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DEPARTMENT OF NATIONAL DEFENCE
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OPERATIONAL RESEARCH DIVISION

DIRECTORATE OF OPERATIONAL RESEARCH (MARITIME, LAND, AIR)

DOR(MLA) RESEARCH NOTE RN 2002/04

EVALUATING FORCE MISSION EFFECTIVENESS USING THE HIERARCHICAL FRAMEWORK ANALYSIS TOOL

BY

JASON OFFIONG

MARCH 2002

OTTAWA, CANADA

National Defence Défense nationale

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EVALUATING FORCE MISSION EFFECTIVENESS USING THE HIERARCHICAL FRAMEWORK ANALYSIS TOOL

by

Jason Offiong

Recommended by: G.L. Christopher, TL/LFORT

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OTTAWA, ONTARIO MARCH 2002

Abstract

The mission effectiveness of a number of force options for OPERATION PALLADIUM, Rotations 9 through 11 in Bosnia, has been investigated using the Hierarchical Framework for the Analysis of Mission Effectiveness (H-Frame), an options analysis decision support tool. This report will present those results and will describe the use of H-Frame as a tool to support force structure planning and assessment. Although due to external influences the modelling effort was cut short, the force option preferred by the Army appears to have the highest level of mission success. Ultimately this was the option that was deployed for the ninth rotation of OPERATION PALLADIUM.

Résumé

L'efficacité d'un grand nombre d'options relatives à l'utilisation des Forces pour l'opération *Palladium*, Rotations 9 à 11 en Bosnie, a été étudiée à l'aide de la structure hiérarchique pour l'analyse de l'efficacité (H Frame, un outil de soutien décisionnel sur l'analyse des options). Le présent rapport renferme les résultats de cette démarche et décrit la façon dont le H Frame a été utilisé pour la planification et l'évaluation de la structure des Forces. Bien que les démarches de modélisation aient été abrégées en raison de facteurs externes, l'option relative à l'utilisation des Forces que l'Armée préfère semble être celle qui a remporté le plus de succès en mission. C'est d'ailleurs celle qui a été utilisée pour la neuvième rotation de l'opération *Palladium*.

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List of Abbreviations

AOR	Area of Responsibility
APC	Armoured Personnel Carrier
Arty	Artillery
CIMIC	Civil-Military Co-operation
CORT	Central Operational Research Team
Coy	Company
DCDS	Deputy Chief of Defence Staff
Det	Detachment
DGOR	Director General Operational Research
Div	Division
DLFR	Director Land Force Readiness
Engr	Engineer
EW	Electronic Warfare
H-Frame	Hierarchical Framework for the Analysis of Mission Effectiveness
Int	Intelligence
LAV	Light Armoured Vehicle
LPV	Light Patrol Vehicle
MND(SW)	Multi-National Division (South West)
Msn	Mission
OP	OPERATION
OP PALLADIUM	OPERATION PALLADIUM (Bosnia)
Ops	Operations
Pl	Platoon
Psyops	Psychological Operations
Recce	Reconnaissance
Regt	Regiment
Roto	Rotation
Sqn	Squadron
Tp	Troop
	Unit sized entity (e.g. battalion, armoured / artillery / engineer regiment)
	Sub-unit sized entity (e.g. company, armoured / engineer squadron, artillery battery)
	Sub-sub unit sized entity (e.g. platoon, armoured / artillery / engineer troop)
	Section or Battle Group Detachment
↑↑	Significant increase from present capability level
↑	Increase from present capability level

↔	No change – status quo
↓	Decrease from present capability level
↓↓	Significant decrease from present capability level
 / Red Light	Worst grade of the stoplight scale
 / Yellow Light	Middle grade of the stoplight scale
 / Green Light	Best grade of the stoplight scale

EVALUATING FORCE MISSION EFFECTIVENESS USING THE HIERARCHICAL FRAMEWORK ANALYSIS TOOL

1. INTRODUCTION

1.1 BACKGROUND

1. In January 2001, the Land Staff engaged in a Bosnia Mission Analysis in order to contribute to the Deputy Chief of Defence Staff (DCDS) Bosnia Rationalization, Part II. Starting from first principles, the Army developed force structures that would address several key factors, including force protection, deterrence, humanitarian assistance, etc. The components of these force structures ranged in size from multiple sub-units to a single sub-sub-unit. The permutations were numerous and an objective analysis was required to determine an appropriate force composition that would achieve mission success and economies in terms of equipment and personnel. [1]

2. Hence, staff from the Directorate of Land Force Readiness (DLFR) initiated a study to evaluate the ability of a number of these force structure permutations to address the demands of the key factors that were identified.

1.2 AIM

3. The aim of this research note is to present the results of a force options study for OPERATION PALLADIUM (OP PALLADIUM), Rotations (Roto) 9 through 11 in Bosnia. It will also describe the use of H-Frame as a tool to support efforts in force structure planning and assessment.

1.3 SCOPE

4. This research note covers the limited modelling efforts in the spring of 2001 towards the development of a hierarchical framework for the assessment of the deployed force for OP PALLADIUM.

2. THE HIERARCHICAL FRAMEWORK ANALYSIS TOOL

2.1 INTRODUCTION

5. The Hierarchical Framework for the Analysis of Mission Effectiveness (H-Frame) [2] tool is an analysis tool developed by the Central Operational Research Team (CORT) in the Operational Research Division (ORD). The H-Frame system consists of a number of individual entities arranged in sets of levels that exist in a hierarchical framework. The relationship between the entities in any level and those adjacent to it (one up and/or one down) are then specifically defined.

6. Each entity in H-Frame has a set of performance grades that can be assigned to the entity or assess the entity in terms of level of capability, funding, availability, etc. Using the relationships between the entities on different levels, H-Frame is able to demonstrate the effects of the application of resources at the lowest level on the performance grades assigned to entities on higher levels.

7. The user explicitly assigns a performance grade to each of the entities on the lowest level of the H-Frame hierarchy. Then, using the relationships defined for the higher levels, H-Frame determines the appropriate performance grades for each superior entity. These performance grades that H-Frame assigns for each entity are defined by the minimum requirements specified for the grades of those entities on the level immediately subordinate. Additionally, H-Frame allows Boolean operators to be used to specify the relationships between levels.

2.2 SAMPLE H-FRAME MODEL

8. A sample model is included with the H-Frame package. This four-level model describes naval capabilities. This is shown in Figure 1. On the lowest level (left-hand side) are the constituent platforms within a fictitious maritime force, frigates, destroyers, etc. Note that within the model, some entities extend beyond the bottom of the Figure. The next level in the hierarchy consists of the naval capabilities such as anti-submarine warfare, anti-surface warfare, etc. The third level are missions that this force can complete to some degree and, finally, the fourth level is an assessment of the force's overall ability to meet its assigned tasks.

