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"Covering the 'Bases':" Development of a Framework for Defence Force Planning Scenarios

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"COVERING THE 'BASES':" DEVELOPMENT OF A FRAMEWORK FOR DEFENCE FORCE PLANNING SCENARIOS

By

Shaye K. Friesen, Doug Hales, Neil Chuka, Charles C. Morrisey, Peter Race

Abstract

Scenario development and refinement present unique problems for analysts – it is inherently difficult to evaluate how the combined effects of multiple factors influence a given scenario set. The absence of an effective framework can lead to a situation in which scenario choice (and content) is based more on subjective than objective reasoning. Hence, there is a need to exploit scientific methods and sound analytical approaches for creating a framework to guide scenario development and analysis. This paper discusses the development a comprehensive, unified and tailorable scenario framework in the Canadian Department of National Defence and Canadian Forces. Three innovations were incorporated into the development of this framework. These include: identification of a full range of dimensions; the application of Field Anomaly Relaxation to characterize scenarios; and, the development of a software tool that allows analysts to compare and contrast scenarios, and visualize the results. The consideration of a full range of operating conditions and environments is used as a basis to provide an overall assessment of the scenarios, thereby providing a sense all "bases" have been covered. This paper also discusses the motivation, structure and future research directions of the scenario framework and analysis tool.

Introduction

Scenarios perform a critical function in Capability Based Planning (CBP). In the Canadian Department of National Defence (DND), Force Planning Scenarios (FPS) translate policy into concrete plans and force requirements. The FPS provide a range of domestic, continental and international situations in which the Canadian Forces (CF) anticipates conducting operations. They describe plausible future operational situations to bring greater precision to military assessments of the capabilities and force structure that may be required to support a particular operation. Through the analysis of scenarios, force planners make informed decisions about what requirements the CF might need for future operations, explore different options for delivering military capability and set a coherent force structure for what lies ahead.

Given the importance of the FPS, scenario developers must follow a methodologically rigorous process that is grounded in military doctrine and underpinned by strong stakeholder support. To meet these challenges, a comprehensive, unified and tailorable framework was developed to guide the selection and development of the FPS. This framework allows analysts to test and evaluate the extent to which the FPS set covers a combination of different variables. The development of a systematic process enhances CBP by ensuring scenarios are selected in a defensible and objective way that makes best use of analytical methods and techniques.

The purpose of this paper is to discuss the development of a framework for characterizing the FPS in the Canadian DND. The framework is not just a conceptual model. Rather, it has been applied using a methodology and software tool that allows analysts to overlay the FPS and ensure a range of dimensions, factors and variables are being addressed. This paper discusses the background, motivation, structure and research directions of the FPS tool. The results of this work illustrate the value of having a tool that can be extended to support C2 assessment.

This paper complements and extends the research conducted into the development of a FPS Framework. The work was completed by Defence Research and Development Canada's Centre for Operational Research and Analysis (DRDC CORA), along with CAE Professional Services. The results have been published by DRDC, and are being applied in the development of the current FPS set.[1]

Scenarios and Capability Based Planning

The DND/CF has adopted a CBP process to inform and guide integrated Force Development. CBP - planning under uncertainty - offers a means to confront an ambiguous and violent security environment.[2] Scenarios provide the means to describe and document contextual assumptions, establish boundary conditions and serve as a point of departure for exploration. They are used to relate concept to practice, to determine and define requirements, and to frame and focus training. The FPS are an integral component of CBP used to characterize the "problem space," assess program options and evaluate force structure. Just as CBP seeks to generate a robust set of capabilities in the face of uncertainty, the FPS seek to provide a balanced (not exhaustive) set of threats, hazards and conditions to invoke such capabilities.

Figure 1 illustrates the role scenarios play in translating policy, defining capability targets and supporting analysis.[3] Because they serve multiple audiences, a common set of FPS can contribute to process integration and decision coherence in Force Development. The links to strategic vision and to mission analysis highlight the core function of FPS as providing the context, informed by policy, necessary for developing, applying and evaluating military capabilities.

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[1] Neil Chuka, Larry Cochran, Shaye K. Friesen, Doug Hales, LCdr Darren Harnett, Charles Morrisey, Peter Race, *Development of the Force Planning Scenario Framework: Inputs for the Scenario Analysis Tool*, DRDC CORA CR 2010-017, February 2010; Larry Cochran, Shaye K. Friesen, Doug Hales, Peter Race, *Analysis Tool for Force Planning Scenarios: User's Guide*, DRDC CORA CR 2009-018, February 2010.
[2] For a good primer on Capability Based Planning, consult: The Technical Cooperation Program (TTCP), Joint Systems Analysis (JSA) Group, Technical Panel 3, "Guide to Capability Based Planning," p. 1.
[3] Canada, Department of National Defence (DND), Chief of Force Development (CFD), *Force Development and Capability Based Planning Handbook*, v.5.2 (Ottawa: Department of National Defence, 2008), p. 5.

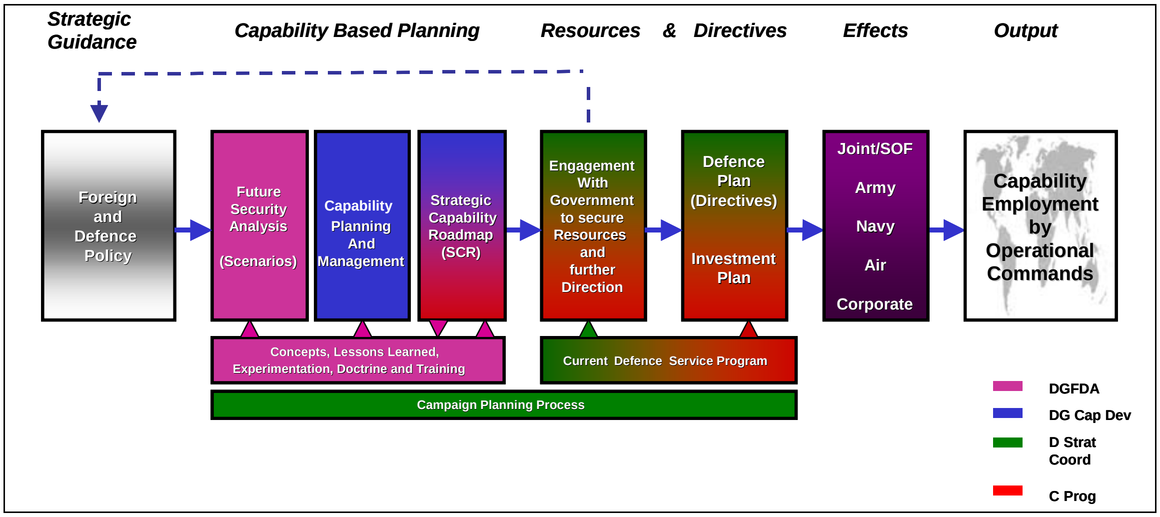

Figure 1: Scenarios and Their Relationship to Capability Based Planning

Background

There have been two previous rounds of scenario development in the DND/CF. An initial set of scenarios, spanning the spectrum of CF operations, was developed in 1999. As part of this effort, a preliminary catalogue of tasks that the CF might be called on to perform was prepared, and scenario parameters (e.g., deployment duration, climatic conditions) were identified. The FPS were reviewed following the 2005 Defence Policy Statement (DPS). At that time, it was concluded that, insofar as possible, scenarios should be based on "real world" conditions and anticipated operating environments. The original set of 11 was expanded to 18. This second iteration of 18 scenarios is depicted in Figure 2.

