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DEPARTMENT OF NATIONAL DEFENCE
CANADA

OPERATIONAL RESEARCH DIVISION

DIRECTORATE OF OPERATIONAL RESEARCH (JOINT & LAND)

DOR(J&L) RESEARCH NOTE RN 2000/18

ASSESSING THE RISK OF CONCURRENT OPERATIONAL DEMANDS

Presentation to
The Seventeenth International Symposium on Military Operational Research (17th ISMOR)
Eynsham Hall, Oxford, England, 30 August 2000

By

R.W. Funk

OCTOBER 2000

OTTAWA, CANADA

National Defence Défense nationale

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R.W. FUNK

Recommended By: T/L SPORT   Approved by: for DOR (J&L)

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OTTAWA, CANADA   OCTOBER 2000

ABSTRACT

The dynamics of the new strategic environment and increased emphasis on operations other than war have caused Canada to seek a better understanding about how the risk of concurrent activities influences the mix of capabilities that are selected. One approach is to simulate the activation of demands within an analysis framework called the Scenario Operational Capability Risk Assessment Model (SOCRAM).

The model utilizes a rigorous analysis structure that requires Strategic Planners to specify capability requirements, first in conceptual terms. Then, the conceptual principles are related to force structure elements (equipment and units) that satisfy the requirements. SOCRAM uses these to calculate the risk associated with each capability, within a force structure, based on the demand generated by concurrent operations.

The presentation will provide an overview of the concepts integrated into SOCRAM and then describe how it was used to generate the distribution of operational demands for a key Air Force structure review.

RÉSUMÉ

La dynamique du nouvel environnement stratégique et l'importance accrue accordée aux opérations autres que la guerre amènent le Canada à vouloir mieux comprendre comment le risque d'être confronté à des activités simultanées influe sur la diversité des capacités qui sont sélectionnées. Une méthode consiste à simuler l'activation des demandes dans un cadre d'analyse appelé le Modèle d'analyse des risques de capacité opérationnelle fondée sur des scénarios (MARCOS).

Le modèle utilise une structure analytique rigoureuse qui exige des planificateurs stratégiques qu'ils indiquent les besoins en capacité. Exprimés en termes conceptuels d'abord, les principes ainsi dégagés sont ensuite associés à des éléments de la structure des forces (équipement et unités) qui permettent de répondre aux exigences. MARCOS utilise ces éléments pour calculer le risque associé à chaque capacité, à l'intérieur d'une structure des forces, en fonction de la demande générée par des opérations simultanées.

La présentation offrira une vue d'ensemble des concepts intégrés à MARCOS, pour ensuite décrire comment il a été utilisé pour répartir les exigences opérationnelles associées à un important examen de la structure de la Force aérienne.

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ASSESSING THE RISK OF CONCURRENT OPERATIONAL DEMANDS

I – INTRODUCTION

BACKGROUND

1. The Scenario-Based Capability-Planning Framework being developed by the Strategic Planning Operational Research Team (SPORT) requires a mechanism to examine aggregate demands simulated by the rigorous activation of concurrent events. The Scenario Operational Capability Risk Analysis Model (SOCRAM), a discrete event simulation to assess the cumulative demand imposed by the distribution of activated scenarios, is being developed with this in mind.

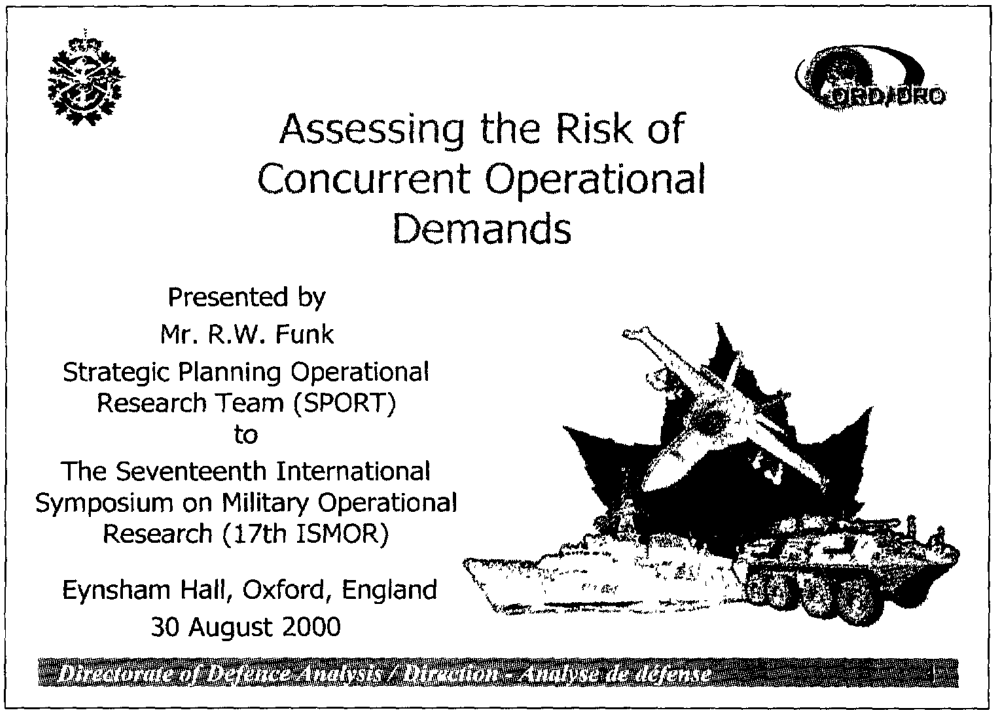
2. SOCRAM has been discussed at length within the Department [1-2] and been exposed to external audiences [3] as it evolved over the past two years. The Department's confidence in the potential viability of the methodology has reached the point to where SOCRAM is considered as a key methodology [4] to quantify the risks associated with responding to the sanctioned Force Planning Scenarios (FPS) as identified in the Defence Planning Guidance (DPG) [5].

3. This document covers the content of a briefing on SOCRAM given to the Seventeenth International Symposium on Military Operational Research (17th ISMOR), Eynsham Hall, Oxford England. The presentation focused on a configuration of the model used to assess the operational risk of air fleet alternatives during an Air Force Structure Exercise. The briefing highlighted significant breakthroughs in the methodology for assessing risk as well as presenting the results. The details have been incorporated in explanatory notes accompanying each slide.

4. It is the author's intention to combine the points raised with more detailed technical descriptions as part of a comprehensive document to formally explain the SOCRAM methodology and its implementation to date.

II - PRESENTATION

OPENING REMARKS



Slide 1: Title Slide

5. This presentation records the state of development work and helps to serve as part of the corporate scientific memory of the directorate. The contents do not necessarily reflect the view of the Operational Research Division or the Canadian Department of National Defence.

6. Questions are welcome and can be directed to:

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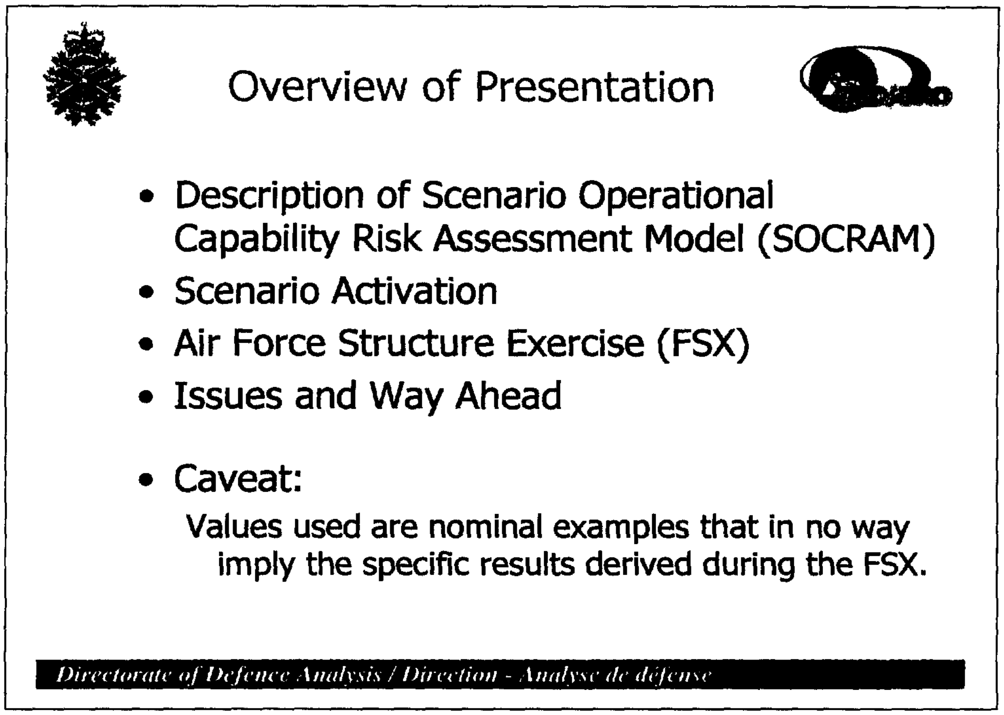


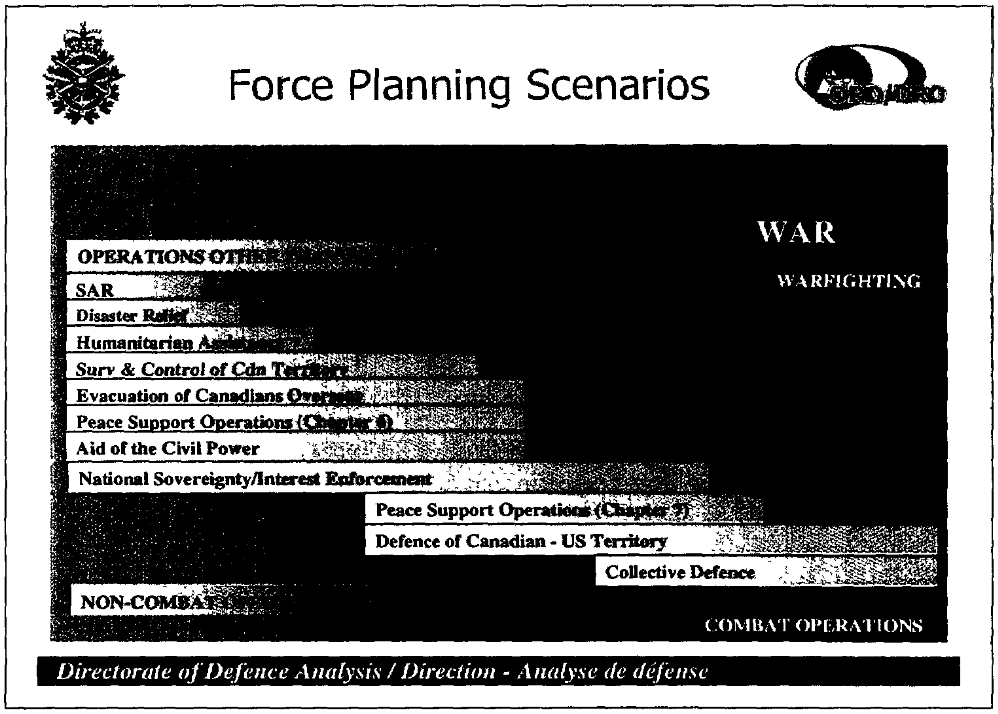
Slide 2: Overview of Presentation

7. The dynamics of the global strategic environment and an increased emphasis on operations other than combat have caused Canada to seek a better understanding about how the risk of concurrent activities influence the mix of capabilities that are selected. One approach is to simulate the activation of demands within an analysis framework called the Scenario Operational Capability Risk Assessment Model (SOCRAM).

8. The presentation explains how the model follows a rigorous analysis structure that requires Strategic Planners to specify capability requirements, first in conceptual terms. Then, the conceptual principles are related to force structure elements (equipment and units) that satisfy the requirements. SOCRAM uses these to calculate the risk associated with each capability, within a force structure, based on the demand generated by concurrent operations.

9. The presentation will provide an overview of the concepts integrated into SOCRAM and then describe how it was used to generate the distribution of operational demands for a key Air Force structure review.

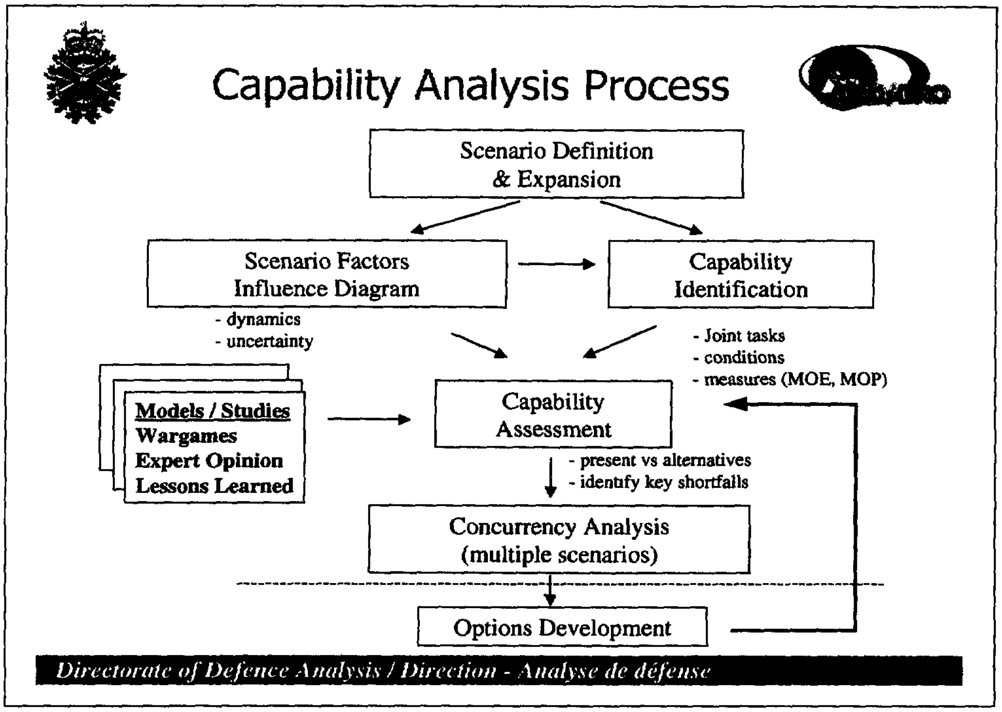
PLANNING ENVIRONMENT



Slide 3: Force Planning Scenarios

10. The Force Planning Scenarios (FPS) are a set of eleven scenarios that provide the context in which CF operates and use this to assess its capability requirements and force structure options. They span the spectrum of conflict (as shown above) and describe representative demands. The scenarios will evolve as required to ensure they continue to reflect the strategic environment and the national defence policy. A brief description of each scenario is contained in the Defence Planning Guidance (DPG).