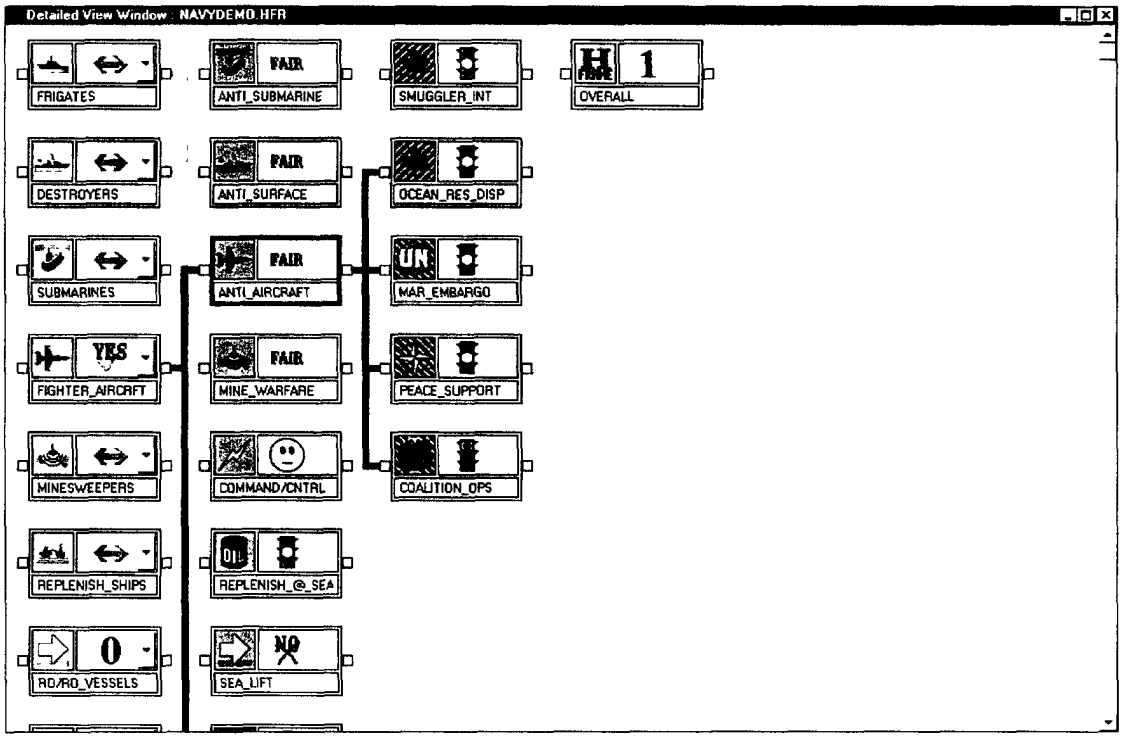


Figure 1 – Sample H-Frame Model

9. The Anti-Aircraft entity on the capability level is selected in Figure 1. This is indicated by the black box around the entity and it also identifies the subordinate entities relevant to that capability and the superior elements it affects. So, in this model, frigates, destroyers, fighter aircraft and surface-to-air missiles (not shown in the Figure) are the platforms that contribute to this capability. Conversely, that capability is required for the tasks of Ocean Resource Dispute, Maritime Embargo, Peace Support and Coalition Operations (Ops). The black lines indicate a Boolean "AND" relationship between entities and the light blue line indicates a Boolean "OR" relationship. Hence a certain minimum performance grade must be achieved in fighter aircraft AND surface-to-air missiles AND (frigates OR destroyers) in order for a given anti-aircraft performance grade to be assigned. Again, the entity for surface-to-air missiles is not visible in Figure 1.

10. In addition to viewing the cumulative effects of policy decisions, H-Frame allows two additional types of analyses: an enhancement analysis and a savings analysis. The former allows the user to select a desired performance grade at any superior level (i.e. not the lowest level) and the software will determine the minimum requirements to achieve that performance grade. For instance, if in the model in Figure 1 an overall performance grade of 3 was desired, the enhancement analysis tool would highlight the lowest level entities that do not satisfy the minimum

requirements for that grade. It will also give an indication of what must be assigned in order to achieve the desired performance grade. The resulting model for this example is shown in Figure 2.

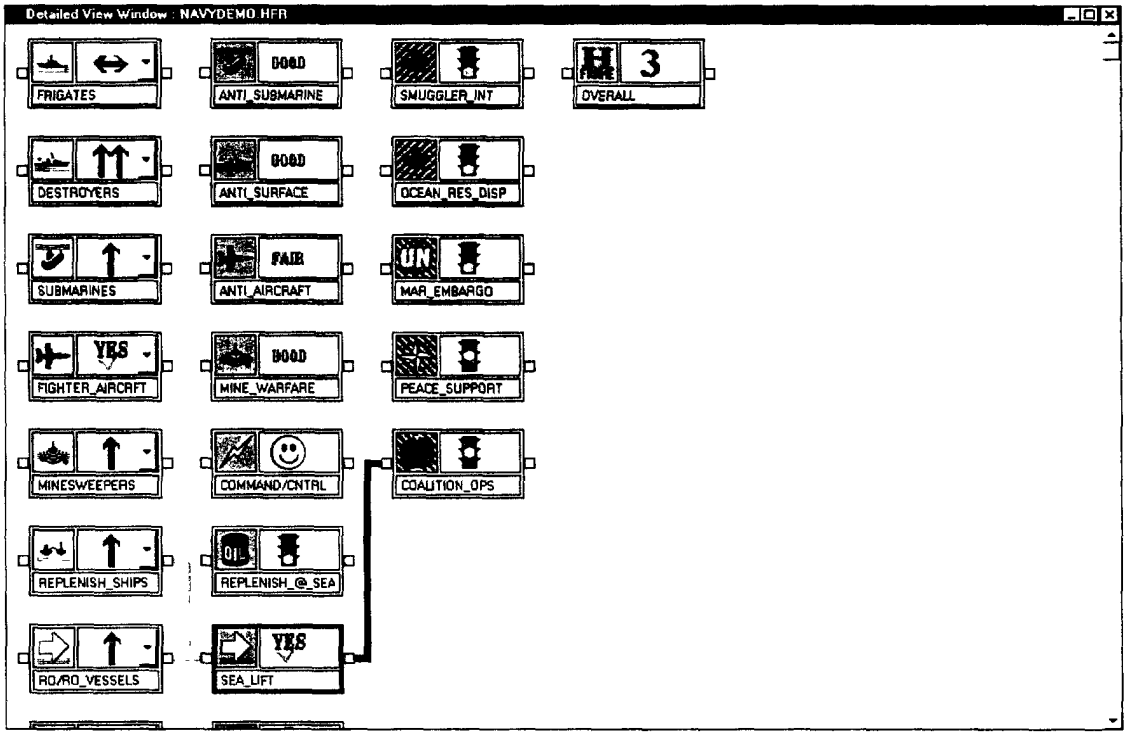


Figure 2 – Results after H-Frame enhancement analysis.

