NAVAL WAR COLLEGE
Newport, R.I.

THE ANALYTIC HIERARCHY PROCESS: ENHANCING OPERATIONAL LEVEL DECISION MAKING

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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10 March 1993

Paper Directed by
Captain H. W. Clark, Jr., U.S. Navy
Chairman, Department of Joint
Military Operations

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT DISTRIBUTION STATEMENT A; APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION OPERATIONS DEPARTMENT 6b OFFICE SYMBOL (If applicable) C	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) NAVAL WAR COLLEGE NEWPORT, R.I. 02841	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

THE ANALYTIC HIERARCHY PROCESS: ENHANCING OPERATIONAL LEVEL DECISION MAKING(U

12. PERSONAL AUTHOR(S)

LCDR BARBARA M. KOROSEC, USN

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
FINAL	FROM ____ TO ____	2/22/93	63

16. SUPPLEMENTARY NOTATION A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Operations. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Analytic Hierarchy Process, Planning, Decision Making, Commander's Estimate, Operational Planning

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ OTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL CHAIRMAN, OPERATIONS DEPARTMENT	22b. TELEPHONE (Include Area Code) 841-3414 / 22c. OFFICE SYMBOL C

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

U.S. Government Printing Office 1988—438-418

Abstract of
THE ANALYTIC HIERARCHY PROCESS: ENHANCING
OPERATIONAL LEVEL DECISION MAKING

The Analytic Hierarchy Process (AHP) is examined as an enhancement to operational level planning. The process is first simply described, followed by the application of the process to two national security grand strategy decisions. Moving down the level of decision making to the operational level, the decision matrix used in the Commander's Estimate of the Situation (CES) to analyze opposing courses of action is examined both in its existing form and under AHP. Lastly, AHP is applied to a specific CES from an operational case study using the software *Expert Choice*. The Analytic Hierarchy Process, as employed in *Expert Choice*, is a simple decision tool, yet provides extraordinary benefits in the areas of group dynamics and the treatment of intangibles, abstractions and uncertainty. Operational level planners are encouraged to test AHP and *Expert Choice* in both deliberate and crisis action planning.

PREFACE

Dwight D. Eisenhower said, "Plans are nothing; planning is everything." Indeed, most people who have had to use a planning methodology to enhance decision making believe that the *process* of planning is more fruitful than the actual production of a plan. The fruit of this process is the illumination that it provides regarding the problem, constraints, alternatives, etc. As decision makers, military leaders are often faced with monumental decisions regarding the use of military force to achieve national interests. Operating in a decision making environment that is often filled with great uncertainties, intangibles and abstractions additional illumination during the planning process would be a welcome commodity for most. The Analytic Hierarchy Process may provide additional illumination.

According to its founder, Thomas L. Saaty, the Analytic Hierarchy Process (AHP) had its beginnings in 1971 while he was working on problems of contingency planning for the Department of Defense (DoD).[1] In this paper, a basic illustration of the planning methodology using AHP is provided, using a case developed around the British decision regarding an amphibious landing in the Falklands and using a commerical computer software called *Expert Choice*[2], which is based on AHP. A more in depth examination of Saaty's work in DoD contingency planning and a more comprehensive application of AHP to current contingency planning is recommended to the individual performing advanced research or embarking on thesis work.

Group judgements used in the Falkland Islands case study were provided by Commander Jill R. Usher, U.S. Navy, Commander Steven Kinney, U.S. Navy, Lieutenanat Colonel Frances M. Early, U.S. Air Force and Commander Richard L. Towner, U.S. Navy. Their patience, persistence and good will is most sincerely appreciated, especially in view of my request for them to display these qualities after Friday lectures! Additionally, Lieutenant Colonel Don Bourdon, U.S. Air Force graciously made *Expert Choice* available for my use.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

THE ANALYTIC HIERARCHY PROCESS: ENHANCING OPERATIONAL LEVEL DECISION MAKING

CHAPTER 1

INTRODUCTION

The methodology provided in Naval Warfare Publication 11 (Ref. F) for the Commander's Estimate of the Situation (CES) is time and battle tested, to be sure. It provides the decision maker with a wealth of information and a very logical analysis of possible courses of action to accomplish a mission, taken against probable enemy capabilities. Ideally, through this tool the planner weighs all possible factors, constraints and events to arrive at a very sound recommendation for action. The process itself is designed to be analytical and robust. However, the process can become cumbersome if the contingency involves significant uncertainty, intangibles and abstractions. Additionally, the decision maker may not be able to ascertain the sensitivity of the recommended course of action to judgments about the events that shape it.

The Analytic Hierarchy Process (AHP), on the other hand, is capable of treating uncertainty, intangibles and abstractions in a manner that does not exceed the cognitive capability of the planners and decision makers. Additionally, through the use of a computer software called *Expert Choice*, which is based on AHP, sensitivity analysis can quickly and easily be performed. Using the Analytic Hierarchy Process during the Analysis of Opposing Courses of Action portion of the Commander's Estimate of the Situation, rather than the decision matrix that is currently used, provides additional enhancement of the process without an incremental increase in effort. Enhancing the process provides the planners and decision makers with greater illumination, thereby improving decision making and the understanding of the factors inherent in the decision.

Following a brief explanation of AHP, two cases of its application to grand strategy decisions will be presented, followed by its application to planning at the operational level. To illustrate the application of AHP to CES, a Commander's Estimate of the Situation was developed for Great Britain's decision regarding where to conduct an amphibious landing on the Falkland Islands during their war with Argentina for control of the islands. In this case study, the application of AHP to group planning is also presented.