11. More detailed descriptions of the scenarios are available from the OPI, Director General Strategic Planning/Director Defence Analysis (DGSP/DDA), or on the DDA Internet and Intranet sites. Requirements for capability, readiness, sustainability and deployability will be derived from the scenarios in conjunction with Defence Objectives and Tasks.



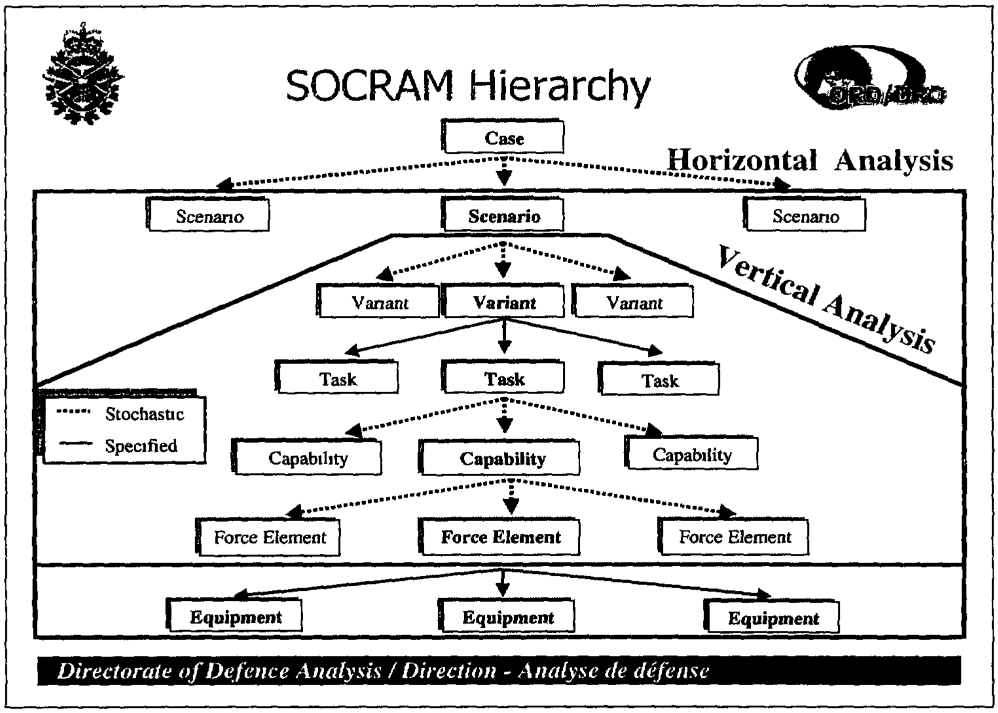
Slide 4: Capability Analysis Process

12. The FPS Project is developing analysis tool sets to deal with each specific component in the slide and will integrate them in a comprehensive Capability Analysis Process (CAP).

13. CAP is designed to ensure all aspects of capability requirements are rigorously considered. It starts with the definition and expansion of a scenario to include the recognition of factors and influences that affect the scenarios using the Canadian Joint Task List (CJTL) as the capability catalogue. These results are integrated into a formal capability assessment that draws upon the most applicable models and studies available to ensure each scenario has been thoroughly analyzed. The capabilities can be constrained to cover any mix of existing or planned capabilities the user needs to assess.

14. The final step in CAP is a rigorous Concurrency Analysis which is really a reality check to ensure the cumulative impact of multiple scenarios have been properly considered. This presentation focuses on the conceptual framework behind the Concurrency Analysis and then describes its implementation in support to the Air Force Structure Exercise (FSX).

PRINCIPLES BEHIND SOCRAM



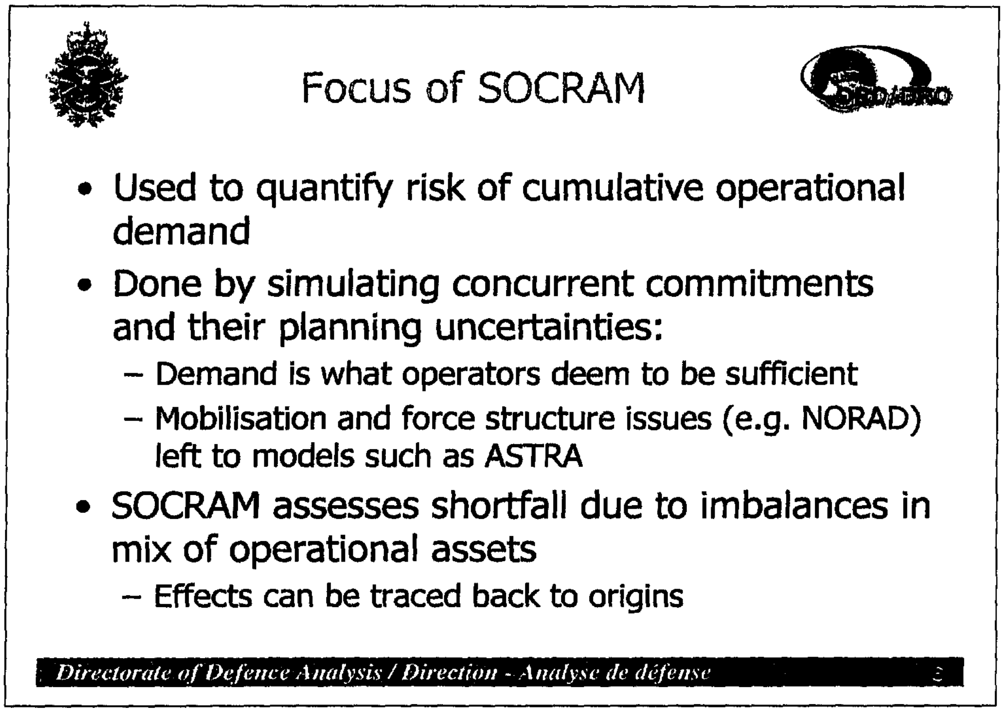
Slide 5: SOCRAM Hierarchy

15. The easiest way to explain SOCRAM relationships is through a hierarchical view which at each level translates theoretical concepts into more practical constructs. The terminology in SOCRAM may appear to be convoluted but it is actually quite logical.

16. The most significant aspect of the vertical analysis within scenarios is that four of the five levels involve linkages of feasible interactions that can involve probability functions. The top two levels activate variations within scenarios to specify the capabilities as tasks to be performed under a set of conditions. The third link converts tasks into practical implementation constructs called capabilities. The fourth linkage translates these into viable combinations of operational entities called force elements. The fifth linkage converts cumulative requirements into equipment to account for employment between competing scenarios of multiple capability platforms. As an example, Humanitarian Assistance (level 1 – scenario) has a response that involves the deployment of the DART (level 2 – variant) that requires strategic lift (level 3 – capability) using air transport (level 4 - force elements) made up of CC130 Hercules aircraft (level 5 –equipment).

17. The horizontal analysis calculates the impact of activating several concurrent scenarios. As the presentation will show, simulating the possible outcomes leads to an accumulation of evidence that can be analyzed as the basis for assessing the risk of shortages due to concurrent demands.

18. Force generation and attrition allowances must be factored into an asset mix before it is converted into any specific force structure. SOCRAM leaves this analysis to force structure applications because of the great deal of details required prior to selecting a specific configuration.



Slide 6: Focus of SOCRAM

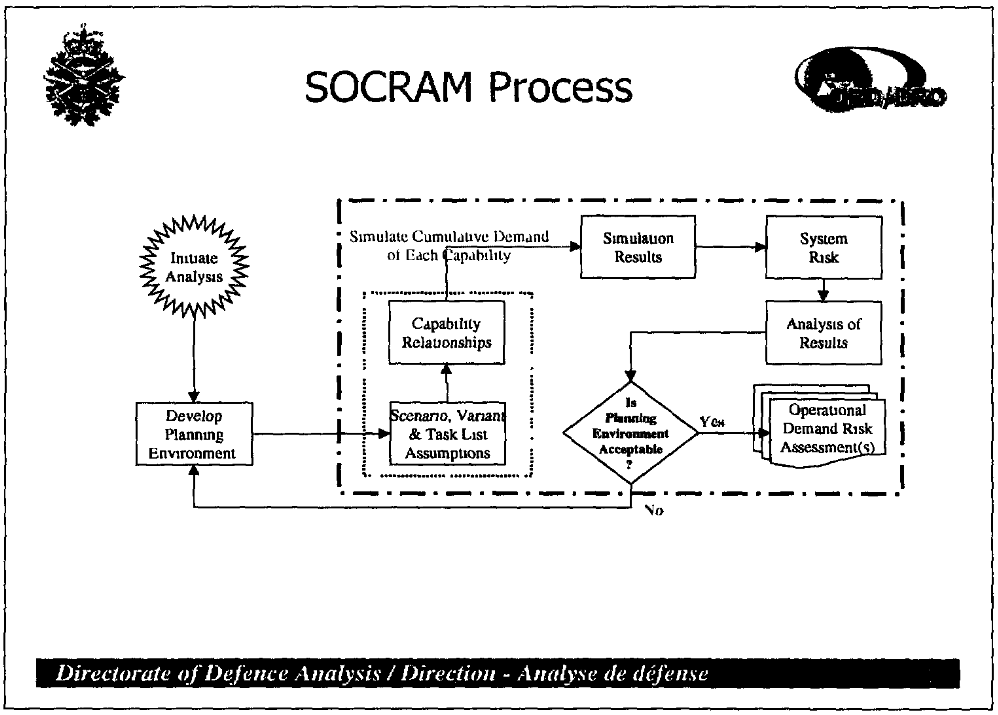
19. SOCRAM provides an indicative and descriptive overview of how major components of operational demand accumulate at the macro level. The key aspects about SOCRAM are:

a. It provides a method of articulating and activating scenario interactions that is methodologically sound and recognizes the practical limitations of the available data;

b. It is based on analysis principles which focus on capturing a set of practical business rules and articulating them within a sensible framework that is logical to the strategic planning staffs. The intent is to avoid, to the extent possible, the imposition of any new conceptual constructs on top of an already confusing situation; and,

c. Risk is assessed as the percentage of time that a given level of demand is exceeded. The data come from evidence accumulated through a systematic simulation of scenario interactions. The users specify the level of demand that satisfies each activated scenario.

20. SOCRAM does not attempt to be everything to all people. It is neither definitive nor prescriptive in its conclusions because it avoids detailed calculations where broad relationships will suffice.

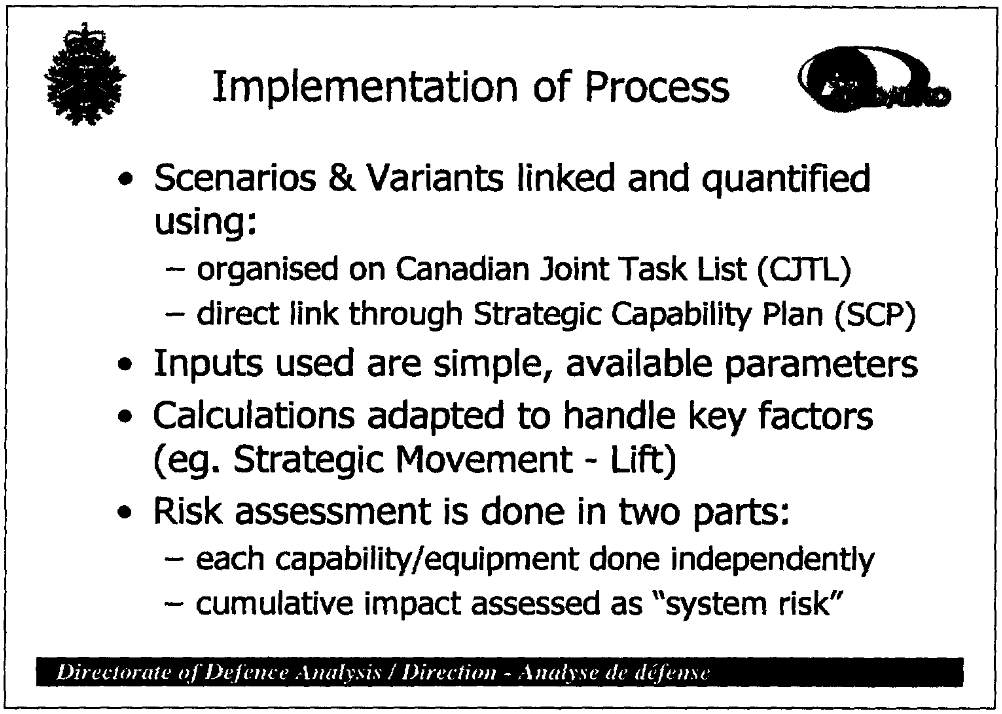


Slide 7: SOCRAM Process

21. The SOCRAM process begins with definition of the planning environment. The key factors include the rates by which scenarios and their variants are activated. Next, the selected responses are related to capabilities via tasks to be performed and then through force elements to equipment platforms.