11. The savings analysis allows the user to investigate the possibility of reducing the resources assigned at the lowest level without realizing a reduction in the performance grades at higher levels. In other words, the savings analysis identifies entities where excess resources have been expended that are not required to achieve the current grade. So, if for instance in Figure 2 the grade assigned to Destroyers were decreased to a single up-arrow, the overall performance grade would drop to 2. This is shown in Figure 3.

12. When a savings analysis is then performed on the model, H-Frame indicates that several other of the lowest level entities can also have their performance grades reduced without impacting the overall assessment. This is shown in Figure 4. Notice that the majority of the entities in Figure 3 with a single up arrow, indicating an increase is required from the current capability, have been reduced to a level that maintains the status quo in Figure 4, yet the overall assessment remains a 2. However, the assessments for the capabilities and / or the missions have also been degraded ("good" to "fair", "green light" to "yellow light", etc.).

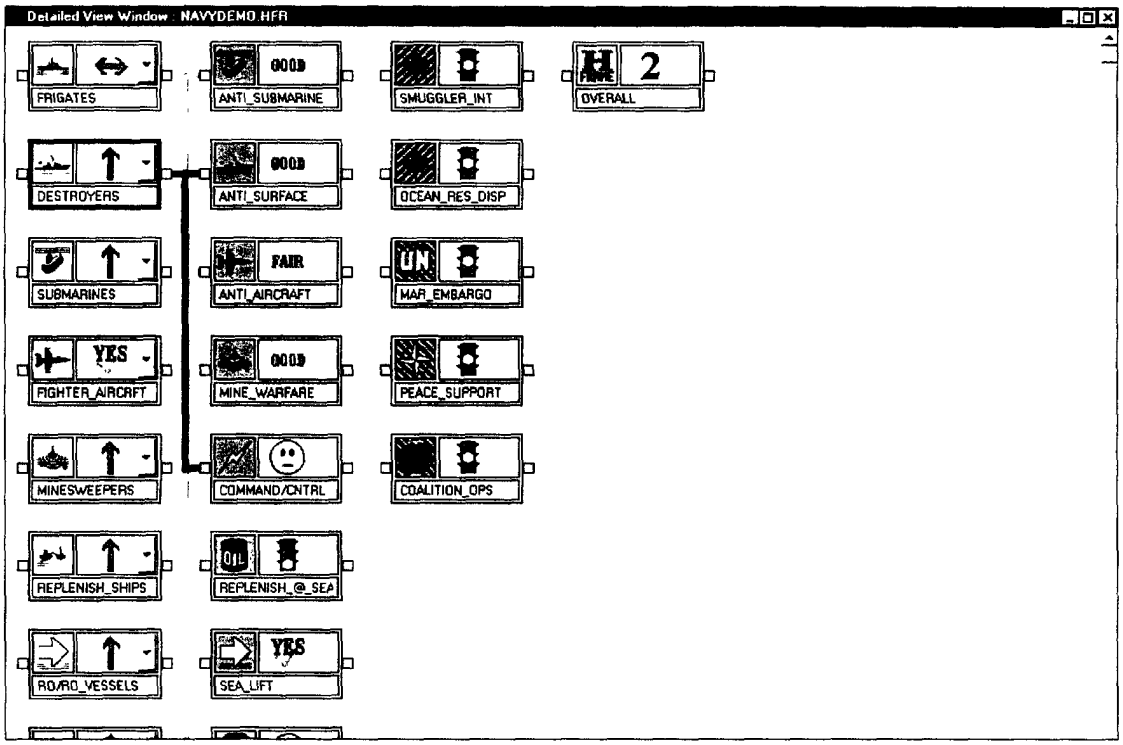


Figure 3 – Sample model from Figure 2, with the assessment of the Destroyers platform reduced.

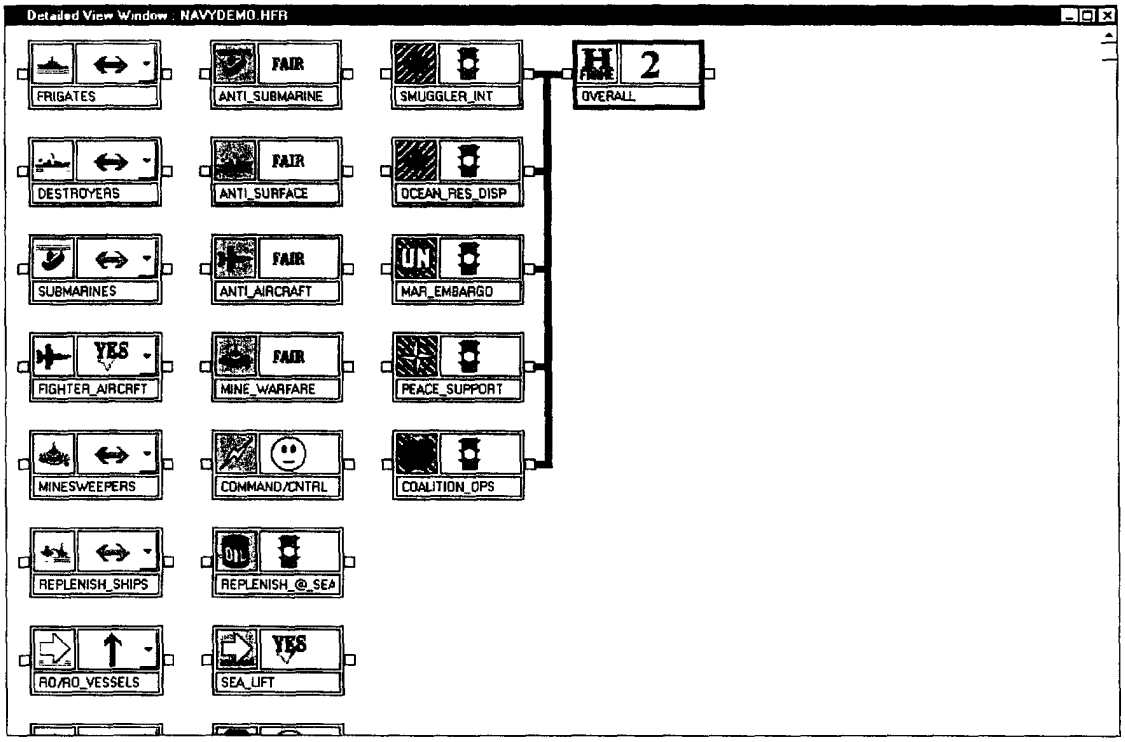


Figure 4 – Naval demonstration model in Figure 3, after Savings Analysis.

2.3 DATA REQUIREMENTS

13. In order for H-Frame to assign a performance grade to the entities on the higher levels, determine minimum requirements for improvement or potential areas for savings, it requires a significant amount of data.

14. First, the levels themselves must be defined. Again, in the case of the naval demonstration model, there are four levels (platforms, capabilities, missions and overall performance).