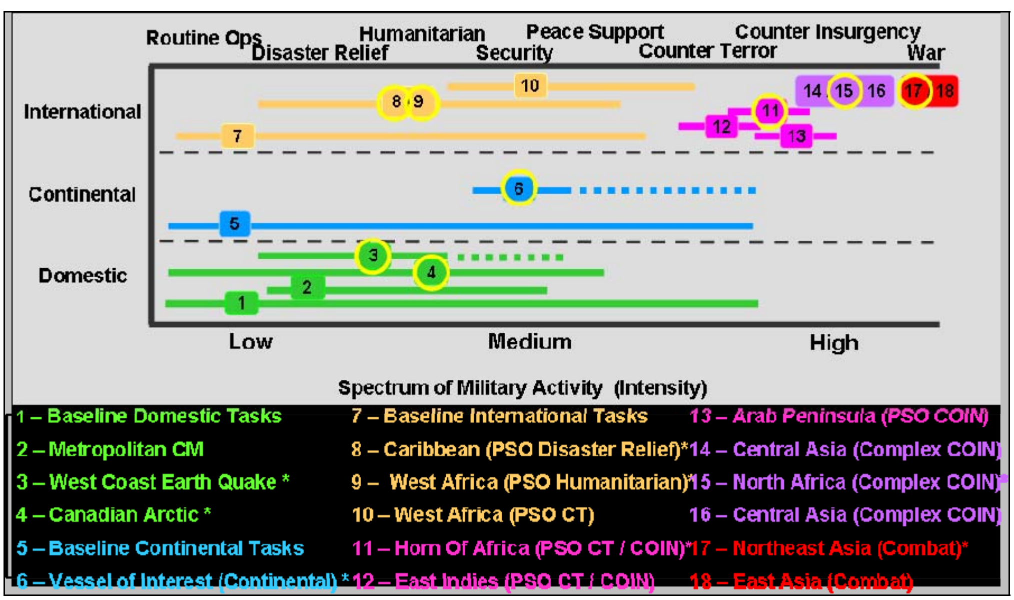

Figure 2: Force Planning Scenarios and Spectrum of CF Operations

As shown in Figure 2, the scenario set was characterized in terms of spheres of operations (domestic, continental and international), campaign themes (routine ops, operations other than war through to combat) and military activity intensity. While these initial efforts provided valuable insight and a departure point, there was no effective or systematic means used to ensure completeness or optimization. Development of a scientifically defensible and substantive process for selecting scenarios and ensuring portfolio balance was called for.

This brief history underscores the requirement for periodic re-assessment and refreshment, to cater for revised perceptions of the future operational environment and associated policy adjustments. The release of the *Canada First Defence Strategy* (CFDS) in 2008 prompted a more thorough review and refreshment of the existing scenario set, and ultimately led to a third iteration of FPS development. The CFDS outlines the vision of CF capabilities through six core missions that address the future security environment:

1. Conduct daily domestic and continental operations, including in the Arctic and through NORAD;
2. Support a major international event in Canada, such as the 2010 Olympics;
3. Respond to a major terrorist attack;
4. Support civilian authorities during a crisis in Canada such as a natural disaster;
5. Lead and/or conduct a major international operation for an extended period; and
6. Deploy forces in response to crises elsewhere in the world for shorter periods.[4]

These six broad missions serve as strategic planning inputs, establishing operational boundaries and guiding current FPS development. To ensure the scenario evaluation aligns with defence policy, these missions will be used as a lens for scenario analysis. After evaluating the range of plausible scenarios for the FPS set, they can be evaluated against these mission types to understand the degree of policy coverage from a given set of FPS.

Motivation

While there is considerable defence policy guidance and lessons learned for improving scenario development and supporting follow-on analysis, there existed no effective framework that dealt specifically with the FPS and its key dimensions. A FPS framework was needed to permit analysts to gauge scenarios against the full spectrum of potential campaign themes, types of operations, environments and operating conditions.

In the DND/CF, there is a need to exploit scientific approaches and sound analytical methods for producing a comprehensive framework that supports scenario development and their applications in the context of CBP. The development of a unified, tailorable and comprehensive framework provides a means by which analysts can develop scenarios that discuss and describe volatility, uncertainty and ambiguity associated with the future security environment. Key scenario dimensions, factors and variables must be defined in

[4] Government of Canada, *Canada First Defence Strategy* (Ottawa: Government of Canada, May 2008), p. 3.

order to ensure the most relevant elements are considered during the scenario development process, which in turn facilitates the ability of force planners to design a robust and agile defence force most appropriate for potential future operating environments. A practical and rigorous framework is required to identify the total set of relationships for a given set of scenarios, and assess gaps in the FPS that may require new scenario development.

Stakeholder Communities

There are three major communities that exploit the FPS: capability managers, capability planners and capability employers (see Figure 3). Capability employers focus on the near future, looking at current inventories and task lists to apply capability for current operations. Capability managers are concerned with the transition from planning to employment, and must address gaps, propose options and balance investment across portfolios. Capability planners are interested in the longer horizon (e.g., defining the shape of the CF in 2020). While each group has to tackle similar challenges, the time horizon is different for each stakeholder community. The FPS are primarily designed to support capability planners in addressing the future security environment, though they have application across all communities.

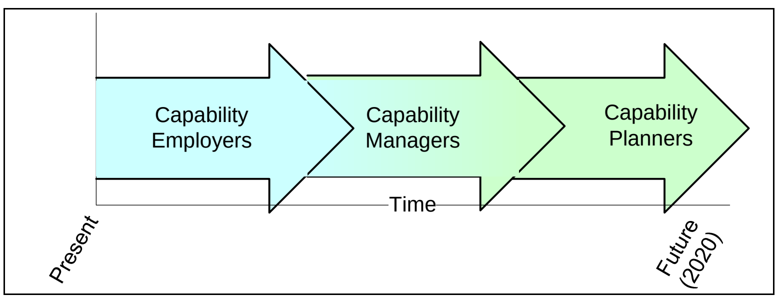

Figure 3: Spectrum of Scenario User Communities

None of the communities operate alone. Indeed, long-term capability planning functions often involve experienced military subject matter experts (SMEs). The prime roles of these military SMEs are as a "repository of deep-lasting knowledge and competence, as well as the source of most innovations" and provide the means to satisfy operating objectives: forces, equipment and doctrine.[5] Similarly, although capability employers are not prone to taking the longer-term view, the "potential importance of [force employers] lies not in setting national strategy but in translating it into operating objectives and in turn expressing demand for capabilities to achieve those objectives, thus allowing strategy and resources to be linked."[6] As such, the FPS framework is designed as a common context to accommodate a range of stakeholders.