22. The uncertainties of the planning environment are synthesized by simulating the potential interaction of scenarios and tabulating the results into a matrix. This data set is analyzed to determine the risk that the system has inadequate assets to fulfill the operational demands.

23. The results are analyzed using a variety of displays to gain insight into various aspects of the problem. The analyst uses these to assess how well the simulation portrays the planning environment. Sensitivity analysis of the planning inputs are then used to refine the estimates. The final operational risk assessments are then made available for any subsequent force structure analyses.



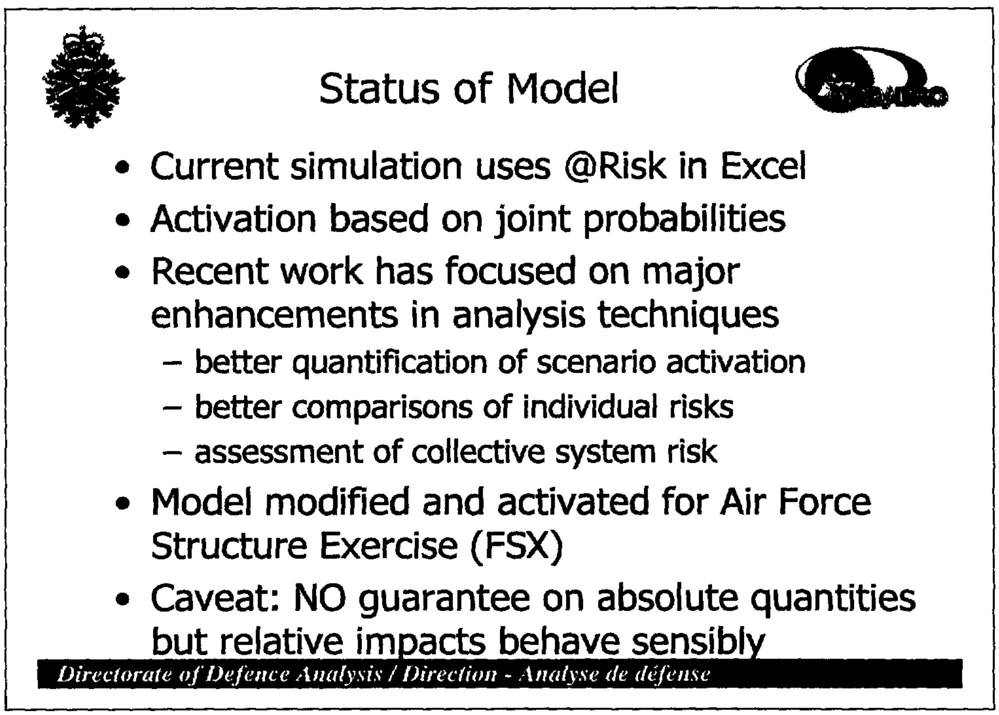
Slide 8: Implementation of Process

24. The bulk of the SOCRAM simulation effort is to specify the valid set of scenario and variation combinations, link them together and develop a mechanism to activate them. The associated set of capabilities involve a combination of relevant tasks and constraints organized around the Canadian Joint Task List (CJTL) as modified through the Strategic Capability Plan (SCP) matrix to specify the level of autonomy or coalition contribution required for each task.

25. An important feature of SOCRAM is to ensure the parameters used in the model are both simple and readily available. The hierarchy is designed so it can be readily adapted to handle whatever calculations are required. An example of this is the Strategic Movement calculation which is covered later on in this presentation. Metrics of each capability are specified independently.

26. Once the framework is in place, it is a simple case to simulate the activation of scenarios and accumulate resulting iterations into a data table. The data is used as the basis to calculate the risk (i.e. percentage of time) a given level of each demand is exceeded.

27. System risk is a term developed to specify the ability of a set of capabilities to fulfill the range of possible outcomes. It is calculated by comparing the asset mix to all iterations of the simulation in order to determine the percentage of time the asset mix falls short of the cumulative demand.



Slide 9: Status of Model

28. The current version of the SOCRAM is laid out as a spreadsheet in Excel and uses @Risk to run the simulation. The scenarios are activated using a random variable to select the permutation to which the joint probability corresponds.

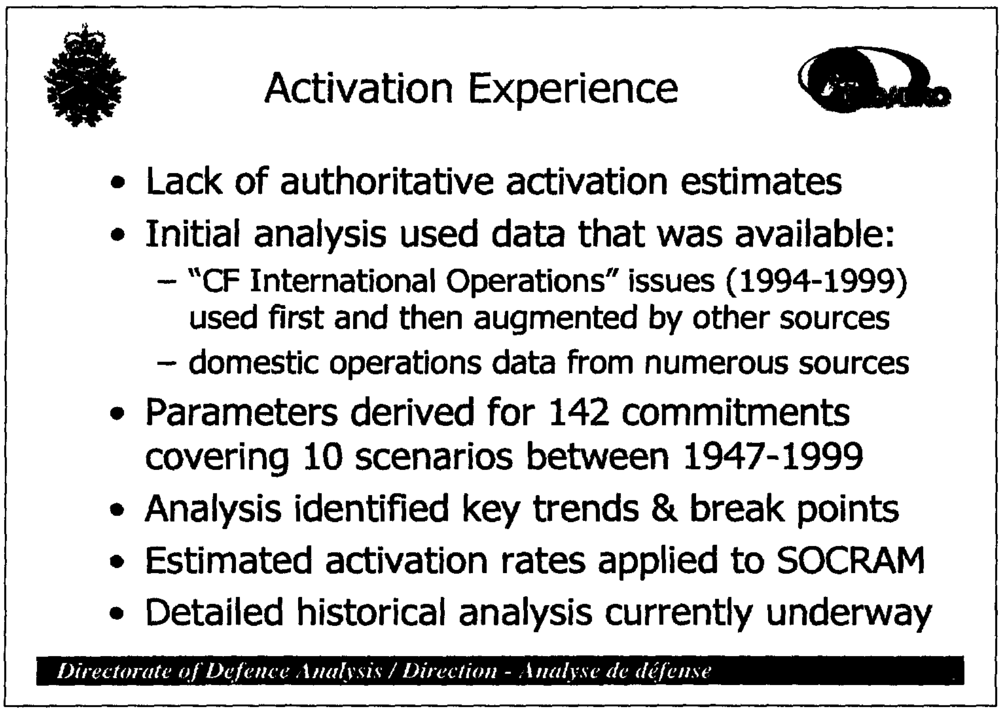
29. Recent work has focused on major enhancements in analysis techniques to allow:

a. better quantification of scenario activation;

b. better comparisons of individual risks; and

c. more accurate assessment of collective system risk.

30. The latest versions of the model was modified to take the above into account and then activated it to support the Air Force Structure Exercise (FSX). The rapid development comes at a price; the above effort produces relative impacts that behave sensibly but there is NO guarantee about the absolute quantities that are produced by this specific SOCRAM implementation.



Slide 10: Activation Experience

31. At the start of the project there was a general awareness that concurrency is an issue but there was no general agreement or definitive guidance as to what activation estimates to use. It was therefore decided to conduct an assessment of past experience to infer what to expect as patterns of activation. The initial analysis used data that was available and it consisted of two major parts:

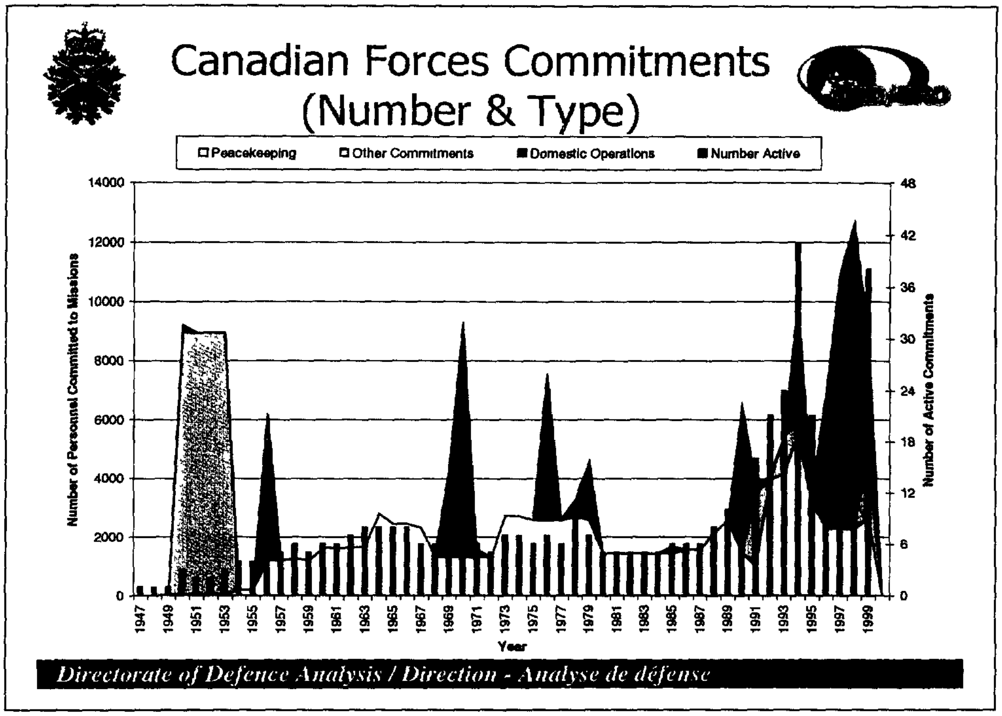
a. "CF International Operations" issues (1994-1999) used first and then augmented by other sources; and,

b. Domestic operations data from numerous sources.

32. The data collation effort derived several parameters for 142 commitments covering 10 scenarios between 1947-1999. Next the analysis identified key trends & break points. These estimated activation rates were then applied to SOCRAM. The initial effort was recognized as being incomplete; a much more detailed historical analysis is currently underway.

33. A word of caution is needed about what the activation rates describe. SOCRAM assumes the derived probabilities are for the instantaneous rate of activation (i.e. at a point in time rather than over a prescribed period). The current activation method assumes that any activated set of variants will be completed before the next set is activated. This assumption is in the process of being scrutinized to ensure it is sensible. Note that the SOCRAM framework retains its utility even if this key activation assumption has to be revised.

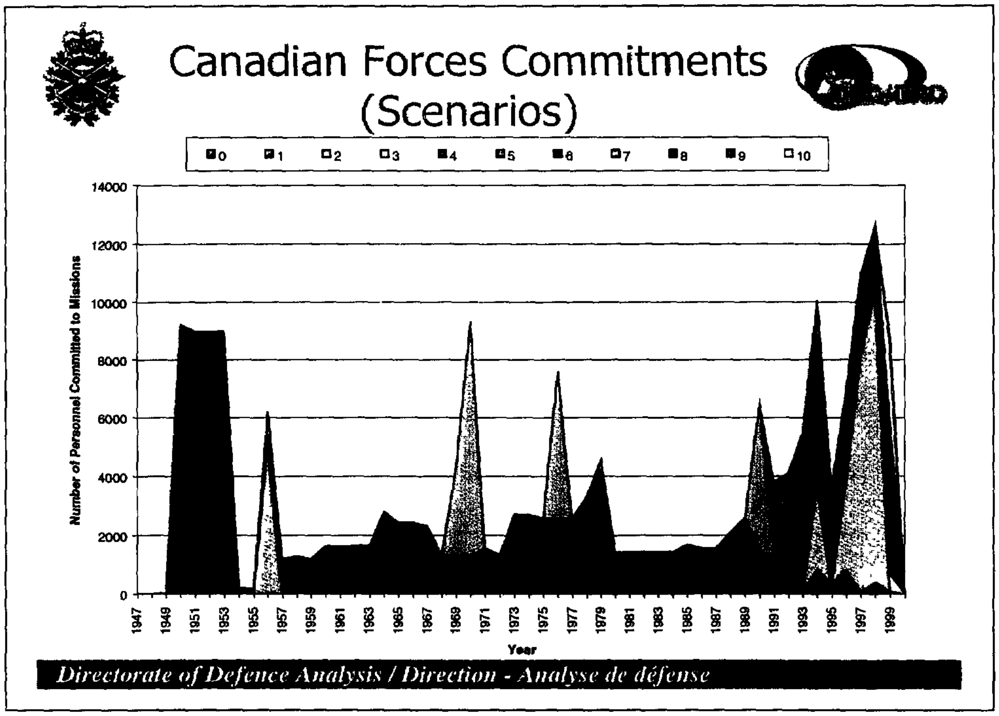
ANALYSIS OF CANADIAN FORCES COMMITMENT EXPERIENCE



Slide 11: Canadian Forces Commitments (Number and Type)

34. The analysis of the data set started with compilation of a timeline to display available data to identify any obvious trends. The most obvious display was to tabulate the personnel deployments in response to CF commitments since the end of the Second World War (WWII). This was accomplished by using the available data to estimate the annual personnel demand for each commitment between its start and end years. Personnel shown here are limited to those that are deployed away from permanent infrastructure, including Canada's European Bases.

35. The figure displays the timeline segmented by type to illustrate the nature of the commitments. The graph clearly indicates several of the major deployments that could easily be traced back to their cause; the Korean War 1950-1953, Red River Flooding (1956), the October crisis in 1971, the Persian Gulf War (1991) and the Ice Storm (1998). The graph illustrates that prior to 1990 the nature of commitments was one of relative stability involving ongoing peacekeeping efforts with only a few major interjections due to a variety of domestic operations. During the 1990s, the number of deployed personnel exhibited an abrupt shift that occurred in tandem with a fundamental shift in both the number and variety of commitments.