15. Next, the entities that make up each level must be specified. The entity definition includes setting the scale for the performance grade. The possibilities for the scale include, but are not limited to:

a. descriptive labels such as "good", "fair" and "poor" or "yes" and "no";

b. numeric, monetary or percentage values;

c. stop light (red, yellow, green); and

d. up and down arrows to indicate increases or decreases.

16. The number of individual grades for each entity must also be specified. That is, it must be decided for instance whether a scale from 1 to 10 will be chosen or a scale from 1 to 5 or will "good", "fair" and "poor" be sufficient or are "very good" and "very poor" required to provide additional qualification. Finally, for each chosen performance grade, the requirements at the level immediately subordinate to achieve that grade must be specified. The table in which these requirements are defined is known as the "Entity Matrix". When one considers the number of performance grades for each entity on each level, and the possible relationships between each performance grade and the entities' states on the subordinate level, the amount of data required by the model and the potential difficulties in assigning consistent and realistic relationships can be appreciated.

17. For example, in the naval demo model, the Mine Warfare capability is determined by two platforms, Minesweepers AND Maritime Helicopters, according to Table I. Note the Boolean "AND" capitalized in the preceding sentence which denotes that both subordinate entities must achieve the prescribed grade in order for the Mine Warfare assessment to improve. So as shown in Table I, in order for the Mine Warfare capability to be assessed as "Very Good", the Maritime Helicopter

platform must be improved and the Minesweeper platform must be significantly improved.

TABLE I
ENTITY MATRIX FOR MINE WARFARE[1]

Mine Warfare Assessment	Minesweepers	Maritime Helicopters
Very Good	↑↑	↑
Good	↑	↔
Fair	↔	↔
Poor	0	0

18. The final data requirement for H-Frame is the assessments of the values or states of the lowest level entities. This can be done either by an individual or a committee whose results are averaged in some way to determine the group's assessment of each entity.

19. In spite of the simplicity of the process of developing and using an H-Frame model, the software package is fairly data intensive. Building a large model or one where the entities have performance grades with many possible scores increases the data required to populate the entity matrices. This can lead to inconsistencies within the model or undesirable results. Also, the linkages between levels are difficult to keep consistent, particularly when complex Boolean statements are required to properly address the connection between entities on one level and the next.

[1] The symbols used in this table are described in the Table of Abbreviations.

3. OPERATION PALLADIUM ROTATIONS 9 AND 10 MISSION ANALYSIS

3.1 BUILDING AND POPULATING THE H-FRAME MODEL

20. The H-Frame model that was built for the force options analysis for OP PALLADIUM consisted of three levels and is shown in Figure 5.

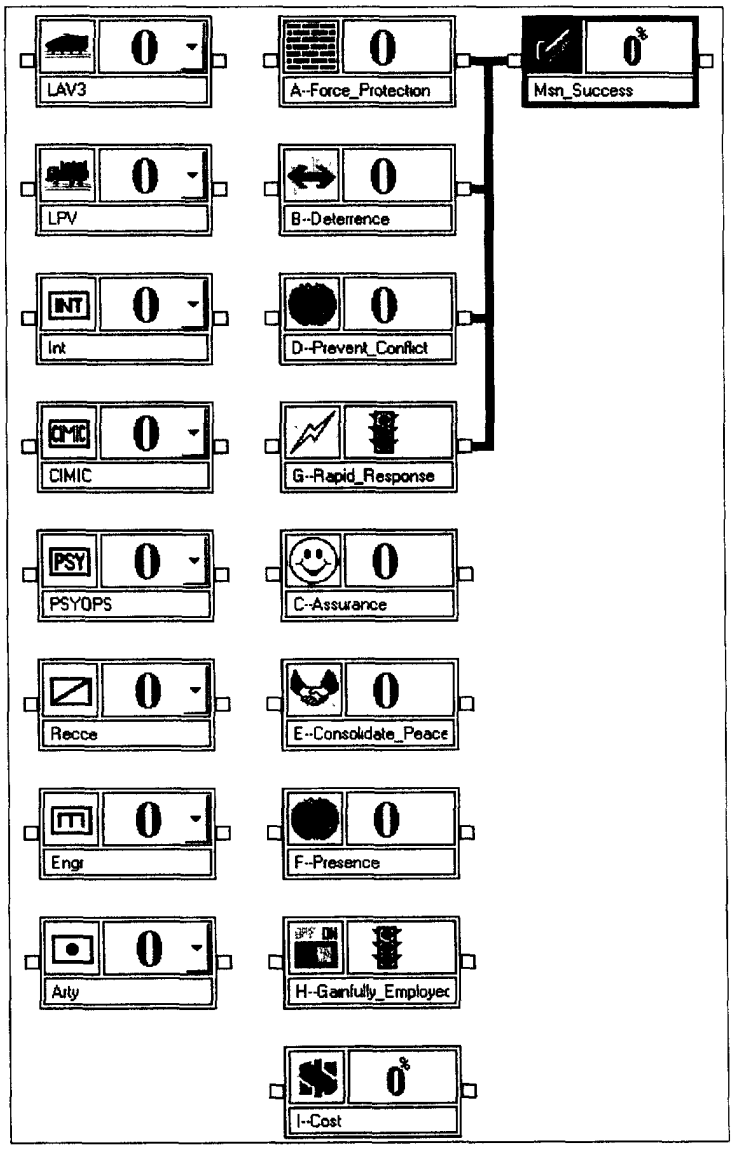


Figure 5 – OP PALLADIUM H-Frame Model

21. The first level contains the units and equipment that were being considered for deployment on OP PALLADIUM Rotos 9, 10 and 11. At the time, it had not been decided whether the LAV-III (the third generation of the Light Armoured Vehicle) armoured personnel carrier (APC) would be employed for those rotations, or whether a Light Patrol Vehicle (LPV) such as an Iltis or other jeep-type vehicle would be deployed.

22. The second level consists primarily of the roles or tasks that the deployed force could be asked to undertake. The last level is an overall assessment of the capability of the force. Note that as shown in Figure 5, only the top four items in the second level actually contribute to the overall assessment. The remainder of the entities in the second level were included to provide additional insight into other considerations (utility, value and cost) for the force that would be deployed.

23. DLFR 3-3 defined the entities for the H-Frame model and, in turn, provided the data to populate it. The details of the performance scales and the entity matrices for each item in the H-Frame model are provided in Annexes A through C.

24. It should be noted that due to external influences, the efforts toward the development of the entity matrix and the subsequent investigation of force structure and equipment options were truncated and ultimately halted. The results presented in §3.2 are intended to be indicative of the type of detailed analysis that can be performed given sufficient time and resources. In order to maximize the utility of H-Frame, an adequate amount of time must be dedicated to ensuring that the linkages between the levels are consistent and model real-world events or outcomes as realistically as possible.

3.2 RESULTS

25. There were several potential equipment and unit mixes being proposed at the time of this study and these were investigated in the H-Frame model. The four force options are summarized in Table II.