[5] David C. Gompert, Paul K. Davis, Stuart E. Johnson and Duncan Long, *Analysis of Strategy and Strategies of Analysis* (Santa Monica: RAND, 2008), p. xv.
[6] Ibid., p. xiii.

All three of the above stakeholder groups interact with scenarios. Two other groups that interact with scenarios include policy developers, who shape the assumptions for FPS, and Defence Scientists, who must provide the scientific rigour and analysis necessary for effective scenario development. Taken collectively, these five groups are shown in Figure 4.

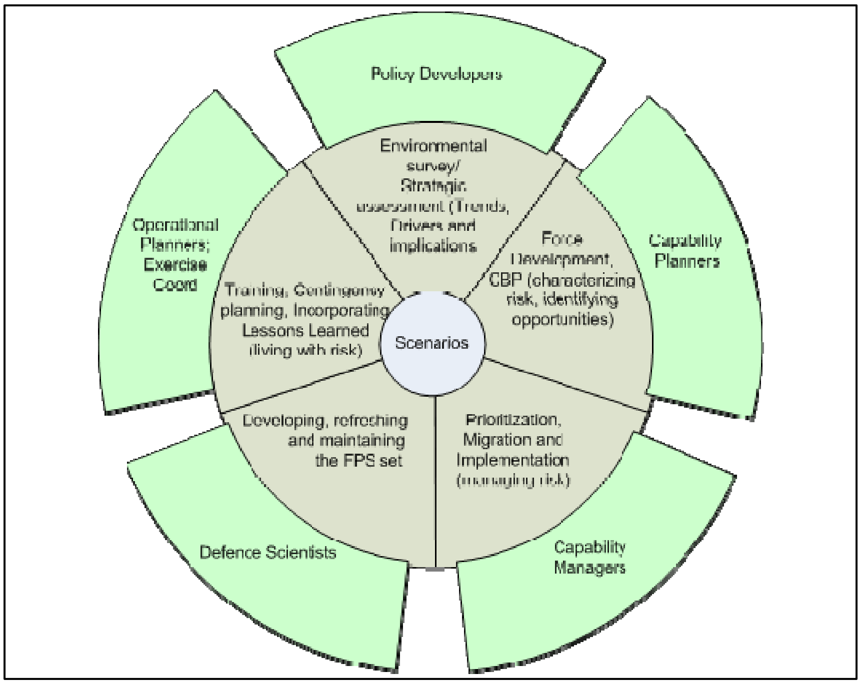

Figure 4: Stakeholder Communities and Functions

Policy Developers. As policy provides the conceptual framework that outlines the future CF, it is important that the scenario set is reflective of this policy. Any scenario assumptions related to own-force engagement (e.g., duration or level of commitment) would need to be modifiable.

Capability Planners. CBP revolves around the use of scenarios. In the Force Development Handbook, CBP is described as a "modified Operational Planning Process," involving the use of scenarios to conduct mission analysis, grouping of tasks and capabilities and eventual capability prioritization.[7]

Capability Managers. Capability managers are responsible for developing and maintaining a balance of capability investment across all capabilities. They ensure that identified gaps are being addressed, and use the FPS as the context to help weigh these gaps. As a result, the ability to prioritize capabilities based on a review of the scenario set would be required.

[7] CFD Handbook, p. 19.

Operational Planning and Exercise Coordination Community. Capability employers, in their roles as operational planners, make use of scenarios in much the same way as capability planners. The scenarios are used to conduct mission analysis on potential upcoming missions. As a result, the scenario set serves to provide the foundation to generate and evaluate Contingency Plans (CONPLANS). Once CONPLANS are developed, they are brought into training to introduce and clarify roles, standards and processes are in place. Exercise coordinators use the context and assumptions of the FPS to exercise the Concept of Operations (CONOPs) and develop the Master Scenario Events List (MSEL) to achieve training objectives. The feedback from such exercises, when combined with lessons learned from the operational elements, help provide insight into capability analysis.

Defence Scientists. It is the role of Defence Scientists within the research and analysis community to develop an FPS set that most accurately represents the potential future operational environment. Drawing on policy and operational information, as well as literature on changing future threats and adversaries, Defence Scientists must present an objective and balanced set of scenarios for use by all other users. This research is designed to primarily support this user group, thus enabling the creation of a robust set for use by the other communities.

Characterizing the Force Planning Scenarios

A framework is a schema designed to provide a structure for addressing problems with multiple stakeholders with differing accountabilities, multiple perspectives, divergent interests, and considerable autonomy. A framework is independent of application, and does not prescribe use, methodology or process.[8] By remaining independent of organizational and institutional processes, a framework supports the aggregation and simplification of multiple components, dimensions or elements. The framework developed in the Canadian DND/CF makes use of this function for sorting and filtering, displaying, searching, analyzing and selecting scenarios. It is designed to be expanded and extended to capture new information and scenarios, and grow to meet new users and new requirements.

The FPS framework is derived from a set of explicit principles. These principles are designed to ensure the scenario tool, once developed could be effectively applied as a way of improving decision support capabilities. The principles are listed as follows:

- The framework should facilitate coverage of the three CF roles to defend Canada, defend North America and contribute to international peace and security;
- The framework should provide a link into defence policy as articulated by the Government of Canada in the CFDS, ensuring that the set includes at least one scenario for each mission;
- The framework should be capable of accommodating all classes of users, supporting continued expansion through ready access and evolution;

[8] John A. Zachman, “Enterprise Architecture Fundamentals Masterclass”, Zachman International, 2006.

- The framework should support logical, plausible and relevant situations that the CF may encounter in the future;
- The framework should draw on variety of authoritative and credible sources of information (e.g., government reports, journal articles etc); and,
- The framework should remain internally consistent with Canada's historical deployments, current military doctrine, future security environment analysis and concept development activities.

In developing the FPS framework, there are inherent trade-offs between the number of dimensions, factors and variables, and the acceptable level of detail that must be considered. It is important that the framework be comprehensive enough to permit thorough and systematic analysis without becoming too detailed to the point that it is overly cumbersome, difficult characterize or simply unusable for the purposes of providing effective decision support. Moreover, if the dimensions are based on a fully complete depiction of all future threats, trends and drivers associated with the future security environment, its level of detail would impose difficulties on analysts to provide compelling analysis, and thwart their ability to maintain a coherent grasp of the most relevant variables for the purposes of scenario development.

There is also the problem in making a given dimension too ambiguous by assigning multiple factors, variables or values to the point that it loses parsimony and distinction. It is recognized that a finite or closed model in which scenarios are compared against a range of variables entails accepting a certain amount of risk that the proposed solution or framework may not be wholly accurate. Yet, it is also clear, based on the analysis of the literature and consultation with the broader defence scientific community, that a scenario framework is representative of user-defined set of dimensions, factors, variables and values that are germane to the problem confronting analysts in the scenario development process. The literature review examined the development of past FPS and their critical elements, using the criteria developed above to refine and refresh several of these attributes. The resulting set of dimensions, factors and variables were thus a continuation of past efforts, adjusted and extended to address all relevant aspects of the future operational environment.

