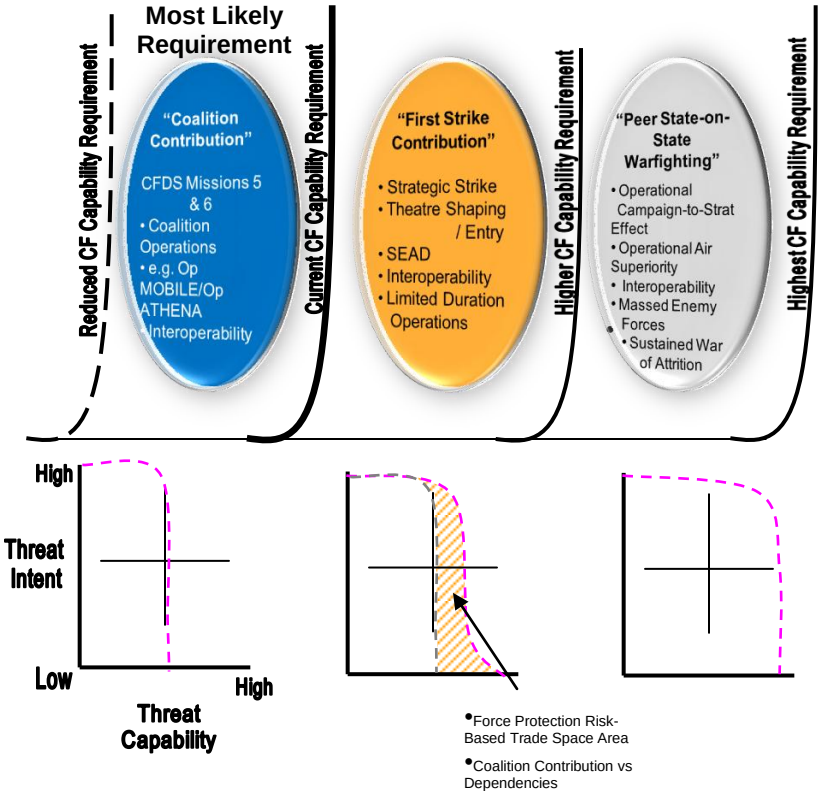
Expeditionary Requirement. The substantive discussion around the CF188 replacement must involve a nuanced appreciation for the fact that this platform will almost surely see action overseas at some stage in its life and, when combined with air-to-air refuellers, a fighter package is among the fastest-deploying capabilities in the CAF. This will entail substantial risks to the aircraft and its crew likely from air-breathing and ground-based systems; the latter being more sustainable and pervasive. Risks to human life and equipment in missions abroad are, and are assessed to continue to be, far more acute than in domestic mission sets. Figure 4 below is similar to Figure 3 but depicts the expeditionary context. As mentioned earlier, the domestic context is relatively easy to conceptualise as a continuum of threats from the present environment through to a large scale sophisticated assault on North America. In contrast, expeditionary operations cover a broad spectrum of operations with multiple combinations of factors. Thus, the illustration in Figure 4 seeks to group expeditionary environments into three broad categories from most likely on the left to least likely on the right; enduring operations after an initial strike, the initial strike phase and full spectrum operations war fighting. While the defence of Canadian sovereignty is a non-discretionary role for the CAF, expeditionary operations are manifestly more discretionary. Not only does Canada have choice *in* participation, there is also choice in *how* Canada participates. Such decisions are arrived at with the benefit of military strategic advice on the risks of employing capabilities in a certain regional and local contexts.

> While expeditionary operations remain discretionary, domestic operations are non-discretionary

The *Coalition Contribution* area is where a failed or failing state is in crisis during the 'sustained operations' phase – that is, after the initial force intervention/initial strike has occurred and reflective of enduring peace enforcement or combat operations. In this area, the failing state apparatus directly contributes to the degradation of state military capabilities so forces are operating in the hybrid warfare space. This is assessed as the most likely strategic and operational-level condition-set from which fighter mission requirements should primarily derive. This area is where *Canada First* Defence Strategy (CFDS) missions 5 and 6 can occur and it is an inherently lethal

environment where many threats exist. The *First Strike Contribution* area is a possibility under CFDS missions 5 and 6, but represents offensive operations in the earliest stages of a coalition intervention, commonly referred to as *surge operations*. In this context, the CF188 replacement would operate in a higher threat environment than during *sustained* operations.[34] The right-most *Peer State-on-State Warfighting* area represents a protracted conventional war against a state adversary with sophisticated (integrated, networked and replaceable) air defence systems. In this context, both the scale and sophistication of the threat are at their highest levels. The lower graphs in Figure 4 are different to those in Figure 3 because, on expeditionary operations where aircraft are being used in an offensive role, it is more likely that a higher level of threat will exist than in Canadian aerospace defence operations. The Capability Based Planning analysis, supported by the Tyche analysis,[35] suggests that the sustained operations context is by far the most likely.