TABLE II
VARIOUS OPTIONS FOR ROTATIONS OF OP PALLADIUM[2]

Equipment / Units	**DCDS Roto 9**	**Army Roto 9**	**DCDS Roto 11/ Army Roto 10**	**Div[3] Troops**
Light Armoured Vehicle-III (LAV-III)	45	30	30	0
Light Patrol Vehicle (LPV)	0	15	15	0
Intelligence (Int)				
Civil Military Co-operation (CIMIC)				
Psychological Operations (PSYOPS)				
Reconnaissance (Recce)				
Engineers (Engr)				0
Artillery (Arty)			0	

26. These four option-sets were loaded into the H-Frame model as the assessments of the lowest level force structure and equipment entities. The resulting H-Frame determination of the superior entities is shown in Figure 6 through Figure 9.

[2] The symbols used in this table are described in the Table of Abbreviations.

[3] The Army had proposed a force structure concept, called Divisional Troops, that would be a Multi-National Division (South West) (MND(SW)) asset. Through offering specialist troops (electronic warfare (EW), arty, recce, int, CIMIC, PSYOPS, etc), Canada could reduce its OP PALLADIUM footprint by withdrawing the battle group (BG) and relinquishing an Area of Responsibility (AOR). Specialist troops would allow Canada to reinforce partner nations across the Division.

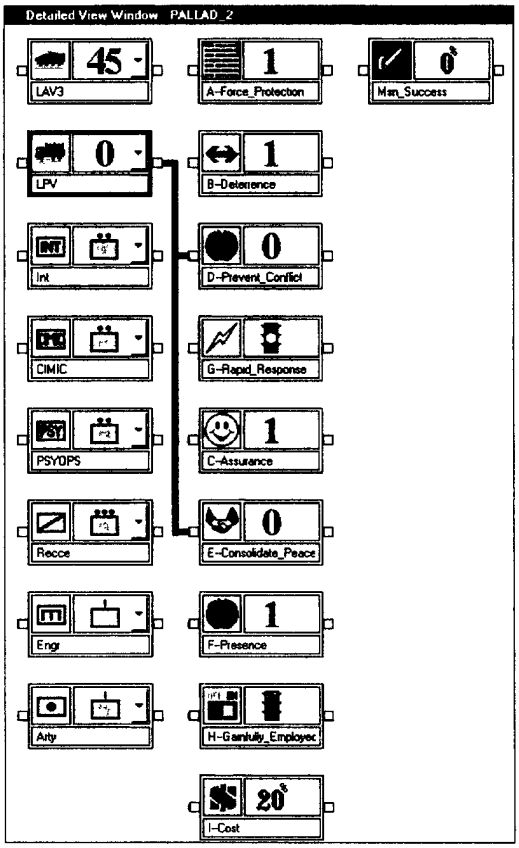


Figure 6 – DCDS Preferred Force Option for OP PALLADIUM, Roto 9.

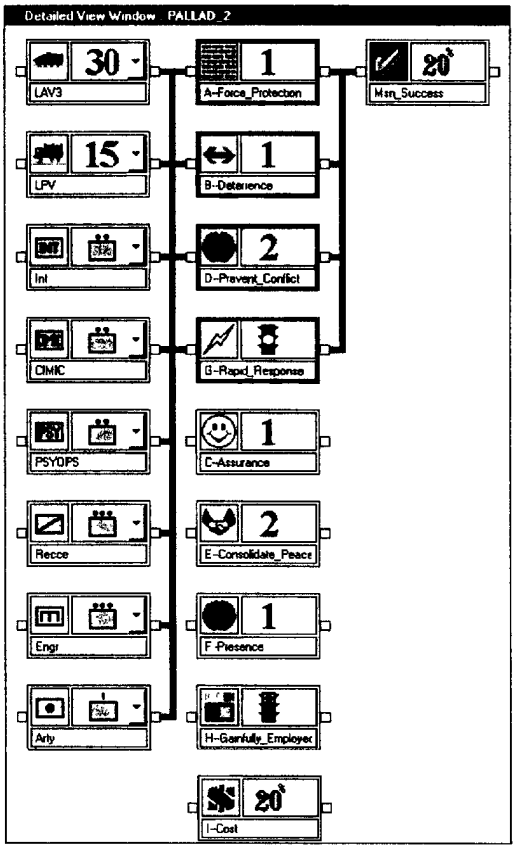


Figure 7 – Army Preferred Force Option for OP PALLADIUM, Roto 9.

27. In each of Figure 6, Figure 8 and Figure 9, the complete absence of one of the Army platforms or units cause the assessed mission success to be nil. The critical platforms or capabilities are emboldened in these Figures to show the dependent entities in adjacent levels. This is clearly not consistent with the true capabilities of a deployed force. In reality, at least some of the capabilities of a "missing" platform could be accomplished by alternate platforms, albeit with a potentially decreased capacity. This lack of realism is a direct result of the truncated development of the entity matrix and the linkages between the three levels, as discussed previously.

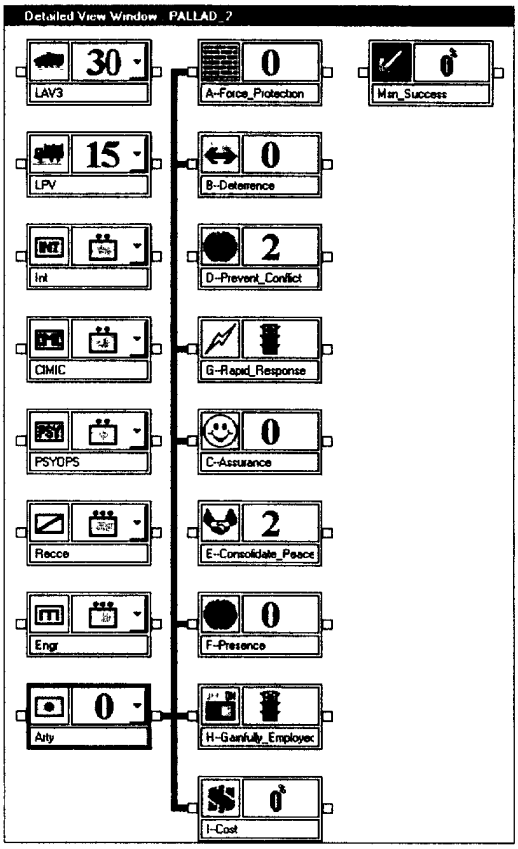


Figure 8 – DCDS Preferred Force Option for OP PALLADIUM, Roto 11 or the Army's for Roto 10.