Equally important, the scenario framework was not designed to provide insights into the specific timing, nature and location of events that may trigger CF involvement. The framework is, thus, a planning tool that is designed to improve the ability of Defence Scientists to analyze gaps in the existing scenario set and generate new scenarios that most effectively satisfy the requirements of force development using a consistent and structured approach. This involves the consideration of a range of dimensions, factors and variables that influence the existing scenarios and current operations, as well as anticipating the future threats, environments and missions for which defence forces must be developed and assessed in the context of CBP. Therefore, an appropriate balance must be achieved by stating the guiding principles upon which the framework is based and using expert judgement to capture dimensions, variables and factors deemed most relevant to scenario development in the DND/CF.

Accordingly, in identifying a list of dimensions, it is necessary to take into account the existing scenarios that have been developed, and those that are currently under development, to aid in the identification of the appropriate level of detail that is required. Yet, this process alone is insufficient. Existing scenarios provide guidance on the appropriate level of detail for enabling more in-depth analysis and decomposition. However, the scenarios themselves need to be expanded upon in order to highlight new variables and condition sets. To date, the current force planning scenario effort covers a broad range of strategic challenges. The analysis of doctrine, lessons learned, future concepts and integration of emerging trends in the international security environment define the attributes and permit the tailoring of new scenarios in non-traditional areas. A refined set of scenarios is required to create a wider variety of challenges for planning and assessing the adequacy of capability employment and force structure rather than reinforcing conventional deficiencies. The methods chosen for scenario analysis must offer an overt, systematic, objective and replicable way of filtering the number of scenarios and variables down to a manageable level. Ultimately, it is a combination of usability, utility, functionality, availability of information and relationship to the aims, purpose and need for the tool that establishes appropriate and acceptable levels of detail. This process cannot be accomplished through a simulation or database, but must rely on expert judgement.

Force Planning Scenario Framework Structure

Several dimensions are required to meet the framework requirements. Each dimension serves a unique purpose, enabling both the development of a complete FPS set and characterizing scenarios for planning. As a result, there is a degree of crossover between some of the dimensions (e.g., “geographic settings” and “terrain”). To assist the user in applying these dimensions, they have been organized into three types:

- Drivers (red): Includes the core elements of future scenarios. These driver dimensions are used to evaluate the range of plausible scenarios in evaluating the set as a whole.
- Descriptors (green): Used to characterize the important details within a scenario. Descriptors are necessary for developing individual scenarios to ensure they are suitable for mission analysis and CBP.
- Derivatives (yellow): Includes all dimensions that are invoked by a particular scenario.

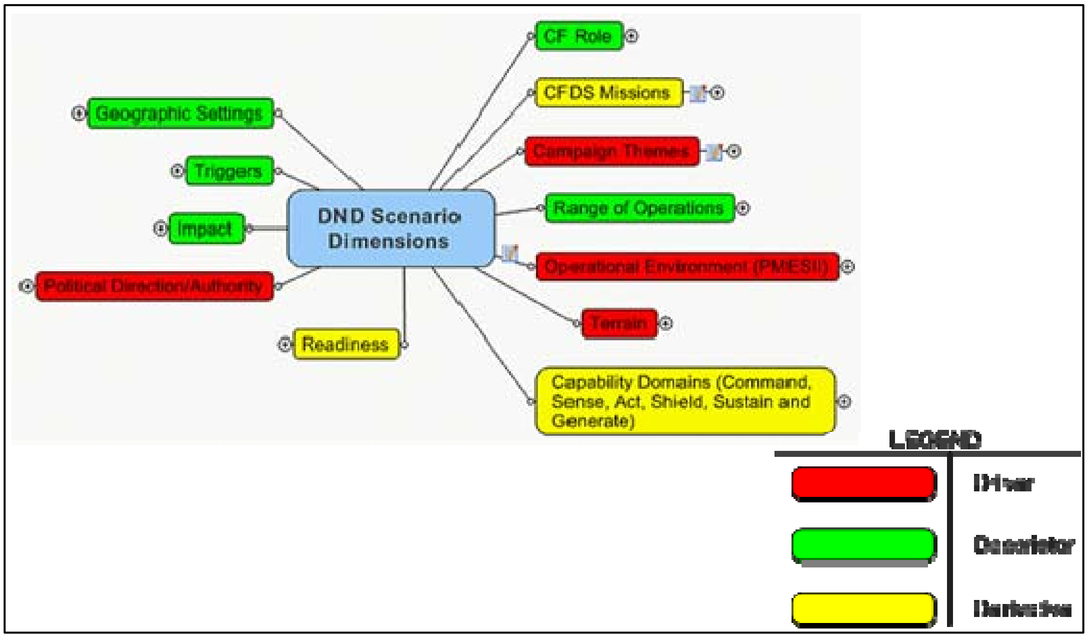

Figure 5: Dimensions as Drivers, Descriptors and Derivatives

The colour coding in Figure 5 outlines the current drivers, descriptors and derivatives within the framework. There are three exceptions of note. First, the Political, Military, Economic, Social, Infrastructure and Information (PMESII) dimension (see next section) includes all elements of the operational environment. However, the red force subset of the military dimension is the only portion considered a driver. Second, within the natural environment, the dimensions of weather and climate are considered descriptors; terrain is the driver within the dimension. Finally, the CFDS missions are anomalous, as they provide bounds for scenario development without functioning as a driver. The most appropriate categorization is derivative, as a final check to ensure the full FPS set adequately addresses the policy bounds laid out by the CFDS.

As noted previously, the FPS framework needed to balance between accessibility and completeness. That is, it needed to have a high-level component for ease of navigation, as well as a level of detail sufficient for describing all key aspects of the future security environment. Therefore, as a result, the framework was developed with three levels of decomposition, which are depicted in Figure 6.

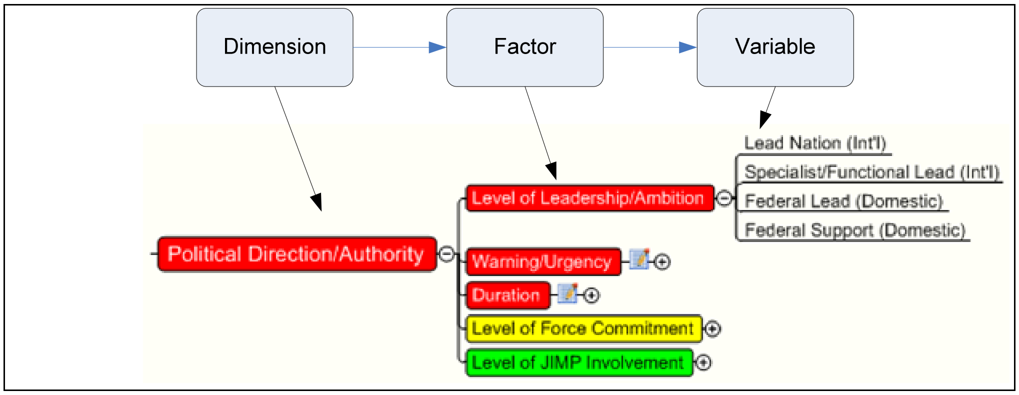

Figure 6: FPS Framework Structure - Dimensions, Factors and Variables

While the framework has three levels of decomposition, scenarios are only characterized using variables. As a rule, every scenario developed through Field Anomaly Relaxation (FAR) will include one variable from each driver factor. Force Planning Scenarios are a cluster of the FAR scenarios, and include at least one variable from each driver factor. The descriptors are then applied to each FPS to assist in mission analysis.