Expeditionary CAF Fighter Capability



[34] It is impossible to neatly delineate what separates the first two condition-sets; Sustained and Surge operations. It is situation dependent on several factors like enemy capabilities, resilience, operational art, proximity to lines of communication to supporting regional actors et. al. For CFD's purposes in this report, Surge is defined as the initial wave(s) of Tomahawk land attack missiles as well as manned and unmanned Suppression of Enemy Air Defences (SEAD) strikes specifically designed to neutralize essential components of an opponent's air defences. It may be that Sustained operations occur very shortly thereafter and will almost certainly face aspects of opponent air defence systems well into that operational phase. In this instance, even if the 'integrated and networked' aspects of the enemy's system are degraded, individual distributed or locally networked systems can be lethal. CAF fighter operations in both Kosovo and Libya occurred very proximate, in time and space, to initial SEAD strikes but the essential point is not to confound CAF capability ambition by suggesting the CF188 or its replacement is a Surge asset as defined by this analysis.

[35] Defence Research and Development Canada. *Scenario Frequency and Concurrency Analysis Report*. (In support of Chief of Force Development's Capability Based Planning Spiral 1 Activities 2011/12). dated 16 May, 2012.

Figure 4: Expeditionary Threat and Capability Mapped to Operating Environments

Expeditionary operations within a higher threat context are considered from the perspective that they will occur within a coalition context. This has been Canada's reality since the Boer War at the turn of the 20th century. This provides Canada with latitude to decide how to contribute, especially in the maritime and aerospace environments where Canadian assets tend to operate more as an integrated sub-element of a coalition force than land forces might. Given the breadth and depth of the capability portfolios of major allies such as the United States, the salient factor is where Canada can make a meaningful contribution, rather than ensuring Canadian fighters could take any one potential role. The assessed capability requirement, similar to that delivered now by the CF188, allows for a meaningful contribution to be made in the assessed most likely environment. Clearly, a more capable aircraft would create additional latitude for the Government of Canada (GoC). Any decision on Canadian contribution to an expeditionary operation would be informed by a fulsome assessment of advances in threat capabilities and intent within a failed or failing state context. Acceptable levels of risk in relation to achieving GoC policy objectives will be determining factors in decisions to employ military capabilities.

In the expeditionary role, the assessed focus area for the CF188 replacement largely shifts to Land Effects with Aerospace Control as a tertiary role.[36] Our analysis suggests that the asymmetric environment, judged to dominate in the Future Security Environment, does not fully employ the breadth of air-to-air features of a very high technology fighter aircraft except in the earliest stages of conflict after which demand transitions more into air-to-ground effects. These latter effects available from a fighter can, in many instances, also be delivered by other platforms that, among other characteristics, have greater dwell potential, are less expensive and expose the human to less risk (i.e. field artillery, UAVs, maritime fires, etc). A final proviso is warranted. Operations in Libya and, to a lesser extent, Kosovo reveal instances where nations might elect to contribute solely airpower to the resolution of international crises without 'boots on the ground'. While Chief of Force Development (CFD) acknowledges this, the CBP assessment was compiled by Joint Capability Planning Teams that included air experts. Capability Based Planning draws on historical lessons learned in its analysis but is not limited by past experiences in assessing future capability requirements.