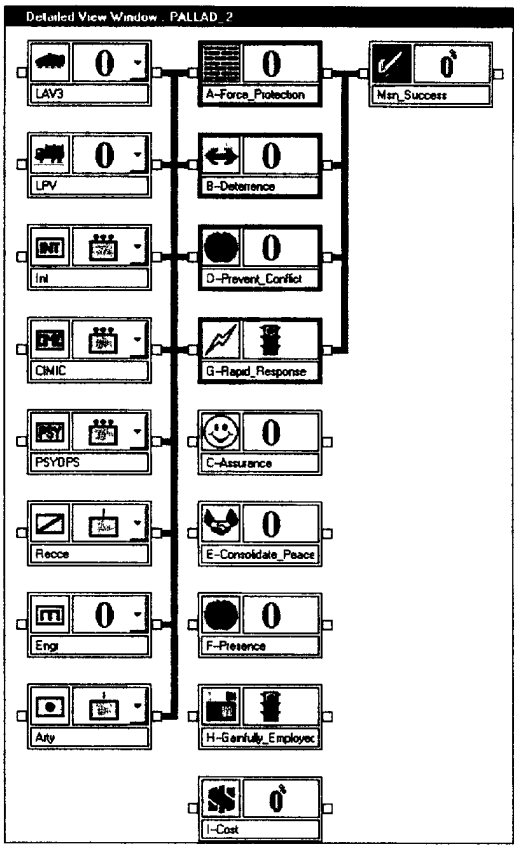


Figure 9 – Divisional Troops

28. The only force structure that has any ability to achieve mission successes whatsoever is that preferred by the Army for OP PALLADIUM, Roto 9 (Figure 7). This force has the required balance across all platforms, but insufficient numbers of all platforms to achieve a high likelihood of success. Again, this is a direct result of the requirements defined in the entity matrix. Additional model definition would be required before any prescriptive or definitive results could be obtained.

29. In spite of the obvious deficiencies in the definition of this H-Frame model, members of the DLFR staff were interested in making use of the resident enhancement analysis capability. They wanted to know, based on the force assessments provided, what would be required to achieve 40%, 60% and 80% mission success. These required force structures are shown below in Figure 10 through Figure 12.

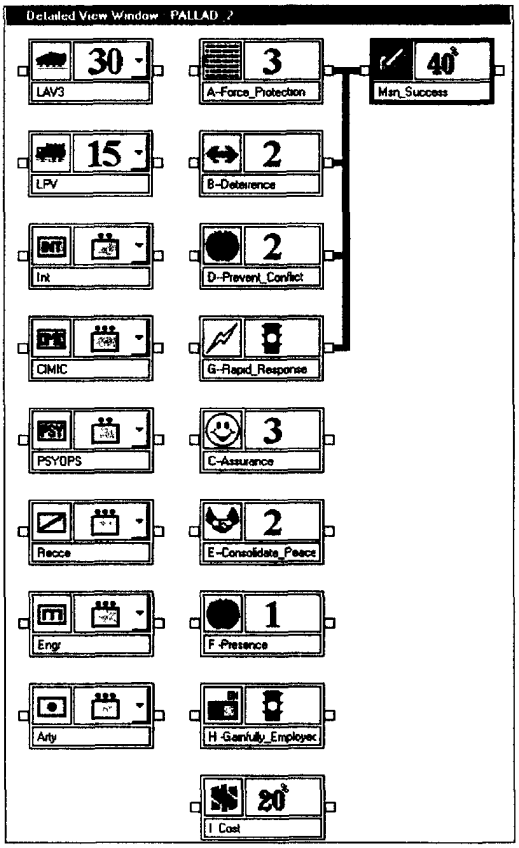


Figure 10 – Force option requirements to achieve a mission success of 40%.

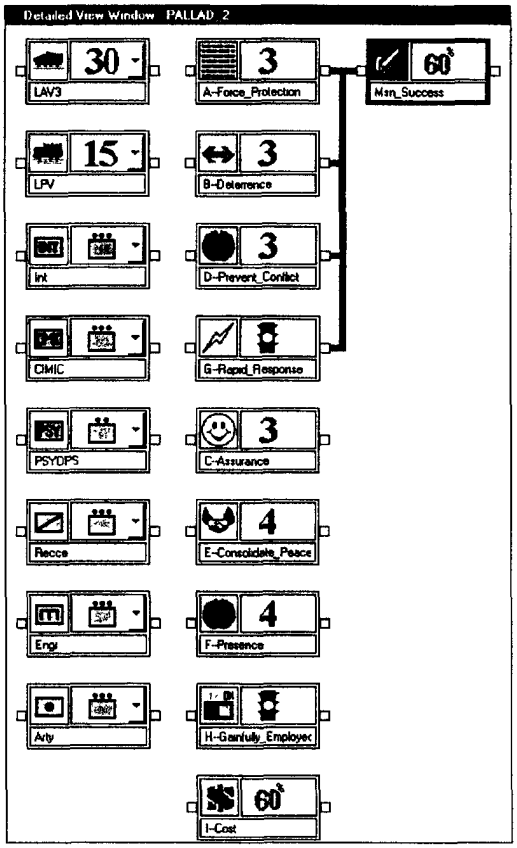


Figure 11 – Force option requirements to achieve a mission success of 60%.

30. Comparing Figure 7 and Figure 10, it is apparent that in order for the mission success to increase from 20% to 40% simply requires increasing the Civil-Military Co-operation (CIMIC) contingent from a detachment sized entity to a full platoon. As well, the Artillery component can be decreased since a battery is not a requirement for that performance grade. In order to achieve a mission success of 60%, Figure 11, also requires only a single change; increasing the size of the Intelligence detachment to a full platoon.

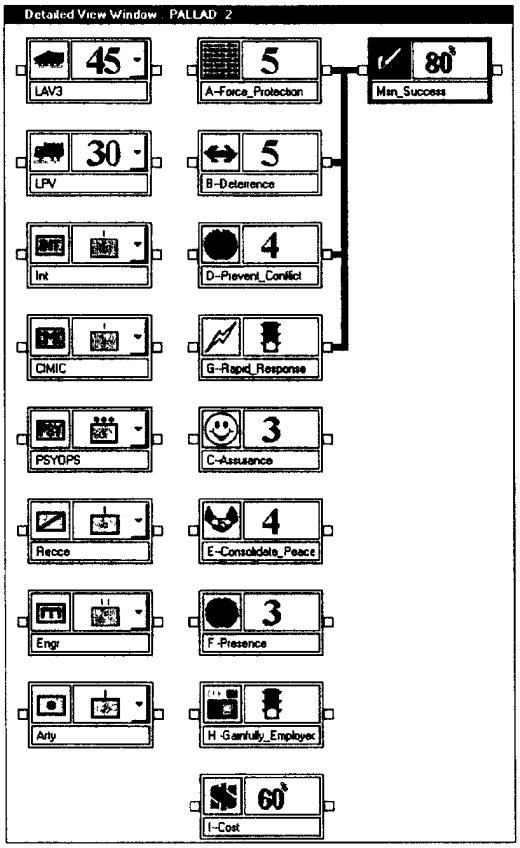


Figure 12 – Force option requirements to achieve a mission success of 80%.