PMESII: An Illustrative Dimension

Every operational environment will be unique. The key for planning is to select from a spectrum of environments in order to accommodate uncertainty, and provide a balanced set of scenarios. To ensure logical consistency, typically the operational environment is primarily used as a supporting dimension (i.e., to exemplify the campaign theme). As defined in the *Joint Intelligence Preparation of the Operational Environment* (JIPOE), the operational environment is "the composite of the conditions, circumstances, and influences that affect the employment of capabilities and bear on the decisions of the commander."[9] The Operational Environment is further broken down according to PMESII, as shown in Figure 7.[10]

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[9] United States, Department of Defense, *Joint Intelligence Preparation of the Operational Environment*, Joint Publication JP 2-01.3 (Washington: Government Printing Office, 16 June 2009), p. xi.

[10] The PMESII model is expanded in as PMESII + PT, which includes the two additional elements of Physical Environment and Time. In developing the scenario dimensions, the physical environment was given its own dimension to account for the natural environmental conditions of terrain, weather and climate. Time was addressed through the Duration dimension, which determines the length of the CF mission. See DND, Chief of Land Staff, *Intelligence Field Manual*, B-GL-357-001/FP-001 (Kingston: DND, 2000); also United States, Department of the Army, *Tactics in Counterinsurgency* FM 3-24.2 (Washington: Department of the Army, April 2009), 1-3.

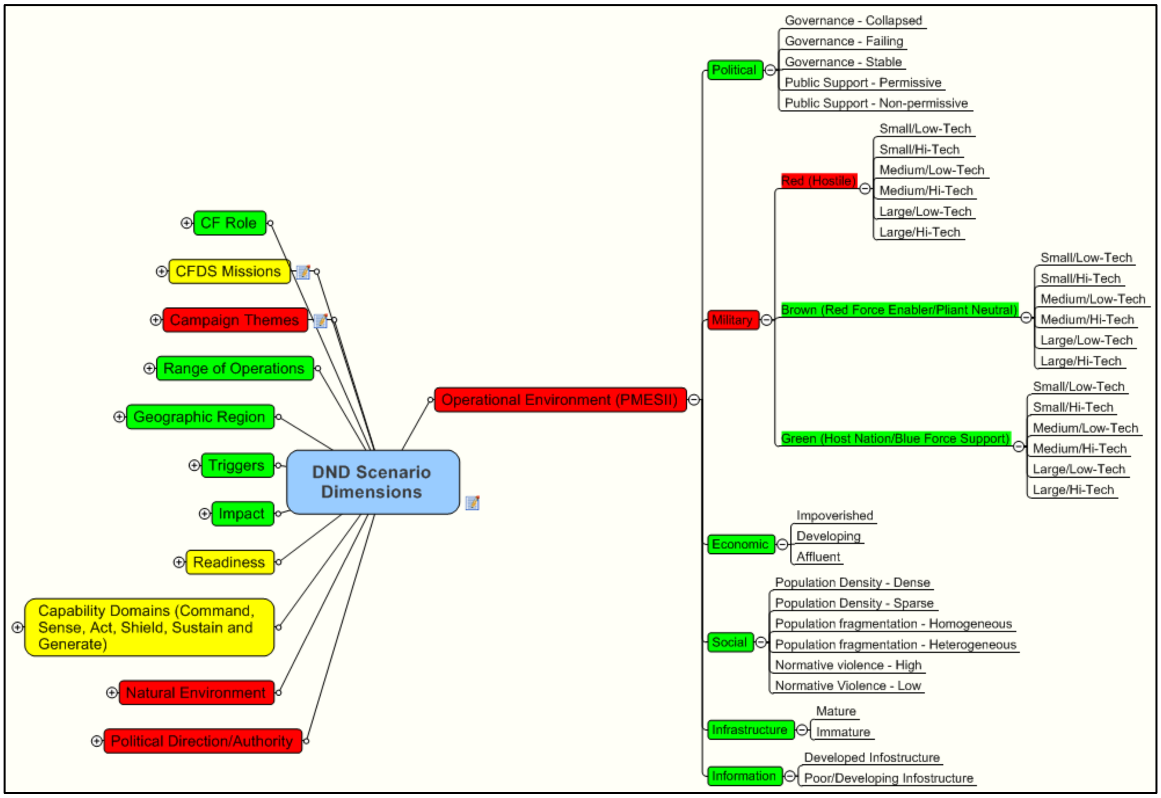

Figure 7: FPS Framework Operational Environment (PMESII)

The use of PMESII for categorizing scenarios allows the characterization of the adversary as well as the actors and other factors that could potentially influence the outcome of an operation. The original basis for requesting CF support will be strongly linked to the macro-level structural conditions conducive to instability. PMESII also provides an accepted framework of inter-related operational variables that aids in analyzing the operational environment.[11] As a result, the use of PMESII serves two purposes: first, it serves as a means to ensure a balanced set that accounts for the human footprint of the operational environment; and, secondly, it serves as a possible link to support mission analysis, contingency planning and exercise design. The prime use of the operational environment domain is to characterize the scenario rather than to drive scenario selection. Only the red force military subset of the dimension is considered a driver. The range of potential adversaries is a fundamental aspect of any scenario set, and thus is useful for evaluating the completeness of a set of plausible scenarios.

[11] PMESII has been applied to analyze effects as a part of nodal analysis and operational net assessment (ONA). ONA is “the integration of people, processes, and tools that use multiple information sources and collaborative analysis to build shared knowledge of the adversary, the environment and ourselves.” United States, Department of Defence, Joint Warfighting Center, *Doctrinal Implications of Operational Net Assessment (ONA)*, Joint Doctrine Series Pamphlet 4. (Suffolk VA: Joint Warfighting Center, 24 February 2004), p. 4.

Applying and Exploiting FPS Using Field Anomaly Relaxation

The primary purpose of the FPS framework is to promote the development of a balanced set of FPS for CBP. With any scenario analysis, the goal is to develop a manageable number of representative scenarios to support planning. This requires an appropriate analytical methodology to ensure the scenario set includes all the critical elements of the future operational environment.

Scenario identification and selection can be conducted in two broad ways:

- Non-Bayesian Method: Morphological Analysis (MA), FAR and Batelle; and,
- Bayesian Method: Cross- impact analysis using a system of equations.

The use of a Bayesian analysis provides the value of assigning weights and values to individual scenario aspects, and can provide a wide distribution of potential scenarios based on mathematical models. However, the manipulation of scenario variables takes into account the range of all possible scenarios, including those which have a low plausibility of occurrence. As a result, a non-Bayesian analysis is required prior to any Bayesian approach.