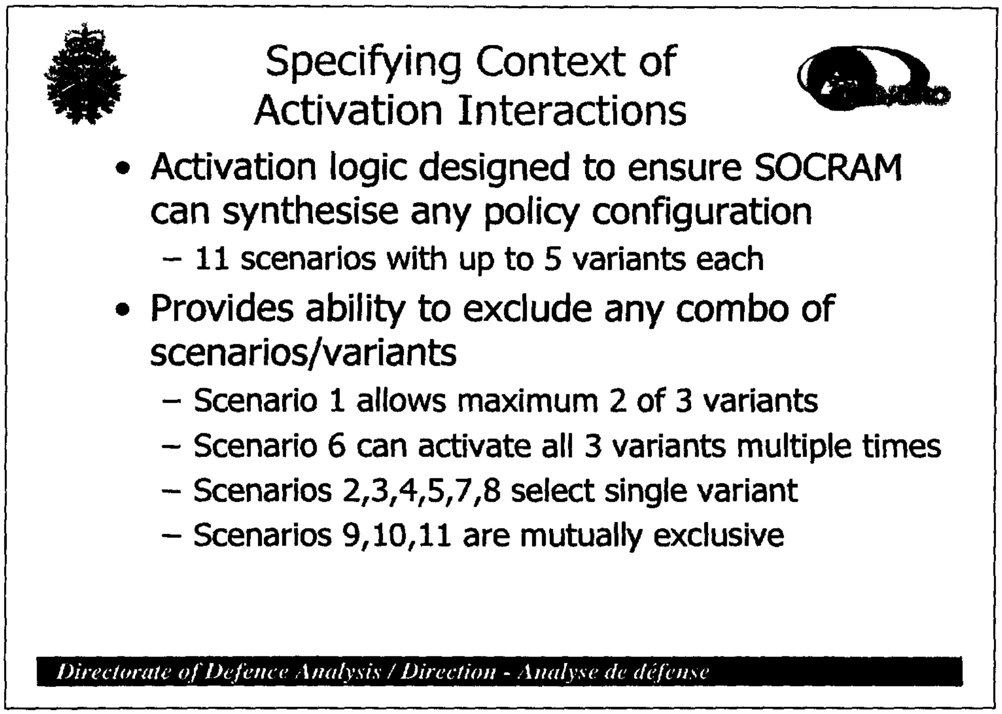


Slide 12: Canadian Forces Commitments (Scenarios)

36. The figure illustrates how during the Cold War the focus of effort was centered on Scenario 6 - Peacekeeping superimposed with a few major domestic operations. In 1990, an abrupt shift occurred in the tempo, variety and location of commitments. In effect, Canada shifted from a static defence posture involving a reactive policing role to deploying forward in support of government policy of proactive direct intervention. The change included a significant shift towards Scenario 3 - Humanitarian Assistance and Scenario 9 - Peace Support Operations (Chapter 7).

37. A review of the regions involved also demonstrated how the Cold War commitments were focused in the Middle East and Asia but then shifted to the Balkans, Africa and Central America during the 1990s. The last decade also saw a major increase in the variety and extent of domestic operations.

38. The scenario commitments are clearly mingled together. It also highlights the increased volatility during the 1990s when a much wider variety of scenarios were activated for far shorter periods.



Slide 13: Specifying Context of Activation Interactions

39. The historical activation rates are useful but SOCRAM has to be kept as generic as possible if it is to provide planning insights. As a consequence, a great deal of effort was invested into designing activation logic into SOCRAM so it can synthesize different policy configurations. The result is a spreadsheet can handle the activation of any permutation of up to 11 simultaneous scenarios with each having up to 5 simultaneous variants (and more can be accommodated).

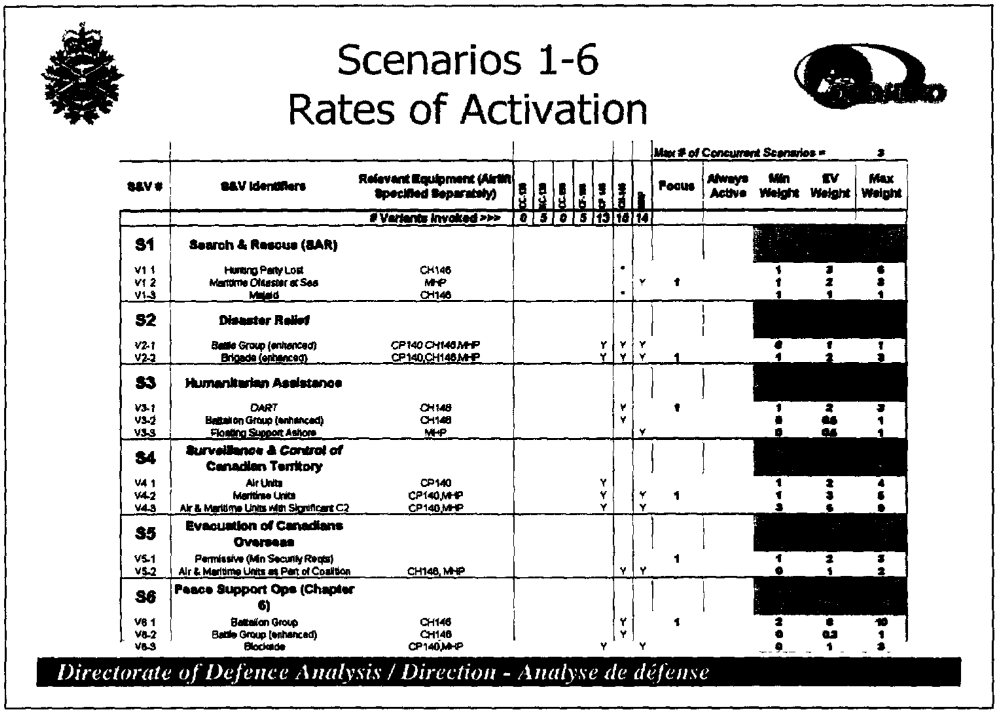
40. The range of permutations is impressive but the activation logic's greatest power comes from its ability to exclude any combination of scenarios or variants and thereby automatically adjust the affected distribution functions. The following example policy modifications illustrate the range of planning flexibility that is allowed:

a. Scenario 1 allows maximum 2 of 3 variants

b. Scenario 6 can activate all 3 variants multiple times

c. Scenarios 2, 3, 4, 5, 7, 8 select single variant

d. Scenarios 9,10,11 are mutually exclusive



Max # of Concurrent Scenarios = 3

S&V #	S&V Identifiers	Relevant Equipment (Airlift Specified Separately)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Focus	Always Active	Min Weight	EV Weight	Max Weight
		# Variants Invoked >>>	0	5	0	5	13	16	14					
S1	**Search & Rescue (SAR)**													
V1 1	Hunting Party Lost	CH146						•				1	3	6
V1 2	Maritime Disaster at Sea	MHP							Y	1		1	2	3
V1-3	Majaid	CH146						•				1	1	1
S2	**Disaster Relief**													
V2-1	Battle Group (enhanced)	CP140 CH146,MHP					Y	Y	Y			0	1	1
V2-2	Brigade (enhanced)	CP140,CH146,MHP					Y	Y	Y	1		1	2	3
S3	**Humanitarian Assistance**													
V3-1	DART	CH146						Y		1		1	2	3
V3-2	Battalion Group (enhanced)	CH146						Y				0	0.5	1
V3-3	Floating Support Ashore	MHP							Y			0	0.5	1
S4	**Surveillance & Control of Canadian Territory**													
V4 1	Air Units	CP140					Y					1	2	4
V4-2	Maritime Units	CP140,MHP					Y		Y	1		1	3	5
V4-3	Air & Maritime Units with Significant C2	CP140,MHP					Y		Y			3	6	9
S5	**Evacuation of Canadians Overseas**													
V5-1	Permissive (Min Security Reqts)									1		1	2	3
V5-2	Air & Maritime Units as Part of Coalition	CH146, MHP						Y	Y			0	1	2
S6	**Peace Support Ops (Chapter 6)**													
V6 1	Battalion Group	CH146						Y		1		2	6	10
V6-2	Battle Group (enhanced)	CH146						Y				0	0.2	1
V6-3	Blockade	CP140,MHP					Y		Y			0	1	3

Slide 14: Scenarios 1-6 Rates of Activation

41. The historical analysis was used to calculate rates of activation. Scenarios 1-6 are displayed in the above slide. These scenarios are those that occur fairly frequently because they are at the lower end of the spectrum of conflict. There is ample historical evidence in this area so the reliability of the estimates should remain quite stable. That said, the confidence in the values must be considered with some caution because the activation experience is largely driven by the government's willingness to take on the obligations. In the past, the rates of activation were based on a larger military force so it remains to be seen if the military can continue to sustain this tempo of operations.

42. The associated variants can have significantly different weights because the body of evidence suggests some bias towards certain variants within a scenario. In the cases displayed here, the "guesstimated" values were those applied by the analyst and do NOT reflect government policy on levels of appropriate response to any given scenario.

Scenarios 7-11 Rates of Activation

Max # of Concurrent Scenarios = 3

S&V #	S&V Identifiers	Relevant Equipment (AirRR Specified Separately)	CC-130	KC-130	CC-150	CF 188	CP-140	CH-146	MHP	Focus	Always Active	Min Weight	EV Weight	Max Weight
		# Variants Invoked >>>	0	5	0	5	13	15	14					
S7	**Aid of the Civil Power**													
V7-1	Battle Group (enhanced)	CH146						Y				0	0.6	1
V7-2	Brigade (enhanced)	CH146						Y		1		1	1	1
S8	**National Soverlegnty & Enforcement**													
V8-1	Surveillance Assets	CP140, MHP					Y		Y	1		1	1	1
V8-2	Escalation to Violence	KC130, CF188,CP140, MHP		Y		Y	Y		Y			1	1	1
S9	**Peace Support Ops (Chapter 7)**													
V9-1	Battle Group (enhanced)	CH146						Y				1	1	1
V9-2	Vanguard Brigade	CH146						Y				1	1	1
V9-3	Vanguard Air Squadron	KC130, CF189		Y		Y				1		1	1	1
V9-4	Task Group	CP140, MHP					Y		Y			1	1	1
S10	**Defence of Canada-US Territory**													
V10-1	Brigade (enhanced)	CH146						Y				1	1	1
V10-2	Full MCF	KC130, CF188 CP140 CH146 MHP		Y		Y	Y	Y	Y	1		1	1	1
S11	**Collective Defence**													
V11 1	Vanguard Brigade	CH146						Y				1	1	1
V11-2	Vanguard Air Squadron	KC130, CF188,CP140		Y		Y	Y					1	1	1
V11-3	Task Group	CP140 MHP					Y		Y			1	1	1
V11-4	Full MCF	KC130, CF188, CP140, CH146, MHP		Y		Y	Y	Y	Y	1		1	1	1

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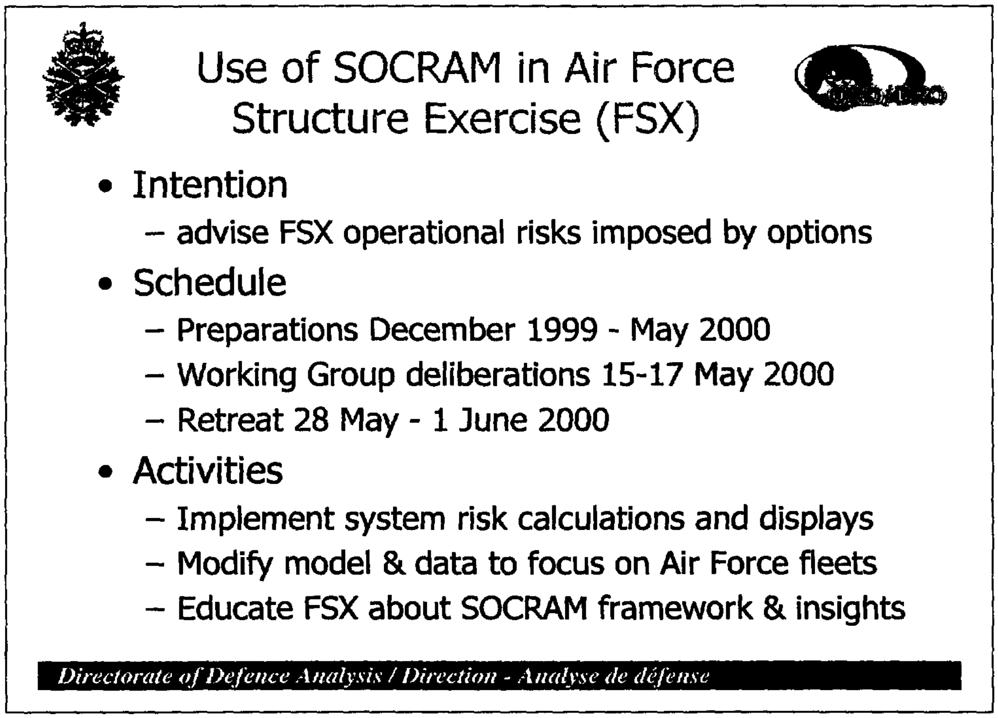
Slide 15: Scenarios 7-11 Rates of Activation

43. The calculated rates of activation for scenarios 7-11 are displayed in the above slide. Overall, these scenarios are estimated to occur less frequently than scenarios 1-6. This is in keeping with the fact that they are at the higher end of the spectrum of conflict. The scant historical evidence in this area also implies greater uncertainty about the reliability of the estimates. That said, the confidence in the values are vastly superior to the previous guesses that were used to bound the problem.