31. From Figure 12, however, it is clear that to achieve a mission success of 80%, significant increases are necessary, including some beyond the maximum unit sizes that were originally specified by DLFR 3-3 (shown with red box and unit size indicator).

4. CONCLUSIONS

4.1 MISSION EFFECTIVENESS

32. The mission success of four proposed force structures has been investigated. Although based on the results obtained, none of them seem particularly attractive, this is most likely due to the incomplete definition of the key linkages between the levels of the hierarchy as defined by DLFR staff. Still, the results do seem to indicate that the Army's preferred force option for OP PALLADIUM, Roto 9 seems to have the greatest potential for success. Additionally, with relatively minor force augmentation, the mission success can be doubled or even tripled.

33. Prior to the completion of this study, external influences dictated that the Army's position was the most palatable [3]. Hence, there was no further need or support for the options analysis and the model development was halted.

4.2 THE WAY AHEAD

34. The H-Frame application proved to be very suitable for this task. In fact, the care and rigour that were required while DLFR 3-3 was populating the entity matrices provided deeper insights into the understanding of the force option problem.

35. The model does have a few limitations, however.

a. The scales used for the performance grades of each entity are purely ordinal. This means that a stoplight scale (red, yellow, green), a numerical scale of 1, 2 or 3 or a monetary scale of $0, $50M and $100M are all equivalent. It is debatable whether this is a limitation in actuality, however, the user must be aware that the actual numbers or symbols in the performance grade do not affect the grades at higher levels. This is determined purely by the minimum requirements to achieve that grade as defined in the superior entity's matrix.

b. It would be useful if a secondary performance scale could be assigned to entities. This would be particularly useful in this case where a specific cost can be attributed to utilizing one sized force over another.

The ability to tabulate the cost and perhaps even optimize based on cost would be constructive so that questions like "Is there a force that has a mission success of x, while costing less than $y?" could readily be answered.

c. The performance grades on any given level must be monotonically increasing with changes on the subordinate levels. In other words, applying more resources to a subordinate entity must cause either no change or an increase in the performance grade of a superior entity. It is impossible to define an entity such that an increase in a subordinate entity causes a decrease in the superior entities' grade. This can often be addressed by careful definition of the meaning of each entity, however, this is not always possible, particularly if some subordinate entities tend to increase a superior one, while increasing others would decrease its grade. An example of this phenomenon would be if in the OP PALLADIUM H-Frame model, all the second level entities were included in the overall assessment. As the size of the force increases so would the cost of deploying the force. Logically, this should cause the desirability of the force option to be decreased, which is in opposition to the increased effectiveness of this larger force.

d. Fully, and consistently, populating H-Frame models is not a trivial task. Care must be taken to ensure that the results provided by the model represent the real-world processes as accurately as possible.

e. Finally, H-Frame provides a useful, though subjective method of quickly investigating the secondary effects of making changes to a force structure – effects which may not be immediately apparent in a complex operation.

5. REFERENCES

1. E-Mail Maj P Mann / Mr. J Offiong, 18 Jan 02.

2. Jolicoeur, L. (Machina Sapiens, Inc.), D.W. Mason, *H-Frame: Hierarchical Framework for the Analysis of Mission Effectiveness, User's Guide*, September 1997.

3. E-Mail Maj P Mann / Mr. J Offiong, 2 Apr 01.

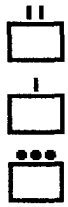
ANNEX A
DOR(MLA) RESEARCH NOTE RN 2002/04
MARCH 2002

H-Frame Model Platforms Level

The Platform level of the H-Frame model consisted of either vehicles or units. The vehicle performance scales were the numbers of vehicles to accompany the deployed force. The units were assessed based on the size of the contingent for that unit-type. Note that all symbols used in Table A-I are defined in the List of Abbreviations.

TABLE A-I
PLATFORM LEVEL PERFORMANCE SCALES WITH LINKAGES

Platform	Performance Scale	Superior Linkages (black text indicates Boolean AND relationship, bold cyan is Boolean OR)
LAV III	45 30 15 0	• Force Protection • Deterrence • Rapid Response • **Assurance** • **Presence** • **Gainfully Employed** • **Cost**
Light Patrol Vehicle	45 30 15 0	• Prevent Conflict • **Assurance** • Consolidate Peace • **Presence** • **Gainfully Employed** • **Cost**
Intelligence	 0	• Force Protection • Deterrence • Prevent Conflict • Consolidate Peace • Presence • Cost
Civil-Military Co-operation	 0	• Force Protection • Deterrence • Prevent Conflict • Rapid Response • Assurance • Consolidate Peace • Presence • Cost

Platform	Performance Scale	Superior Linkages (black text indicates Boolean AND relationship, bold cyan is Boolean OR)
Psychological Operations	 0	• Force Protection • Deterrence • Prevent Conflict • Rapid Response • Assurance • Consolidate Peace • Presence • Cost
Reconnaissance	 0	• Force Protection • Deterrence • Assurance • Presence • Gainfully Employed • Cost
Engineers	 0	• Force Protection • Deterrence • Rapid Response • Assurance • Consolidate Peace • Presence • Gainfully Employed • Cost
Artillery	 0	• Force Protection • Deterrence • Rapid Response • Assurance • Presence • Gainfully Employed • Cost

ANNEX B
DOR(MLA) RESEARCH NOTE RN 2002/04
MARCH 2002

H-Frame Model Capabilities Level

The Capabilities level of the H-Frame model consists of tasks and measures of effectiveness of the deployed force. Only four of the nine entities contribute to the superior Mission Success level. Table B-I shows the entity matrices for each item on the Capabilities level. The first column of the matrix is the performance scale (either numerical or stoplight in this instance). The remaining columns have the minimum requirements for each subordinate entity to achieve the performance grade on that row. The minimum requirements of ALL subordinate entities must be met in order to achieve the grade on any given row. If the same minimum requirement appears in two or more rows (for a single Platform), the higher performance grade will be assigned. For example, for Force Protection, 45 LAV-IIIs are required to achieve a grade of 4 for the capability. However, 45 LAV-IIIs are also all that are needed to obtain a grade of 5. In this case, if 45 LAV-IIIs are deployed, that platform will meet the minimum requirement for a grade of 5 to be assigned. Again, black text indicates a Boolean AND relationship with the other Platform entities and cyan text indicates a Boolean OR amongst the cyan entities. Note that all symbols in Table B-I are defined in the List of Abbreviations.