MA is "a method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable problem complexes."[12] MA is of use in determining the scope of the possible permutations of scenario combinations; stimulating consideration of possible scenarios that may have otherwise been overlooked. However, it leaves the analyst with an extensive list that must be refined through a labour intensive and time-consuming elimination process.

There are several versions of MA. This project adopted the FAR, a modified version of the typical approach to include a greater degree of accuracy in evaluating scenarios. FAR is a version of MA that involves the evaluation of a scenario set using a series of filtrations to arrive at the final set. Typically, compatibility is evaluated using a binary rating (i.e., compatible/incompatible). However, similar to the Batelle approach, this FAR process applies a five-point plausibility rating to evaluate each pair.[13] The result is a compatibility value, averaging the value of each pair-wise comparison for a particular scenario.

The original architect of FAR outlined a four-step method (Figure 8).[14]

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[12] Tom Ritchey, "General Morphological Analysis: A General Method for Non-Quantified Modeling". Swedish Morphological Society, 2009. http://www.swemorph.com/ma.html. Accessed 10 August 2009.
[13] M.–T. Nguyen and M. Dunn, *Some Methods for Scenario Analysis in Defence Strategic Planning* DSTO-TR-2242 (Canberra: Australian Defence Science and Technology Organisation, February 2009).
[14] Russell Rhyne, "Whole-Pattern Futures Projection Using Field Anomaly Relaxation," *Technological Forecasting and Social Change* Vol. 19 (1981), pp. 331-360; Russell Rhyne, "Field Anomaly Relaxation - The Arts of Usage," *Futures* Vol. 27, No. 6 (1995), pp. 657-674.

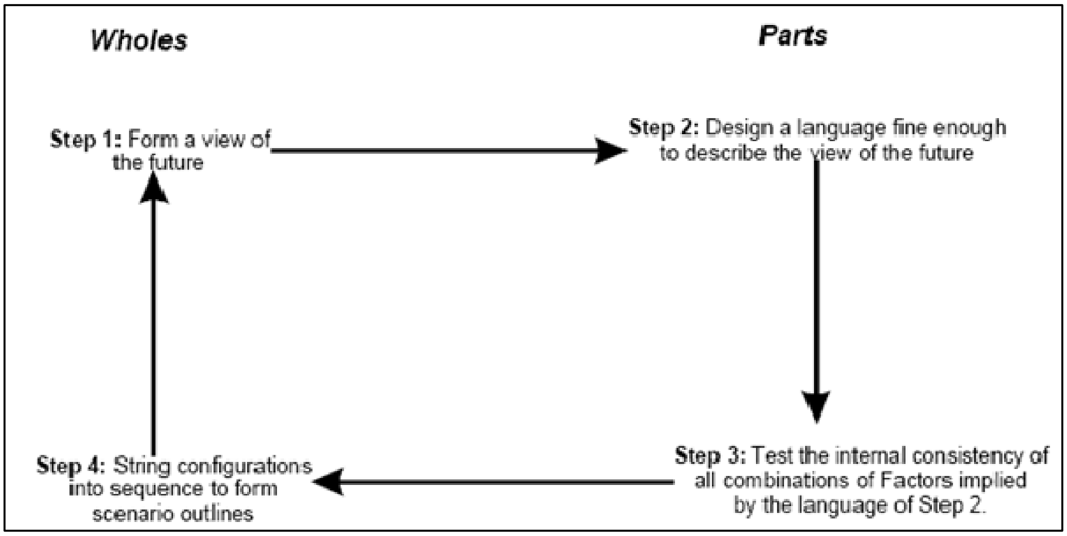


Figure 8: The Field Anomaly Relaxation Cycle

Step 1: Form an initial view of the alternative futures that could unfold within the area of interest. For this project, the framework is informed by policy and an understanding of the future security environment.

Step 2: Construct a language using Sectors that will become the dimensions of describing the area of interest; and Factors, which become the alternative states within each Sector and array these on a matrix to form Whole Field (full sector range) descriptors of all possible configurations.

The typical FAR taxonomy is not used within this study; however, this has no impact on the analytical process. A mapping of terms is included in Figure 9:

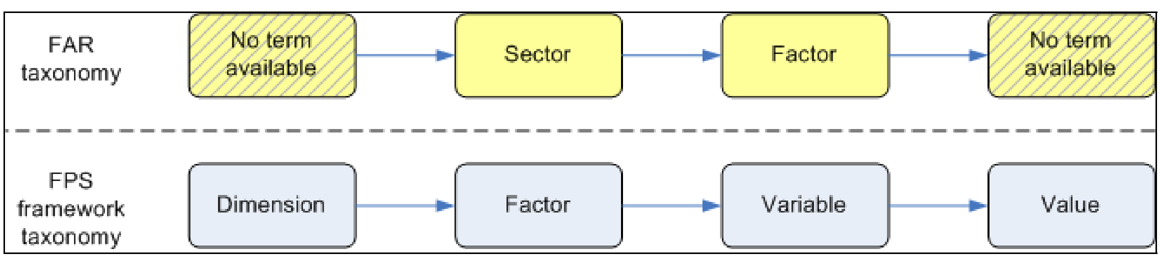
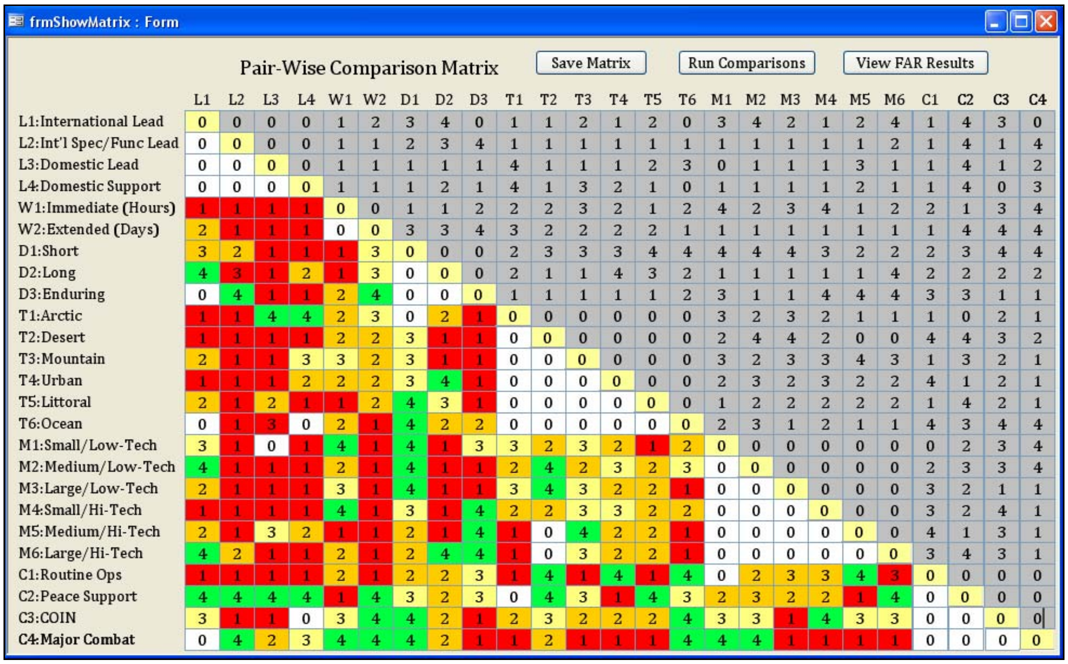


Figure 9: Comparison of FAR and FPS Taxonomy

For each of the driver factors, a variable is selected. The FPS framework uses six factors: campaign theme; terrain; adversary - red force; political leadership/authority; duration and warning. Each scenario is a combination of these variables, such as C_1 A_1 T_1 L_1 D_1 W_1 (i.e., the first variable in the campaign theme factor, the first variable in the adversary factor, etc).