The question is not whether the Canadian Armed Forces (CAF) needs a fighter aircraft to support expeditionary operations but, rather, how capable does this aircraft need to be and what are its likely roles. Conventional wisdom would suggest the value of maintaining an expeditionary fighter capability to ensure that the CAF has options to support potential GoC contributions to international peace and security operations. Recent operations in Libya offer a case in point. The salient question is one of the *quality* and *number* of those aircraft. The start point for considering this question is the primacy of the domestic mission. The minimal strategic and operational performance

[36] John Stillon and Scott Purdue. *Air Combat Past, Present and Future* (RAND Corporation, 2008) examined air-to-air combat identifying a total of 61 engagements in a post-Cold War context largely in the Gulf Wars 1 and 2 and Kosovo conflicts. From this and a wide array of other literature, it is reasonable to conclude that the preponderance of fighter effects in the modern expeditionary battle space occur in the land strike/Close Air Support domains. In this context, however, a fighter must still possess the organic ability to transit to and from the 'support' area. Ergo, it must be capable of fighting against air-breathing threats as well.

thresholds in that domain should use the CF188 as a baseline reference point acknowledging that technological advances will degrade the baseline over time. Every technology has a half-life that degrades its initial promise as counter-technologies are developed. From that qualitative basis, a minimal fleet size to service the domestic mission (with understood force generation needs that underpin it) offers a quantitative baseline. Beyond that, the risks and tradeoffs that allow for an expeditionary capability (based on assumed indications and warning lead times to prepare it for deployment) must be reconciled. This is the purview of military strategic advice to government; to cover defence policy objectives as set by government. What this report offers is insight into the force design considerations in arriving at that advice. In the final analysis, Capability Based Planning recognizes the criticality of ensuring that the CF188 replacement fighter's mission-driven requirements are carefully calibrated in the context of the Canadian Armed Forces' (CAF's) broader capability portfolio.

Section 4 – Other Considerations

Threat. Threats are comprised of capability, exposure and intent. Past and recent history proves that others routinely challenge Canada's sovereignty response. It follows that Canada requires credible and coercive CAF capabilities to maintain its sovereignty. Continental defence obligations reinforce this imperative. It is impossible to define with specificity the threats Canada could face moving ahead but, if history serves as a guide to the future, it is very unlikely Canada will be the target of overt, hostile state-directed military aggression. Our analysis draws three deductions from this. The first is that the premiere role of the CF188 replacement is in defence of Canada's sovereignty and as part of North American Aerospace Defense Command. These are core, non-discretionary critical missions that require a CF188 replacement with finely balanced range, speed, endurance and awareness characteristics superimposed on lethality optimized to this core mission. The CAF must also understand where risks lie when the CF188 replacement is employed beyond this core. Thus, the second deduction is that, in an expeditionary setting, the fighter will face a different set of threats; potentially less sophisticated than what a state may project against Canada but effective (highly so in certain cases) nonetheless. Moreover, those manning the systems will want to down aircraft. So, the risks of employing a fighter abroad are diverse and harder to generalize. While this employment is assessed as most likely to occur in a fragile/failing/failed state context where the preponderance of threat systems are unlikely to be at levels of sophistication one expects of a major regional power/emerging global superpower, it remains the case that more weapons of a somewhat less sophisticated nature still represent a deadly threat. The Canadian Army's experience in Afghanistan with improvised explosive devices proved that old weapons, used creatively, can have significant impact on superior, technologically enabled forces. The military axiom that 'the enemy gets a vote' holds true. The third deduction is that the proliferation of ground based air defence systems and the ability to enhance their effectiveness by combining widely available computing technologies will very likely increase their lethality to aircraft. Prudent military CF188 replacement planning must account for these assessed trends.

Balance. The diverse nature of CAF missions requires its forces to fulfil a broad capability range. This is because of Canada's geo-strategic position as a large country, an Arctic nation, one that shares continental responsibilities with the United States and one that contributes its share to international military burdens. But because the *prima facie* remit of the CAF is to protect Canada's interests at home, this places a clear priority on the Defensive Counter Air mission set. Canada's strategic distances demand a system of systems capability that has the necessary characteristics to maximize mission success with the domestic mission foremost in mind. Capability Based Planning illustrated that *all Measures of Capability are needed* in the CF188 replacement. Ergo, Canada's CF188 replacement fighter's Measures of Capability need to be finely calibrated to both Defence policy objectives and the array of potential threats it might face on a balance of probability basis. Combining the tactical perspective of Task 3 with this strategic and operational assessment will further elucidate an optimized blend. Finding the correct balance can only come from a capability-based approach to the problem.