TABLE B-I
CAPABILITY LEVEL WITH ENTITY MATRICES

Capability / MOE — **Entity Matrix**

Force Protection

Performance Scale	LAV3	Int	CIMIC	Psyops	Recce	Engr	Arty
5	45	Pl	Coy	Pl	Sqn	Sqn	Bty
4	45	Pl	Coy	Pl	Sqn	Sqn	Bty
3	30	Det	Pl	Det	Tp	Tp	Tp
2	30	Det	Pl	Det	Tp	Tp	Tp
1	15	0	Det	Det	Tp	Tp	Tp
0	0	0	0	0	0	0	0

Deterrence

Performance Scale	LAV3	Int	CIMIC	Psyops	Recce	Engr	Arty
5	45	Coy	Coy	Pl	Sqn	Regt	Bty
4	45	Coy	Coy	Pl	Sqn	Regt	Bty
3	30	Pl	Pl	Det	Tp	Tp	Tp
2	30	Det	Pl	Det	Tp	Tp	Tp
1	15	0	Det	Det	Tp	Tp	Tp
0	0	0	0	0	0	0	0

Capability / MOE	Entity Matrix

Prevent Conflict

Performance Scale	LPV	Int	CIMIC	Psyops
5	45	Coy	Pl	Pl
4	30	Coy	Pl	Pl
3	15	Pl	Det	Det
2	15	Det	Det	Det
1	15	0	Det	Det
0	0	0	0	0

Rapid Response

Performance Scale	LAV3	CIMIC	Psyops	Engr	Arty
Green Light	30	Coy	Det	Tp	Bty
Yellow Light	15	Det	Det	Tp	Tp
Red Light	0	0	0	0	0

Assurance

Performance Scale	CIMIC	Psyops	Recce	Engr	Arty	LAV3	LPV
5	Coy	Pl	Sqn	Regt	Regt	45	60
4	Coy	Pl	Sqn	Regt	Regt	45	60
3	Pl	Det	Tp	Sqn	Tp	30	45
2	Pl	Det	Tp	Sqn	Tp	30	30
1	Det	Det	Tp	Sqn	Tp	15	15
0	0	0	0	0	0	0	0

Consolidate Peace

Performance Scale	LPV	Int	CIMIC	Psyops	Engr
5	45	Coy	Pl	Pl	Regt
4	30	Coy	Pl	Pl	Regt
3	15	Pl	Det	Det	Tp
2	15	Det	Det	Det	Tp
1	15	0	Det	Det	Tp
0	0	0	0	0	0

Presence

Performance Scale	Int	CIMIC	Psyops	Recce	Engr	Arty	LAV3	LPV
5	Coy	Pl	Pl	Sqn	Regt	Regt	45	45
4	Coy	Pl	Pl	Sqn	Regt	Regt	45	30
3	Coy	Det	Det	Tp	Tp	Tp	30	15
2	Coy	Det	Det	Tp	Tp	Tp	30	15
1	Det	Det	Det	Tp	Tp	Tp	15	15
0	0	0	0	0	0	0	0	0

Capability / MOE	Entity Matrix

Gainfully Employed

Performance Scale	Recce	Engr	Arty	LAV3	LPV
Green Light	Sqn	Sqn	Bty	45	45
Yellow Light	Sqn	Sqn	Tp	30	30
Red Light	Tp	Tp	0	15	15

Cost

Performance Scale	Int	CIMIC	Psyops	Recce	Engr	Arty	LAV3	LPV
100%	Coy	Pl	Pl	Regt	Regt	Regt	45	60
90%	Coy	Pl	Pl	Regt	Regt	Regt	30	60
80%	Coy	Pl	Pl	Regt	Regt	Regt	30	60
70%	Coy	Pl	Pl	Regt	Regt	Regt	15	60
60%	Coy	Pl	Pl	Sqn	Sqn	Bty	15	45
50%	Coy	Det	Det	Sqn	Sqn	Bty	15	45
40%	Pl	Det	Det	Sqn	Sqn	Bty	15	30
30%	Pl	Det	Det	Tp	Tp	Tp	15	30
20%	Det	Det	Det	Tp	Tp	Tp	15	15
10%	Det	Det	Det	Tp	Tp	Tp	15	15
0%	0	0	0	0	0	0	0	0

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ANNEX C
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MARCH 2001

H-Frame Model Mission Success Level

The Mission Success level of the H-Frame model consists of a single overall measure of effectiveness of the deployed force. Only four of the nine entities on the subordinate level contribute to this level. Table C-I shows the entity matrix for the Mission Success level. The first column of the matrix is the performance scale (a percentage scale in this instance). The remaining columns have the minimum requirements for each subordinate entity to achieve the performance grade on that row. If the same minimum requirement appears in two or more rows, the higher performance grade will be assigned. For example, for a score of 5 for Force Protection is required to achieve a grade of 90% in mission success. However, a score of 5 for Force Protection also earns a mission success grade of 100%. In this case, if a grade of 5 is be assigned to Force Protection, the minimum requirement for a mission success of 100% is achieved by that capability. Given the minimum requirements in Table C-I, the odd numbered performance grades (10%, 30%, etc.) are redundant, but their inclusion would have provided additional resolution had the model, i.e. the linkages between the second and third levels of the hierarchy, been developed further. Note that all symbols used in Table C-I are defined in the List of Abbreviations.

TABLE C-I
MISSION SUCCESS LEVEL WITH ENTITY MATRIX

Mission Success	Entity Matrix				
	Performance Scale	**Force Protection**	**Deterrence**	**Prevent Conflict**	**Rapid Response**
Mission Success	**100%**	5	5	5	Green Light
	90%	5	5	5	Green Light
	80%	4	4	4	Green Light
	70%	4	4	4	Green Light
	60%	3	3	3	Yellow Light
	50%	3	3	3	Yellow Light
	40%	2	2	2	Yellow Light
	30%	2	2	2	Yellow Light
	20%	1	1	1	Yellow Light
	10%	1	1	1	Yellow Light
	0%	0	0	0	Red Light

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Department of National Defence
Ottawa, Ontario K1A 0K2

2 SECURITY CLASSIFICATION (overall security classification of the document, including special warning terms if applicable)

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Evaluation Force Mission Effectiveness Using the Hierarchical Framework Analysis Tool

4 AUTHORS (last name, first name, middle initial)

Offiong, Jason, J.

5 DATE OF PUBLICATION (month Year of Publication of document)	6a. NO OF PAGES (total containing information Include Annexes, Appendices, *etc.*)	6b NO OF REFS (total cited in document)
March 2002	**36**	**3**

7 DESCRIPTIVE NOTES (the category of document, *e.g.* technical report, technical note or memorandum. If appropriate, enter the type of report *e.g* interim, progress, summary, annual or final Give the inclusive dates when a specific reporting period is covered)

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Director Land Force Readiness

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The mission effectiveness of a number of force options for OPERATION PALLADIUM, Rotations 9 through 11 in Bosnia, has been investigated using the Hierarchical Framework for the Analysis of Mission Effectiveness (H-Frame), an options analysis decision support tool. This report will present those results and will describe the use of H-Frame as a tool to support force structure planning and assessment. Although due to external influences the modelling effort was cut short, the force option preferred by the Army appears to have the highest level of mission success. Ultimately this was the option that was deployed for the ninth rotation of OPERATION PALLADIUM.

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