44. The variants tend to be equally weighted in these scenarios because the lack of evidence to support any strong bias towards any one variant.

AIR FORCE STRUCTURE EXERCISE (FSX) USE OF SOCRAM

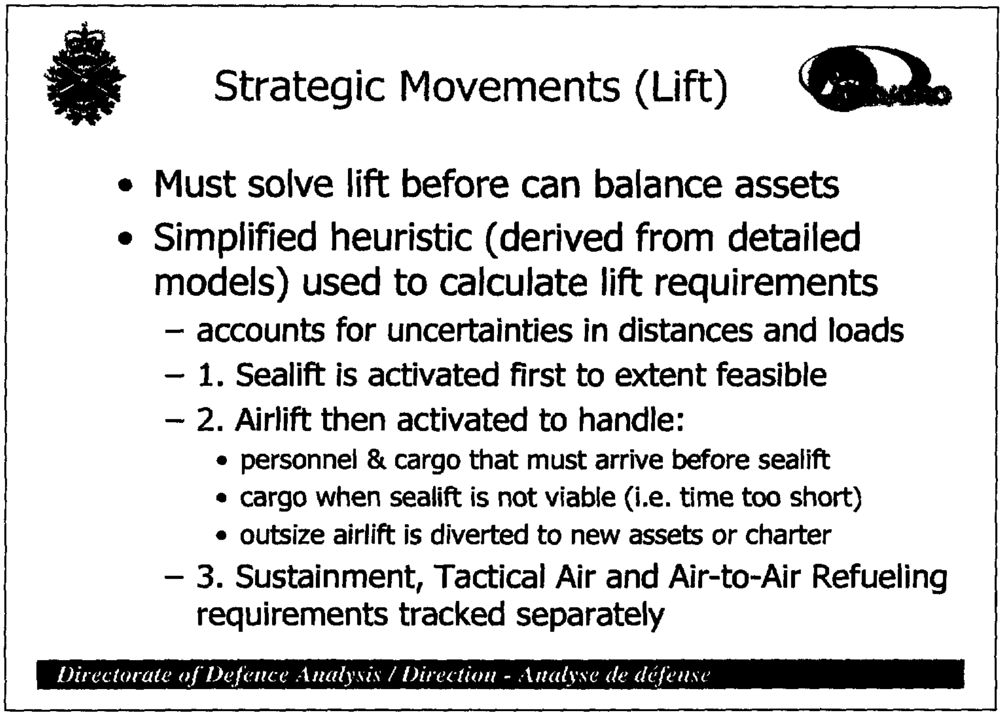


Slide 16: Use of SOCRAM in Air Force Structure Exercise (FSX)

45. When the Air Force Structure Exercise (FSX) was first announced, the original intention was to use SOCRAM to advise the FSX participants on the operational risks imposed by the selected options. The actual force structure deliberations were to be handled by a separate model called the Air Structure Analysis (ASTRA) model.

46. The schedule to support the FSX started in December 1999 and involved an overhaul of the basic SOCRAM model. The modifications were done so the model and data focused on Air Force fleets. Another major effort involved the implementation of system risk calculations and displays to support the analysis of the SOCRAM outputs.

47. The development effort continued up to the point of the Working Group deliberations 15-17 May 2000. At this point the focus shifted to explaining the potential of the analytical approach and then working with the operators to specify the airframe demands for each variant. During the Retreat 28 May - 1 June 2000 the SOCRAM model was adjusted to keep it aligned with the latest operator discussions and then run at the end of the FSX.



Slide 17: Strategic Movements (Lift)

48. During the development of the FSX version of SOCRAM the discussions pointed out the need to solve strategic movement (lift) requirements before we could hope to balance the remaining assets.

49. A simplified heuristic was developed that accounts for uncertainties in distances and loads using the following steps:

a. Sealift is activated first to the extent feasible;

b. Airlift then activated to handle;

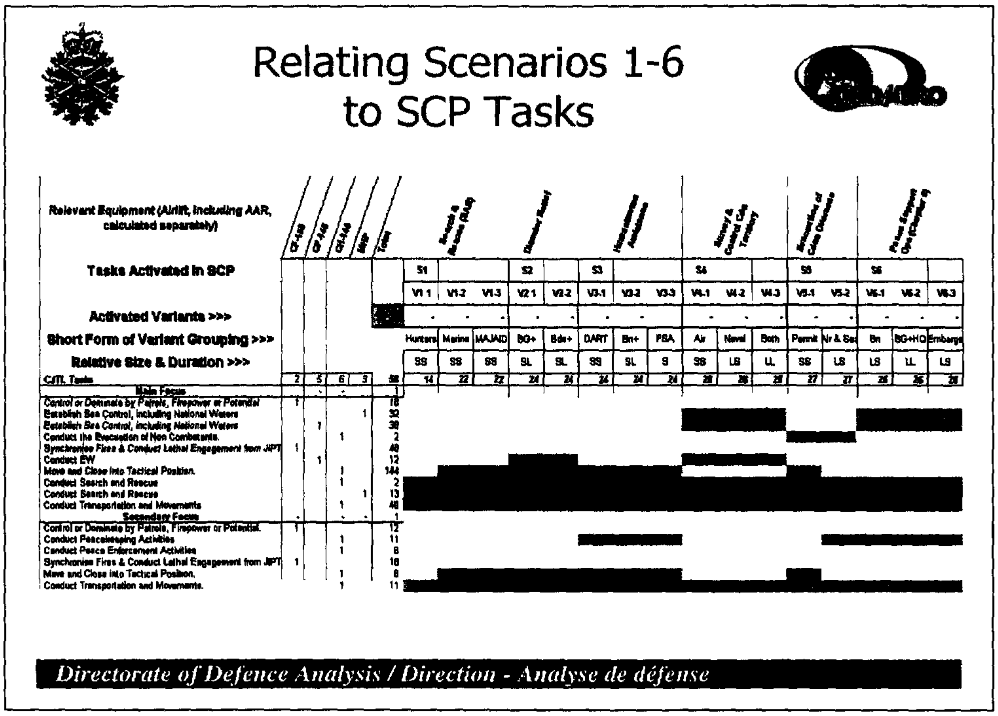
(1) personnel & cargo that must arrive before sealift

(2) cargo when sealift is not viable (i.e. time too short)

(3) outsize airlift is diverted to new assets or charter, and

c. Sustainment, Tactical Air and Air-to-Air Refueling requirements are tracked separately.

50. The heuristic was derived from detailed strategic lift models and in no way attempts to replace them. Instead it strives to cover off the salient features that reasonably approximate the demand for lift. Any question requiring precise lift quantities must be referred back to the detailed models detailed assessment.

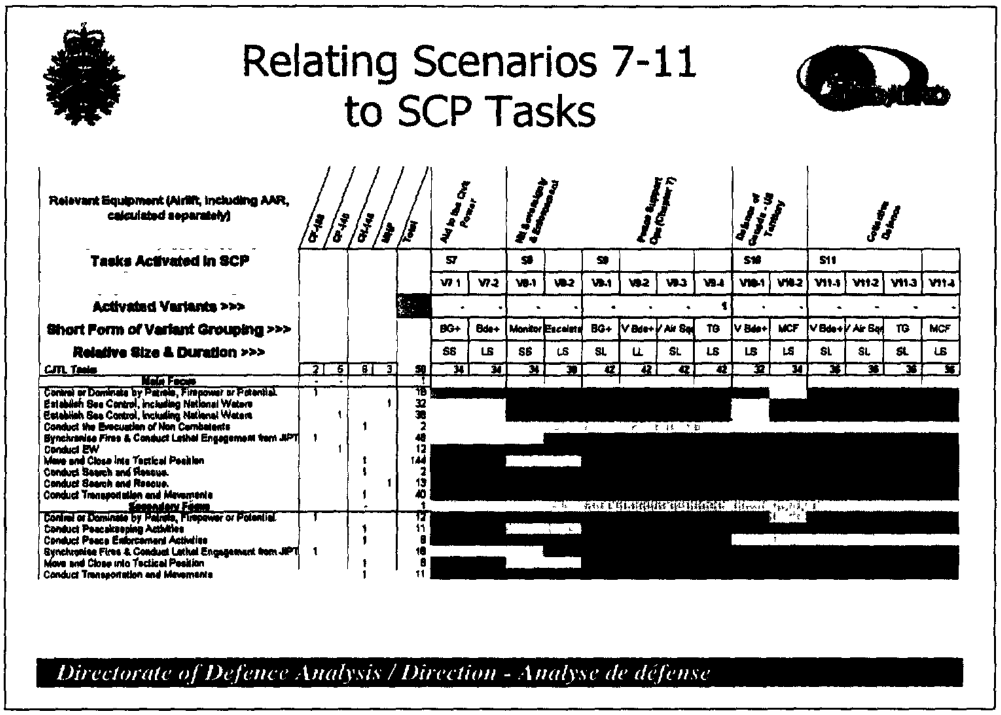


Slide 18: Relating Scenarios 1-6 to SCP Tasks

51. As part of the FSX preparations, SOCRAM was modified to focus on the set of current air fleets conducting operations in support of the current policy objectives. As a result, the CJTL and SCP matrix referred to earlier was reduced to the relevant set of tasks and equipment types. As well the relevant entries were made at levels of response that the operators felt were sufficient to perform the assigned tasks. The use of main and secondary tasks relates to force structure options and does not impact on the operational demands.

52. SCP matrix displays in blue the subset of tasks the operators have assessed as being part of a relevant response. In theory, each variant's capability requirements can be split across several tasks. However, each capability is focused on one major dominant task the other tasks represent associated collateral duties. This simplifies the set of relevant tasks to one per capability. The other blank blue cells contain relevant collateral tasks that the airframe is capable of fulfilling.

53. The SCP matrix for scenarios 1-6 highlights the tendency to use CP 140 (Maritime Patrol Aircraft), CH146 (Tactical Helicopter) and the MHP (Maritime Helicopter) in low-end humanitarian focused scenarios. Note that the associated lift requirements are identified using a separate algorithm.

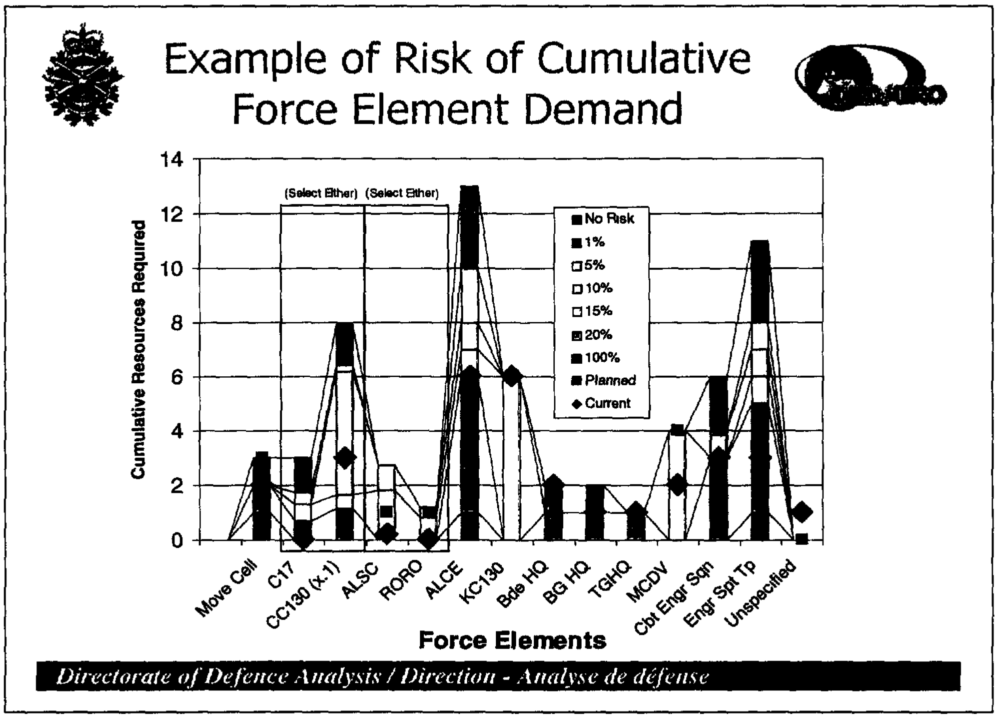


Slide 19: Relating Scenarios 7-11 to SCP Tasks

54. The SCP matrix for scenarios 7-11 is similar to the previous figure but with several distinct differences. The higher end of the conflict spectrum tends to call for more types of aircraft and greater quantities of each. Also the CF188 (Fighter) becomes a major player in several planned variant responses.

55. The expansion of the blue area of relevant tasks also illustrates the tendency for higher end conflicts to call up a much fuller range of capabilities than the low-end scenarios.