Step 3: Eliminate those factor pairs that are illogical or cannot co-exist, forming a reduced set of whole field configurations.

The software tool, built on the FPS framework, incorporates a series of pair-wise comparisons to eliminate illogical pairs. The process is time-consuming, but critical to completeness. The end result can be displayed using a matrix of pairs. Figure 10 shows this pairwise comparison matrix, populated with illustrative data.



	L1	L2	L3	L4	W1	W2	D1	D2	D3	T1	T2	T3	T4	T5	T6	M1	M2	M3	M4	M5	M6	C1	C2	C3	C4
L1:International Lead	0	0	0	0	1	2	3	4	0	1	1	2	1	2	0	3	4	2	1	2	4	1	4	3	0
L2:Int'l Spec/Func Lead	0	0	0	0	1	1	2	3	4	1	1	1	1	1	1	1	1	1	1	1	2	1	4	1	4
L3:Domestic Lead	0	0	0	0	1	1	1	1	1	4	1	1	1	2	3	0	1	1	1	3	1	1	4	1	2
L4:Domestic Support	0	0	0	0	1	1	1	2	1	4	1	3	2	1	0	1	1	1	1	2	1	1	4	0	3
W1:Immediate (Hours)	1	1	1	1	0	0	1	1	2	2	2	3	2	1	2	4	2	3	4	1	2	2	1	3	4
W2:Extended (Days)	2	1	1	1	0	0	3	3	4	3	2	2	2	2	1	1	1	1	1	1	1	1	4	4	4
D1:Short	3	2	1	1	1	3	0	0	0	2	3	3	3	4	4	4	4	4	3	2	2	2	3	4	4
D2:Long	4	3	1	2	1	3	0	0	0	2	1	1	4	3	2	1	1	1	1	1	4	2	2	2	2
D3:Enduring	0	4	1	1	2	4	0	0	0	1	1	1	1	1	2	3	1	1	4	4	4	3	3	1	1
T1:Arctic	1	1	4	4	2	3	0	2	1	0	0	0	0	0	0	3	2	3	2	1	1	1	0	2	1
T2:Desert	1	1	1	1	2	2	3	1	1	0	0	0	0	0	0	2	4	4	2	0	0	4	4	3	2
T3:Mountain	2	1	1	3	3	2	3	1	1	0	0	0	0	0	0	3	2	3	3	4	3	1	3	2	1
T4:Urban	1	1	1	2	2	2	3	4	1	0	0	0	0	0	0	2	3	2	3	2	2	4	1	2	1
T5:Littoral	2	1	2	1	1	2	4	3	1	0	0	0	0	0	0	1	2	2	2	2	2	1	4	2	1
T6:Ocean	0	1	3	0	2	1	4	2	2	0	0	0	0	0	0	2	3	1	2	1	1	4	3	4	4
M1:Small/Low-Tech	3	1	0	1	4	1	4	1	3	3	2	3	2	1	2	0	0	0	0	0	0	0	2	3	4
M2:Medium/Low-Tech	4	1	1	1	2	1	4	1	1	2	4	2	3	2	3	0	0	0	0	0	0	2	3	3	4
M3:Large/Low-Tech	2	1	1	1	3	1	4	1	1	3	4	3	2	2	1	0	0	0	0	0	0	3	2	1	1
M4:Small/Hi-Tech	1	1	1	1	4	1	3	1	4	2	2	3	3	2	2	0	0	0	0	0	0	3	2	4	1
M5:Medium/Hi-Tech	2	1	3	2	1	1	2	1	4	1	0	4	2	2	1	0	0	0	0	0	0	4	1	3	1
M6:Large/Hi-Tech	4	2	1	1	2	1	2	4	4	1	0	3	2	2	1	0	0	0	0	0	0	3	4	3	1
C1:Routine Ops	1	1	1	1	2	1	2	2	3	1	4	1	4	1	4	0	2	3	3	4	3	0	0	0	0
C2:Peace Support	4	4	4	4	1	4	3	2	3	0	4	3	1	4	3	2	3	2	2	1	4	0	0	0	0
C3:COIN	3	1	1	0	3	4	4	2	1	2	3	2	2	2	4	3	3	1	4	3	3	0	0	0	0
C4:Major Combat	0	4	2	3	4	4	4	2	1	1	2	1	1	1	4	4	4	1	1	1	1	0	0	0	0

Figure 10: Pair-wise Comparison Matrix (includes representative data only)

For each campaign theme, different variables are assigned a plausibility value from 0-4, as seen in Figure 11:

0	Highly Implausible/Impossible
1	Implausible
2	Somewhat Plausible
3	Plausible
4	Highly Plausible

Figure 11: Plausibility Values

The pair-wise comparisons are conducted within a series of interfaces, where each comparison is assigned a value. Of greatest relevance are the insignificant variables (i.e., are not relevant to a campaign theme), which are given a value of zero. By assigning this value, the variable is not included in the matrix for further comparison. Each variable must be given a value. A systematic approach is employed to avoid error (e.g., providing a value for all variables associated with the first factor of the first dimension, followed by the second factor of the first dimension, etc.). The results are then included in the pair-wise comparison matrix.

Step 4: Position the surviving whole field configurations on a 'tree' whose branches represent possible future states and transitions from one configuration to the next.[15]

This step is modified to include a filtering based on plausibility value. After populating the matrix with plausibility values, the whole set of plausible scenarios can be displayed and filtered. A plausible scenario is made up of one variable from each factor, and includes no plausibility values of zero. As a result, there are 15 plausibility values that are assessed and averaged for each scenario combination. For example, the plausibility value for scenario C_1 M_1 T_1 L_1 D_1 W_1:

$$= [(C_1M_1) + (C_1T_1) + (C_1L_1) + (C_1D_1) + (C_1W_1) + (M_1 T_1) + (M_1L_1) + (M_1 D_1) + (M_1 W_1) + (T_1 L_1) + (T_1 D_1) + (T_1 W_1) + (L_1 D_1) + (L_1 W_1) + (D_1 W_1)] * [2/(5 * 6)]$$

These values are used to refine and prioritize the most significant scenario configurations.