Flexibility. The Oxford English Dictionary defines this as either "the ability to be easily modified" or "the quality of bending easily without breaking". Both are instructive. The former speaks for itself; possessing an aircraft that is most adaptable is beneficial to the CAF. It offers contingency space to react to unforeseen needs. The second definition addresses the tyranny of complex modern military machinery. Assets that are incredibly complex to the point of being brittle when used in harsh environments under demanding profiles can be defeated through the pursuit of perceived perfection before one operates. Flexibility also goes to the number of platforms, or fleet density, in that quantity offsets expected challenges associated with high technology platforms. Fleet density is a valuable attribute because it offers flexibility and redundancy to mitigate unplanned losses and react to unforeseen contingencies. Numbers are as valuable an attribute, in their own right, astride sensors, integration and the rest. Numbers bring a quality all their own to overall capability effectiveness. And this is especially so given our country's size. Every effort should be made to retain acceptable numbers of fighters, as well as enhanced capabilities, in the final calculus of the CF188 replacement question.

Risk. Many risks will need to be balanced in determining which fighter aircraft is best suited for Canada's needs. The main *strategic* risk is one of affordability in the context of competing CAF capability areas that are in need of investment. This drives the major *operational* risk which is to have available sufficient fighter aircraft and crews to deliver on the domestic sovereignty and North American Aerospace Defense Command (NORAD) missions.

- Force Generation. An indispensible force generation remit underpins these outputs. In the same way as aerial refuellers are an inseparable component of the fighter question, force generation models are equally important. The fighter lead-in trainer, designed to train pilots from basic aircraft to an advanced fighter, is an important consideration to the fighter capability itself. Beyond that, the operational risks speak to prioritizing the needs of the domestic mission ahead of expeditionary requirements, but not to the point where the latter mission is compromised.
- Interoperability. The CF188 replacement must be able to operate effectively abroad; not in the initial Suppression of Enemy Air Defences battle, but as a near-term follow on as a credible Joint Force enabler in support of land and maritime operations or as a credible contributor to coalition air forces if history serves as a guide. This carries with it the explicit need for interoperability within a Canadian system of systems as well as with United States military systems in support of the NORAD mission and for bespoke expeditionary engagements.

The CAF fighter's capabilities are optimized only through designed synergies with other platforms/capabilities in a system of systems context

Section 5 - Conclusion

Capability Based Planning (CBP) is not a panacea answer to every capability question. It cannot produce an algorithmic answer to precisely what the CF188 replacement should be. This report does, however, offer key insights in the context of a broad system of systems perspective advocating for balance across the entire capability portfolio. It does not serve the military enterprise well to have bespoke force elements overreach in one specific area if the benefits of the capabilities offered cannot be exploited as a result of a lack of symmetry in key enabling force elements. That said, it is inherently difficult to predict the future and, for a platform such as the CF188 replacement, great care must be taken to ensure the best – and most reasonable – capability is acquired owing to its singular importance and the reality that it will endure for several decades.

Canada's need for a CF188 replacement is firmly corroborated in the Canadian Armed Forces' CBP analysis. Professional military judgment, combined with defence science and technology expertise, provide a level of rigour of analysis that shows a fighter is the only platform able to react to a full range of airborne threats to Canada's sovereignty. In that context, the majority of the CF188 replacement fighter's output centres on the Defensive Counter Air mission. Given Canada's vast landmass, this speaks to the need to carefully weigh the fighter's characteristics to optimize its performance in this mission. Accepting the CF188 as the minimal performance baseline going forward, the CF188 replacement must be sensitive to the characteristics of lethality, awareness, interoperability, speed, endurance and range as a function of core national tasks. Possessing an aircraft which has difficulty operating in a bi-national NORAD or United States-led coalition context would be problematic. In an expeditionary setting, the threats would potentially be at a lesser technological level but they would likely be more pervasive in numbers and used with overtly malign intent. Accordingly, lethality, awareness and survivability resonate strongly as characteristics essential for missions abroad. The report also calls for the quantity of aircraft to be considered as part of the capability question itself. The history of conflict suggests that *depth* aids in overcoming those frictions associated with the complicated undertaking of delivering military effects. Tertiary enabling capabilities must also be carefully considered as part of the basket of costs and benefits.

Rooted in the *Canada First* Defence Strategy's three roles and six missions, this report is a view of the strategic capability cost versus strategic capability benefit in a traditional business case sense. The combination of this material with the tactical and costing perspectives is where the true strategic decision support contours will emerge to outline the real CF188 replacement costs and benefits to the Canadian Armed Forces, Canada and Canadians.