VISUALIZATION OF SOCRAM RESULTS

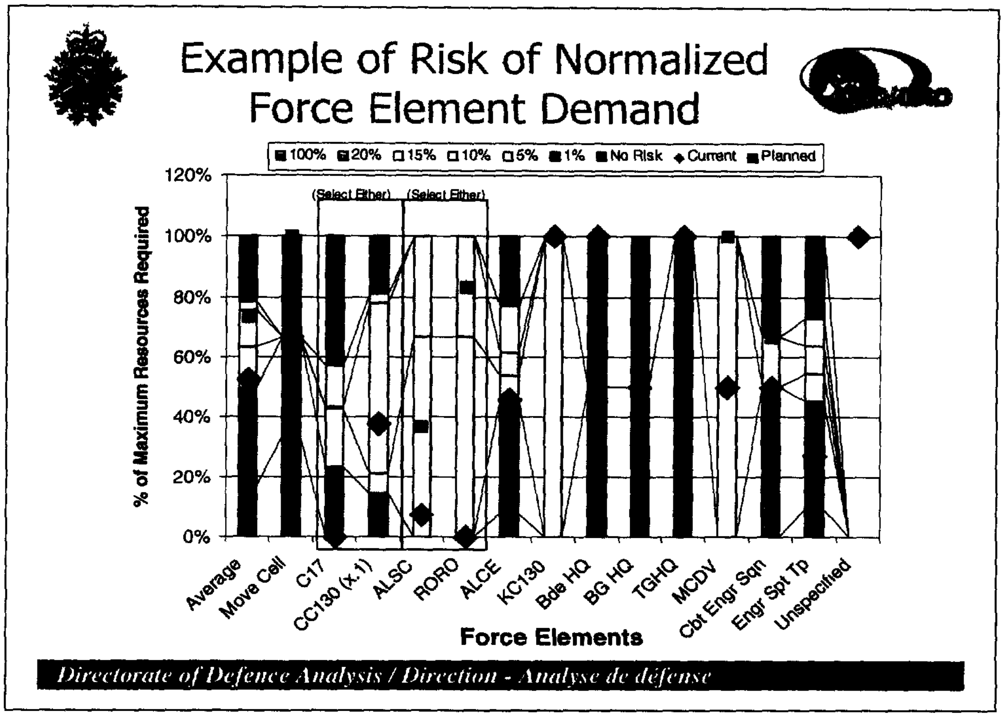


Slide 20: Example of Risk of Cumulative Force Element Demand

56. Once the cumulative demand and risks are calculated the simplest way to portray it is a graph of the results. The results of an earlier trial shown here clearly illustrate that each capability exhibits a unique distribution of demand and risk. The cumulative demand cannot be compared between capabilities because of the lack of a common metric. A minimum level of 1% risk was also imposed due to the limited sample size.

57. SOCRAM retains the ability to display this form of analysis, although it was not used during the FSX. The graphical analysis is based on detailed simulation output data that can be referenced to determine exact risk values. Because of this, it is quite feasible to display the values as a continuous curve or spectrum of colour. Unfortunately, the summary data used limits the graphs to a few bands of risk and this eliminates our ability to interpolate between listed values except by referring to the detailed simulation data.

58. There are also two other key simulation mechanisms available that were not activated during the FSX. The first involves a way of assessing how collateral use of daily operations can be used to provide offsets and thereby reduce the net demand to certain scenarios. The second is a special feature that ensures every combination of scenario and variants are activated at least once.

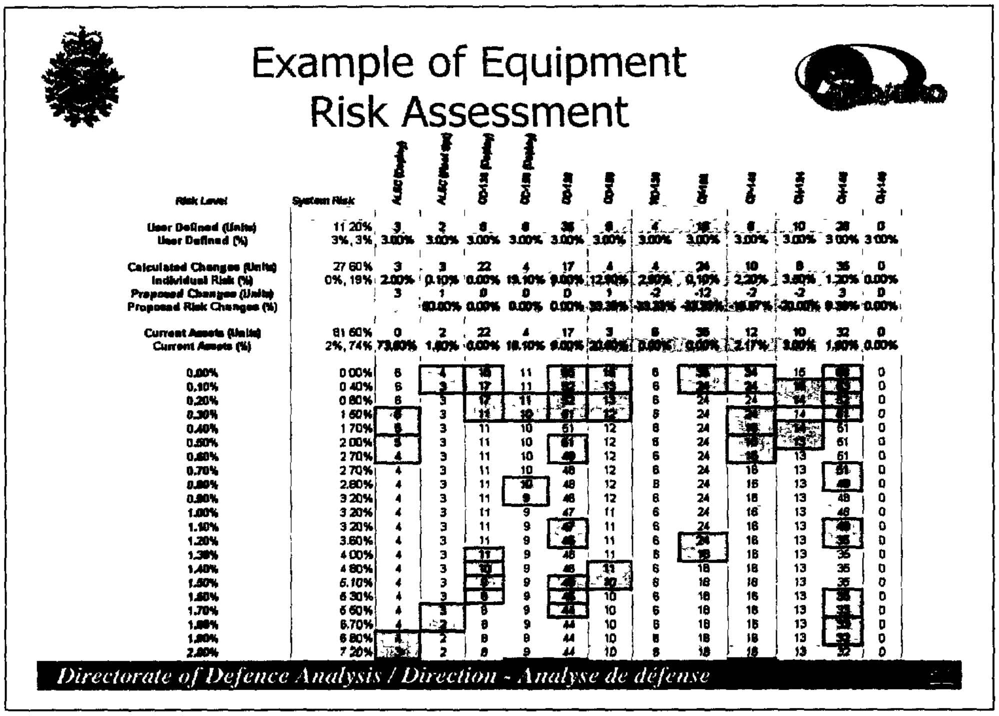


Slide 21: Example of Risk of Normalized Force Element Demand

59. As noted previously, the cumulative capability demand graph provides a concise overview of each capability's impact and risk. However it lacks a common scale for comparisons between capabilities and therefore precludes any easy assessment of how resources can be optimally allocated.

60. The only viable way to facilitate this function is to "normalize" the demands through the use of a common metric. Unfortunately, the list of feasible "equivalent units" is limited because the capabilities involved cover such a wide span of possibilities. A purely artificial equivalent unit can be conceived but it would lack a sensible explanation to support its use. The only practical common metric uncovered so far occurs when we convert a capability's demand to a percentage of its maximum cumulative demand (i.e. when risk is eliminated). The resulting percentage of demand is a dimensionless metric that is conceptually simple to grasp and implement.

61. A significant advantage to using this normalized percentage is that it also provides a practical framework for the optimal re-alignment of capabilities. Capability inventory can be optimized by adjusting capability levels such that they all have the same associated risk (risk balancing). SOCRAM makes use of normalized distributions as the basis for optimizing the mix of capabilities.



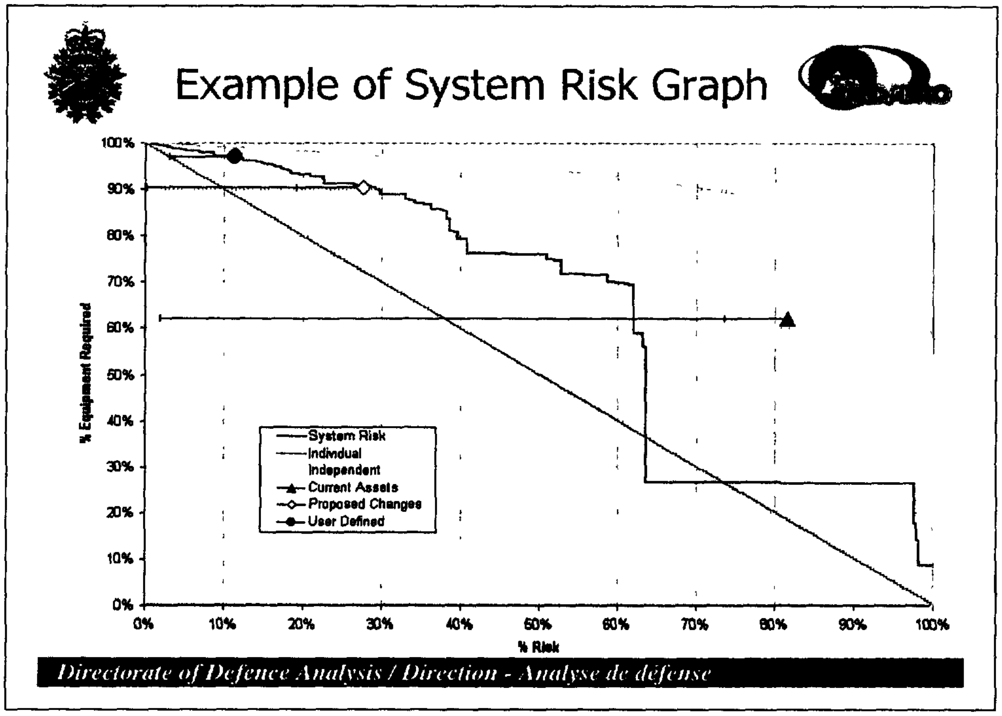
Slide 22: Example of Equipment Risk Assessment

62. The previous graphs provide broad approximations of the how risk accumulates between items. What they lack is a detailed view of how the risk accumulates within and between capabilities. The above table addresses these concerns with a tabular list of each item's demand. Each column lists the demand for each item in descending order from the maximum cumulative demand which equates to the no risk situation. The individual risk in the first column is related to the quantity of each type of equipment in its column.

63. System risk refers to the proportion of time the asset mix in that row cannot fulfill the cumulative demand that the simulation has generated. This has the effect of specifying the minimum amount of resources (efficiency frontier) needed to achieve an overall level of operational reliability.

64. The colored squares highlight which types of equipment are implicated in a change of the system risk. The list clearly illustrates how the reduction of risk to low levels increasingly requires the addition of a greater variety of equipment. It is caused by rarely occurring extreme demands that arise from several large concurrent demands.

65. The three set of blue colored rows at the top of the table are places where levels of current, planned and user defined assets can be specified for individual capabilities as any mix of quantities or risk.



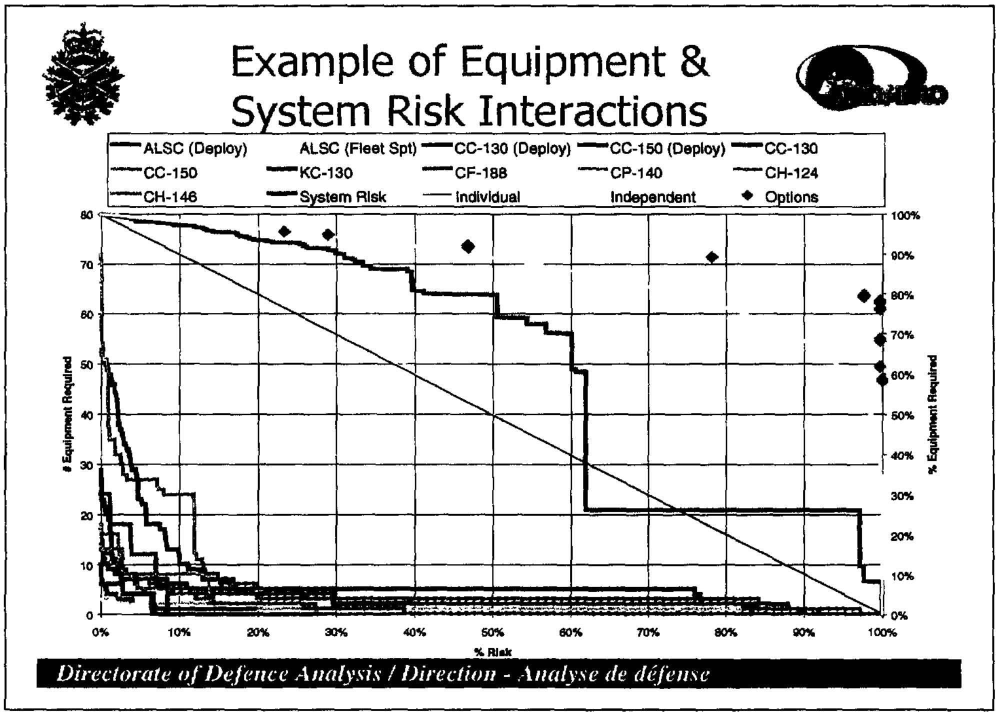
Slide 23: Example of System Risk Graph

66. The previous table provides a very good idea of individual quantities and their associated risks but it is hard to imagine how system risk behaves in the bigger picture. The above chart overcomes this by plotting risk across the full range of values in relation to the percentage of capability needed to achieve it.

67. At the extremes, no capability yields 100% risk while a full range of capability is required to eliminate risk (i.e. 0%). The individual risk is related to capability as a straight line between the two end points. The theoretical independence calculation in the upper right illustrates how a large amount of extra capability that is needed before the risk would be reduced.

68. System risk is plotted from the table as the jagged blue line. As an example, the lower right illustrates how 27% of the maximum capability must be invested before the risk starts to go down. Then the addition of a few assets suddenly covers off the lowest 37% of simulation iterations (i.e. system risk of about 62%). After this, the range of capabilities and quantities must be increased by 46% before the asset mix is able to tackle the broader range of situations. After this, the system risk reduces in synch with capability increases. The system risk curve exhibits some, but not full, independence.

69. The colored points and associated lines are the values from the top of the table. It highlights the severe misalignment that exists in the current mix of assets.