Tool Selection

In developing the software prototype, the first goal was to develop an initial stand-alone tool. The prototype could then be validated amongst a core group of users, with a view to potentially deploying the tool on a network at a future time. To meet the needs of these users, the prototype needed to meet the requirements identified:

- *Relational database:* providing the links to facilitate decomposition of dimensions into factors and variables; tagging of scenarios based on framework dimensions;
- *Field Anomaly Relaxation:* assignment of significance values, pair-wise comparisons, clustering/filtering, as well as monitoring and management of workflow; and,
- *Visualization:* graphical representation of results from FAR, as well as assessing coverage from existing set.

Scenario Characterization

The process of characterizing a FPS is similar to the FAR. Each FPS is characterized through a selection of variables, except that instead of using a scalar value for each variable, a binary selection from all driver and descriptor factors is selected. Within the FAR process, scenario combinations were developed using one variable from each factor. The resulting scenario combinations were very narrow representations of reality. The Force Planning Scenario development involves the creation of scenario clusters, where

[15] M.-T. Nguyen and M. Dunn, *Some Methods for Scenario Analysis in Defence Strategic Planning*.

each FPS is composed of several variables. For example, the FPS may describe a counter-insurgency (COIN) campaign theme that involves desert, mountain and urban terrains, as well as multiple unique red force adversaries. This cluster thus involves at several campaign combinations within the clustered FPS.

The drivers, descriptors and derivatives can be used to characterize both planning scenarios (to establish coverage) and past CF operations (to provide a benchmark). A number of historical case studies were used to populate a representative database. This provided a means to refer to historical operations in validating a set of proposed planning scenarios. The tool includes a dashboard that allows comparison between plausible scenarios (derived from FAR), planning scenarios and historical operations (Figure 12).

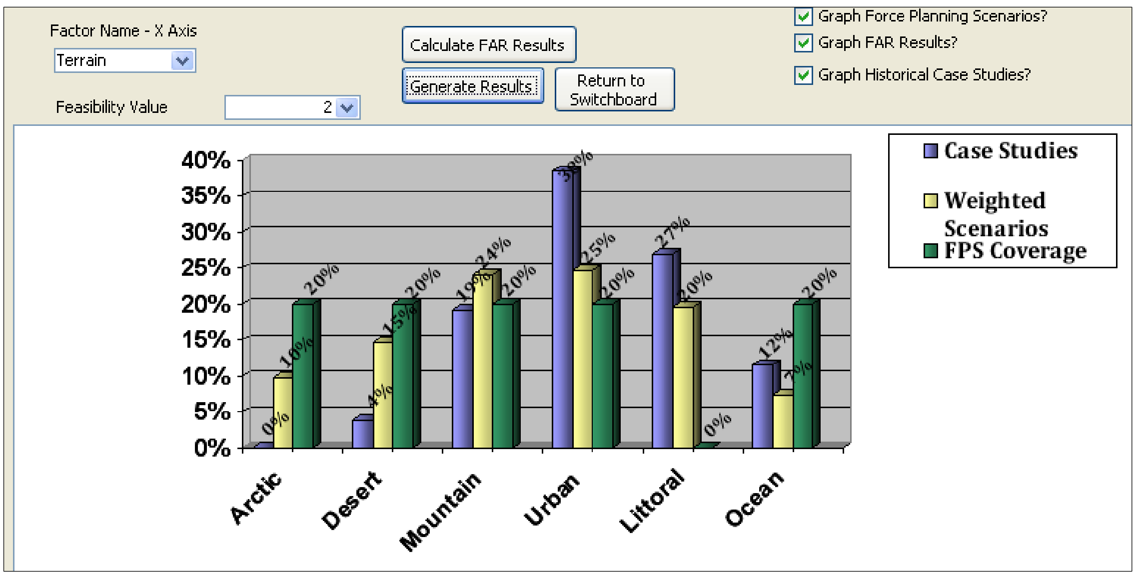


Figure 12: Scenario Analysis Dashboard (Includes Representative Data only)

Future Plans

There is currently no probabilistic model included in the framework. However, the methodology and tool can support the inclusion of absolute and relative probabilities necessary to support decision making. Future plans are to evolve the software tool into a web-based platform. An end-user validation has recently been completed, and the response to the scenario analysis tool has been generally been positive. The use of historical case studies to demonstrate how to employ the software tool proved to be particularly valuable in highlighting the capabilities and functionalities of the tool, and eliciting observations and insights from participants. Future work could include extending the framework and tool to support mission analysis, capability assessments and decision support within the larger planning and operational community.

Initial scenario development is completed using only drivers and descriptors, and as a result derivatives were highlighted as future work. The development and application of derivatives will have future benefits to the capability analysis community. A given FPS undergoes mission analysis, during which capabilities are applied to achieve the desired operational effects. The capabilities for each FPS can be aggregated and analyzed based on desired dimensions, and compared against the results from the FAR analysis. Capability managers are then able to make informed decisions within a rigorously developed operational context. When coupled with historical concurrency analysis, commonly-used critical capabilities can be identified for future investment.

Conclusion

This paper has described the key dimensions, factors and variables of a comprehensive, unified and tailorable framework for characterizing the FPS within the Canadian Department of National Defence. Like all models, the framework is a simplification of elements in the larger strategic environment that are likely to confront future defence forces. The intent is not to be definitive or predictive, but to generalize and ensure representativeness in designing scenarios that are plausible, relevant and challenging for the purposes of CBP. The development of a unified framework served as a start point from which to build a scenario analysis tool that has allowed Defence Scientists to assess the coverage of a given scenario set against a wide range of operating environments and conditions. The framework will be updated, modified and refined on an ongoing basis to reflect changes in defence policy, government priorities and the evolving international security environment. The process of analyzing scenarios against a range of dimensions, factors and variables provides a robust, defensible and transparent method for selecting and justifying scenario development and evolution to meet the requirements of CBP. By mapping the coverage of driving scenario dimensions, a balanced and relevant set of scenarios can be developed and maintained to ensure the development of CF capabilities across the spectrum of roles and environments.

With specific reference to C2 assessment, the tool is scalable and could be reconfigured to take into account different dimensions, factors and variables. C2 variables are probably not too dissimilar from the ones derived in the FPS framework and scenario analysis tool, and metrics (e.g., distribution of information, patterns of interaction) could even be developed to align to some of the values. However, it is important to remember that there are subtle differences between scenario analysis and C2 assessment. Scenarios are used within force development to build future defence forces, while C2 analysis focuses on themes related to situational awareness, quality of plans, information fusion/sharing and decision making. Force planning scenarios provide capability developers with an idea of possible C2 requirements. The primary purpose of scenarios, though, is to guide the development of flexible forces that can adapt to range of challenges in the strategic environment. While there are indeed some differences in definitions and assessment metrics, they amount to nuances. The underlying MA/FAR is probably the most appropriate and universally accepted method across the spectrum of organizations that develop and use scenarios. The foundation of scenario analysis, grounded in a morphological-based approach, will probably continue, and it would be advisable to ensure that these analytical methodologies are tested against allied approaches and industry practices as they continue to mature.