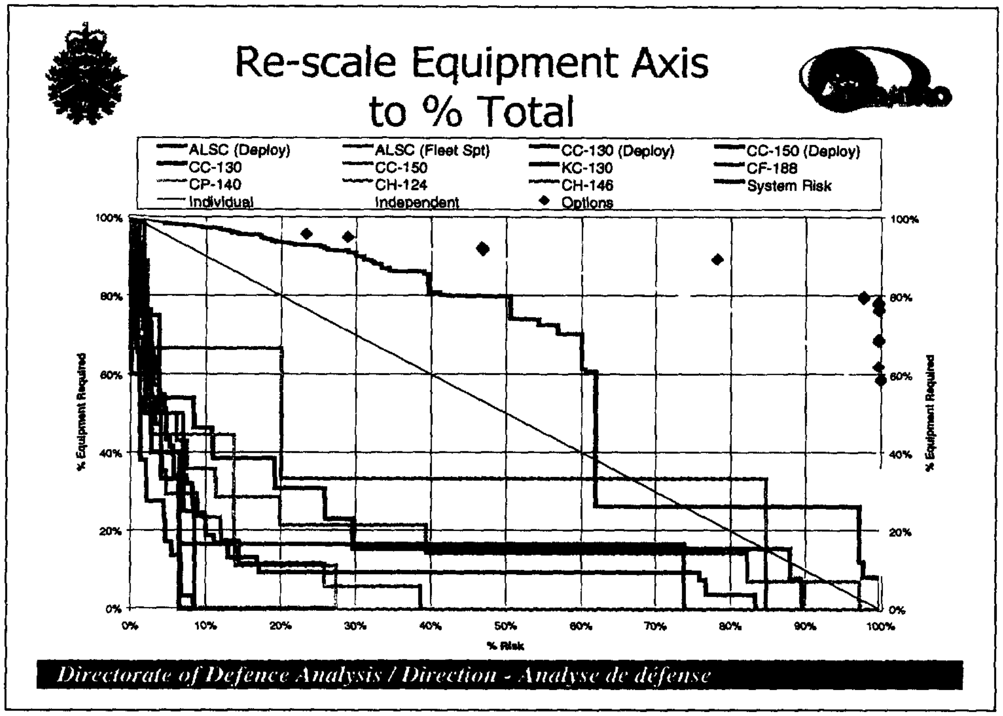


Slide 24: Example of Equipment and System Risk Interactions

70. The system risk curve can be used as a focus point for how capability components interact in order to reduce risk.

71. The above chart expands upon the previous chart to include the capability quantities from the risk assessment table in the bottom left of quadrant. The quantity and variety of equipment involved clearly illustrates how the majority of initial risk reduction is derived from the initial investment of a relatively few items of equipment. Next a wider variety of equipment trickles into the mix while significantly reducing the system risk. Finally, the larger demand variants that have lower rates of activation kick in and are accentuated when concurrent demands occur at the lowest levels of risk.

72. The upper right quadrant contains the calculated system risks for a set of options. The fact that the set options are plotted well above the system risk line indicates that the options represent very inefficient mixes of assets with major shortcomings.

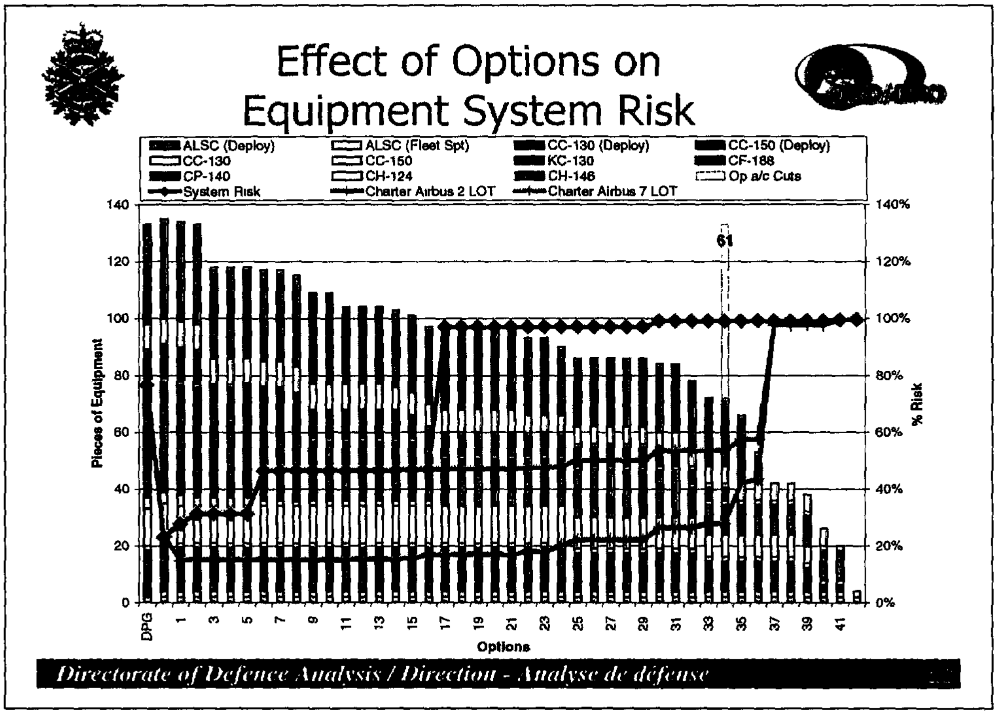


Slide 25: Re-scale Equipment Axis to Percent Total

73. The use of quantity to track equipment asset contribution to reducing risk is useful but limited. However, cost and utility of different equipment types are not directly comparable because some equipment quantities need much larger than other capabilities.

74. One way to more fairly account for the contribution of each equipment type is to re-scale the equipment axis as a percentage of total demand. This has the effect of highlighting the critical nature of key capabilities that have smaller maximum demands. The extent to what each change contributes starts with the point on the risk axis at which the quantity is increased. The user traces the value vertically to where it intersects the individual risk line and then horizontally to intersect with the system risk curve. The horizontal change in the curve corresponds to the impact of that piece of equipment.

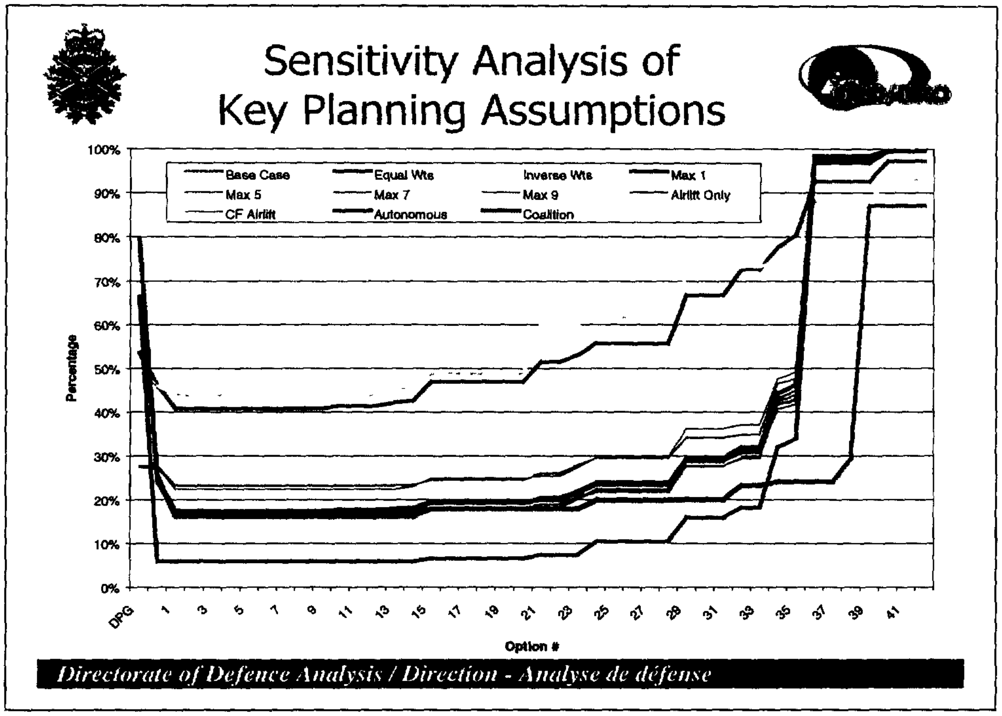
75. The clearest example of this is the case of the addition of the first Advanced Logistic Sealift Capability (ALSC (Deploy)) which occurs at a risk of 73%. Follow the 73% line vertically to where it intersects the individual risk curve. In this case the point is where system risk plummets from 97% to about 62%. The 35% decrease in system risk implies that the initial ALSC (Deploy) is the single most important unit to addressing the operational demands. (Interestingly, the second largest reduction in system risk of 8% occurs when adding the second ALSC for fleet support.)



Slide 26: Effect of Options on Equipment System Risk

76. In the FSX, one group used analytical modeling to select the order of reducing tasks from the current levels to the point where no more air assets remain. The chart above illustrates how SOCRAM was used to calculate the system risk across a full set of options. The start-state was the author's estimate of the current operational assets in the DPG. Two ALSCs were then added to assess the utility of sealift and then the air assets were reduced using a list of prioritized options until only the ALSC remained. The calculated system risk displayed several interesting features. Firstly, the addition of the ALSCs reduces the system risk from 78% to 23%. After that the elimination of CC150 (Strategic Transports) causes the most noticeable increases to risk and makes sense given their pivotal role in several quick response scenarios. In fact, the elimination of CC150s at option #17 appears catastrophic because the Air Force loses its ability to deploy personnel or sustain any scenario.

77. The group had stated that they were assuming they could lease two Lines of Tasking (LOT) of strategic airlift capability. When this is added back, the air assets remain viable up to Option #35. At that point the elimination of other fleets causes the house to crumble. If a strategic airlift project producing 7 LOT goes ahead, the reduced system risk (lower line) shows the impact of eliminating a major resource shortcoming. The ability to show how prioritized options interact makes this a very potent chart.



Slide 27: Sensitivity Analysis of Key Planning Assumptions

78. The prioritized options chart can also be used as the basis for comparing the consequences of changes to the major planning assumptions. The Base Case simulation was subjected to a sensitivity analysis along four major lines of investigation:

a. **Adjusting the activation rate** (Equal Weights, Inverse Weights) away from lower end conflict scenarios caused major increases in risk because the large demand scenarios started to dominate the cumulative demand caused by concurrent scenarios;

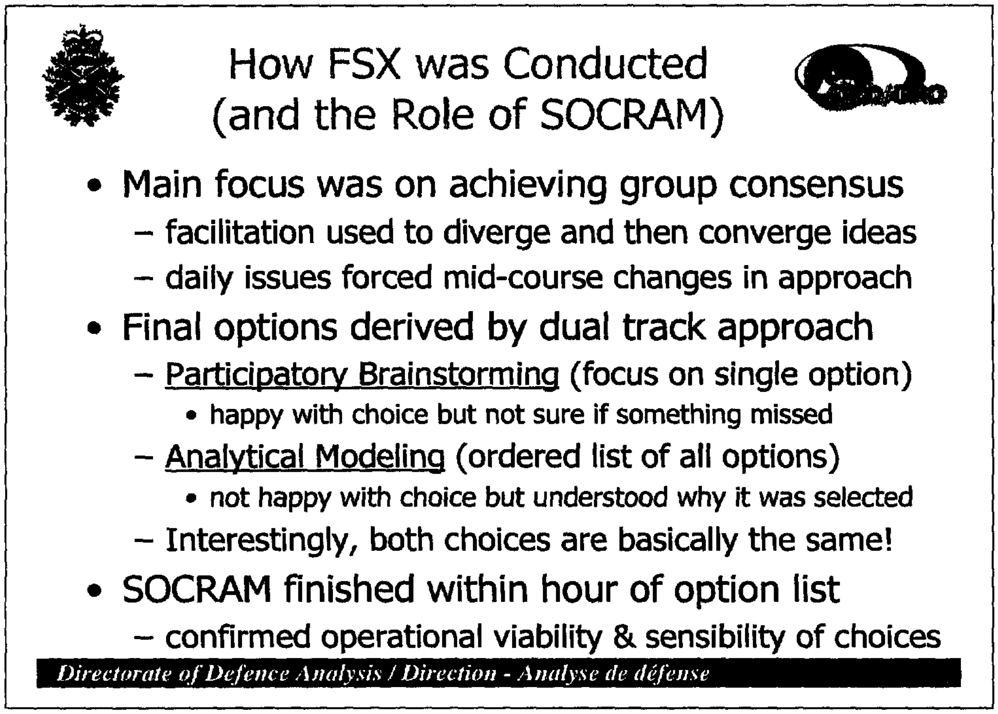
b. **Moving the cap on maximum number of scenarios** (Max 1, Max 5, Max 7, Max 9) from of one to three had the most impact. After that the minuscule joint probabilities and dominance of small scenarios forestalls any chance of much higher cumulative demand;

c. **Eliminating sealift** (Airlift Only, CF Airlift) leads to the anticipated major addition to airlift demands and system risk. Avoiding civilian airlift only aggravates the matter; and

d. **Impact of autonomous needs** (Autonomous, Coalition) has no impact because of the need to retain autonomy across all scenarios. Fighters are more linked to coalition operations than other airframes but still have a role in autonomous operations.

79. The sensitivity analysis can also be used to assess how different ranking techniques and schools of thought could affect the accrual of risk due to changes in the priority of options.

ACTIVATION OF SOCRAM FOR FSX



Slide 28: How FSX was Conducted (and the Role of SOCRAM)

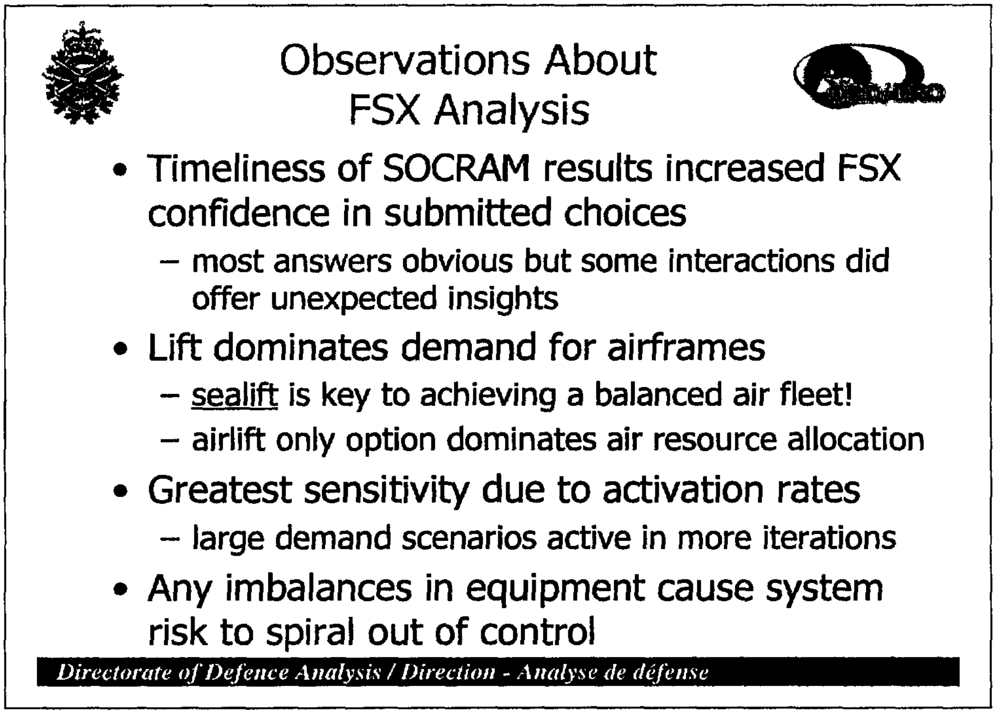
80. The main focus of the FSX was on achieving group consensus that transcended the individual fleet perspective. This entailed facilitation to force discussions outside the normal comfort levels and then direct them towards convergence. Interestingly, daily issues forced the support staff to find new and innovative approaches in order to move forward.

81. Final options were derived using a dual track approach. This was used to reduce the risk of an impasse in discussions:

a. Participatory **Brainstorming** focused on developing a single sensible option that met the cost reduction objective. They ended their deliberations by being happy with their choice but they were not sure if they had missed another more efficient alternative; and

b. **Analytical Modeling** group developed an ordered list of all options to determine the span of options and then determined how far along they had to go in order to achieve the prescribed cost savings. They were less happy with their choice but they understood why the option was selected.

82. The interesting thing about these dual tracks is that both choices ended up being basically the same! Meanwhile, the author's participation in the discussions allowed him to complete the initial SOCRAM analysis within an hour of seeing the consolidated set of options. This document helped to confirm the operational viability and sensibility of the selected choice.



Slide 29: Observations about FSX Analysis

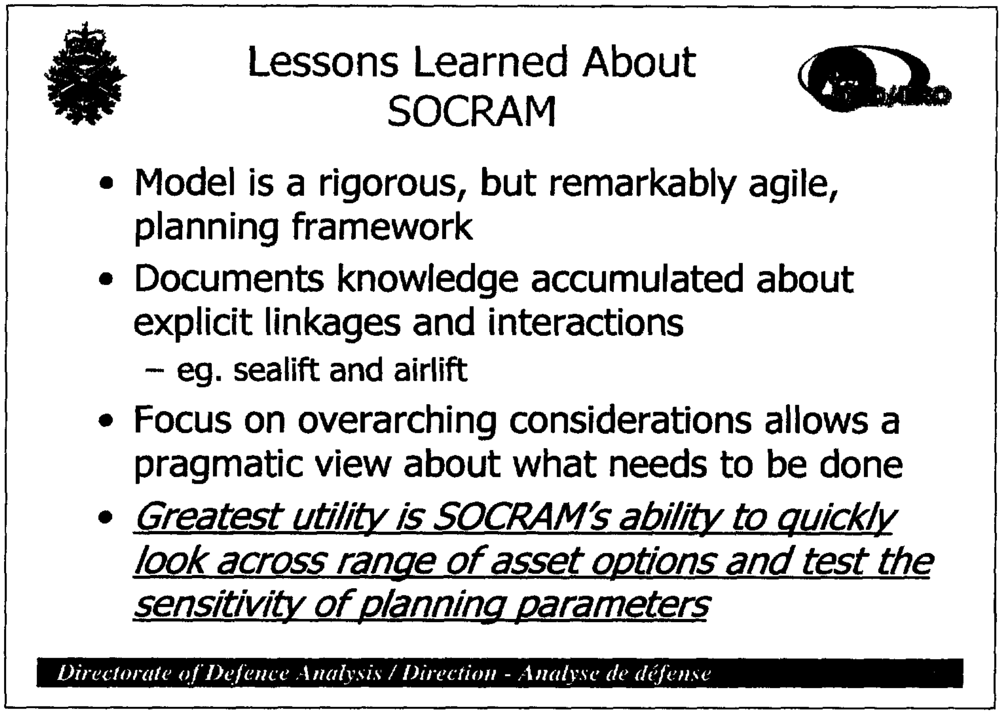
83. Several general observations came out of the FSX analysis experience. The bulk of these were technical enhancements for the analysis tools but several themes were found to be significant.

84. The timeliness of the SOCRAM results increased the FSX confidence in the submitted choices. Most answers were fairly obvious and intuitive but some results did offer unexpected insights about the accumulation of risks. This pointed out the need for the analyst to participate as an active member in the FSX deliberations because many subtle but critical modeling interactions came to light during group discussions.

85. Lift dominates the demand for airframes because the lift demand is a precondition for the scenario variant response. With the demand and response times involved it turns out that sealift is the key element to achieving a balanced air fleet! This is borne out when an airlift only option is imposed; the demand becomes excessive and dominates allocation of air resources

86. The greatest sensitivity turned out to be attributable to activation rates. If the rates are adjusted to incur more high demand scenarios then the large values are activated more often. Any imbalances impose bottlenecks and cause system risk to spiral out of control.

CONCLUSIONS

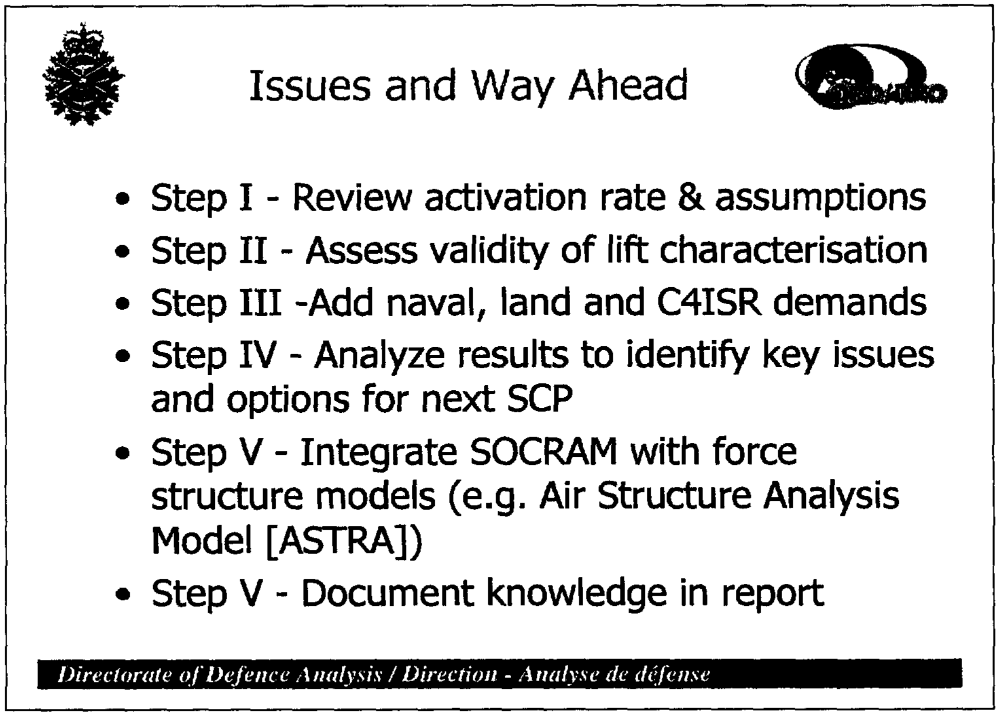


Slide 30: Lessons Learned about SOCRAM

87. The main lesson learned from the FSX analysis experience is that the model demonstrated an ability to be a rigorous, but remarkably agile, planning framework. It successfully documented a significant concentration of knowledge about explicit linkages and interactions. The most explicit example of this was the development of a heuristic algorithm that determines an efficient response by sealift and airlift.

88. The focus on overarching considerations successfully allows a pragmatic view of what needs to be done. The functional considerations dominate rather than the method of delivering them.

89. Perhaps the greatest utility of SOCRAM is its ability to examine quickly the utility of a wide range of asset options and test the sensitivity of planning parameters. Its ability to point out risks caused by interactions of scenarios can also be used to foster a better understanding of the planning environment and associated capability requirements.

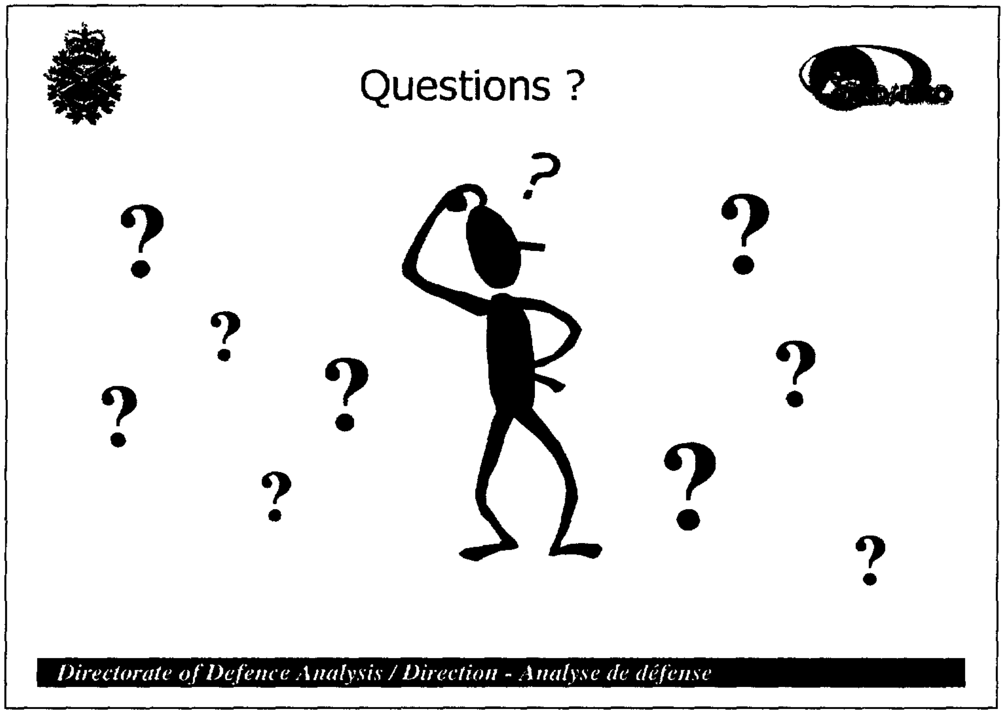


Slide 31: Issues and Way Ahead

90. The SOCRAM results from the FSX demonstrate that the initial test was successful and prove that SOCRAM is fully capable of accommodating a set of real data. The Trial results are sensible and consistent but they are complex and subtle. Because of this it is essential that the results be accompanied by detailed explanations to ensure the results are properly interpreted and understood.

91. The Excel spreadsheet works as advertised and its flexibility allowed the FSX version to adapt quickly to cater for new aspects of the problem. That said, past experience suggests that maintaining the data in the Excel format will become progressively more awkward over the long term so a Visual Basic version is under development. A working version exists but will be realigned to make it compatible with the lessons learned from the FSX.

92. The focus of effort will now shift to completing the implementation of the full-scale problem. The first step involves the expansion of the data set to quantify all significant tasks for a full range of valid variations. Meanwhile, the scenario activation assumptions will be carefully re-assessed and validated to ensure they properly take into account the intended focus of activities. A significant effort will also be needed to refine the scaling metrics to ensure they realistically differentiate between variations.



Slide 32 Questions Slide

BIOGRAPHY

Mr. Ronald (Ron) W. Funk, B.Eng., M.B.A., CD, LCdr (Ret'd)

93. Mr. Funk's career began in 1972 as a naval cadet and he joined the fleet in 1976 with a Bachelor of Engineering (Engineering and Management). In 1983 he graduated with a Masters of Business Administration (Operations Research and Policy Analysis) to work as an analyst on strategic resource allocation issues. His achievements in the military included a key role in developing the Department's corporate level strategic financial framework and design of an integrated Infrastructure Rationalization Process.

94. In January 1993, Mr. Funk retired as a Lieutenant Commander to become a Defence Scientist. Soon after starting at Air Command Headquarters he received the Commander's Commendation for his analytical support to help preserve the core of the Air Force. He then developed the Operational Personnel Risk Assessment Model and received the Deputy Minister of National Defence Commendation for changing the way the Air Force dealt with complex personnel resource trade-offs.

95. Mr. Funk has also headed up the Operational Research Team at Maritime Forces Pacific in Victoria. For three years, he focused on developing innovations to improve the quality of the Command's maritime surveillance. In July 1998, Mr. Funk joined the Strategic Planning Operational Team to develop methodologies for the analysis of force planning scenarios.

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The dynamics of the new strategic environment and increased emphasis on operations other than war have caused Canada to seek a better understanding about how the risk of concurrent activities influences the mix of capabilities that are selected. One approach is to simulate the activation of demands within an analysis framework called the Scenario Operational Capability Risk Assessment Model (SOCRAM).

The model utilizes a rigorous analysis structure that requires Strategic Planners to specify capability requirements, first in conceptual terms. Then, the conceptual principles are related to force structure elements (equipment and units) that satisfy the requirements. SOCRAM uses these to calculate the risk associated with each capability, within a force structure, based on the demand generated by concurrent operations.

The presentation will provide an overview of the concepts integrated into SOCRAM and then describe how it was used to generate the distribution of operational demands for a key Air Force structure review.

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Scenario Operational Capability Risk Assessment Model

Socram

Force Planning Scenarios

Discrete Event

Simulation

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