This paper represents only an overview of AHP and its potential for application to planning at the operational level. While the examples presented here focus on national security issues and the application of military force, a plethora of other applications exist for the Analytic Hierarchy Process. Most notable are applications to negotiation, resource allocation and personnel selection.

CHAPTER II

THE ANALYTIC HIERARCHY PROCESS

The description of AHP provided here is a simple overview intended for the military leader and decision maker, rather then the mathematician or systems analyst.[1] The first step is to define the problem and specify a set of possible outcomes. As applied to operational contingency planning the first step would entail defining the mission, or goal, as well as possible courses of action (outcomes) to accomplish the mission.

Secondly, the planner must construct a hierarchy that decomposes the mission or goal into intermediate levels to reach the final level (courses of action). A generic hierarchy for contingency planning is presented in Table 3. In order to construct a hierarchy, the planner must be able to decompose the mission into levels in which the elements of that level interact with the elements of the levels that are above and below it. While the idea of constructing a hierarchy might seem ethereal or unnatural to some, Saaty offers the following overview:

> "When first faced with a complex problem, we may be overwhelmed by its size and by the amount of detail involved. Our first instinct is to decompose the problem into smaller and more manageable parts; we then subdivide those parts into smaller parts, and so on. This, in essence, gives rise to a hierarchy. Hierarchies are thus a consequence of the effort of the human mind to seek understanding."[2]

Constructing a hierarchy is similar to the formulation step in the Rational Decision Process. As described by McBrien and Ensminger, this phase is the most critical part of the process. They state, "During problem formulation, the primary task is to define what decision needs to be made, how the results of that system will fit into a larger organization or system, and what aspects of the problem are most important."[3] This sounds a great deal like the natural decomposition process that gives rise to a hierarchy.

The third step in the hierarchy is to perform pairwise comparisons of the contribution that each element provides to the governing mission or the criterion at the adjacent upper

level using the ratio scale provided in Appendix III . Although the scale provides for a mathematical solution, most planners and decision makers would opt to use *Expert Choice* in which the user is prompted to make verbal comparisons between pairs and the software computes the mathematical solution. Pairwise comparisons are made at each level of the hierarchy until a composite weight is obtained for each alternative. The alternative receiving the greatest weight is the one that would be recommended. This analysis parallels the evaluation stage in the Rational Decision Process. Evaluation is intended to determine the extent to which each of the alternatives meet the objective, similar to the test for suitability feasibility, and acceptability in the Commander's Estimate of the Situation.

Contrary to the Rational Decision Process, Saaty does not provide for a search phase prior to the evaluation. The search phase is intended to focus on the collection of information to assist in comparisons between alternatives with regard to measures of effectiveness and efficiency. A difficulty in conducting the search phase can be trying to quantify the unquantifiable. This is an area where AHP, by asking for verbal judgments, can be advantageous -- particularly if the only thing a decision maker has to go on is an intangible and subjective funny little internal feeling.

Naturally, the conscientious planner would not stop the analysis here. At this stage of decision making, the Rational Decision Process would call for interpretation and presentation of results. Using AHP, interpretation would include checking the consistency of judgments provided at each level of the hierarchy, as well as the hierarchy as a whole.

For example, under conditions of perfect consistency, if Own Course of Action (OCA) #1 is preferred to OCA #2 and OCA #2 is preferred to OCA #3, then OCA #1 would be preferred to OCA #3. Perfect consistency is rare and in fact, some inconsistency may be perfectly logical. Perhaps OCA #1, #2 and #3 bring different capabilities to bear or are impacted upon differently by the principles of war so that when pairwise comparisons are made there exists some reason why OCA #3 would be preferred to OCA #1. A consistency ratio of 0.10 or less is considered acceptable, meaning that the judgments are consistent at

least 90% of the time.[4] Using *Expert Choice,* consistency ratios are readily available to the user. Without expert choice, significant number crunching is required, making the process too cumbersome for the average planner or action officer engaged in crisis action planning.

Expert Choice is capable of performing quick and easy sensitivity analysis, providing additional interpretation of the results obtained with the Analytic hierarchy Process. This feature allows the planner or decision maker to see how sensitive the composite weights for each course of action are to the weights at higher levels. In other words, it is a capability to answer the question "What if ...?" Thus, this evaluation helps bound the uncertainty associated with a decision. In fact, Albert Madansky proffers there are five ways to treat uncertainty: 1) buy time, 2) get more intelligence, 3) buy flexibility as a hedge, 4) use *A Fortiori* analysis, eliminating alternatives that are not dominant and 5) use sensitivity analysis to show the performance of each alternative as a band or range, rather than a fixed point.[5] Normally, in crisis action planning, time is of the essence and additional intelligence may not be available. A flexible course of action may not meet the test of suitability and in order to simplify the planning process, those alternatives that are not dominant probably would have been eliminated already. Sensitivity analysis may therefore be the only remaining option for treating uncertainty.

CHAPTER III

THE ANALYTIC HIERARCHY PROCESS AND CONFLICT RESOLUTION -- GRAND STRATEGY DECISIONS

In April, 1982 while two-thirds of the British fleet was steaming or preparing to steam to the Falklands, Thomas Saaty was facilitating a session at the University of Pittsburgh's six week seminar "Management Program for Executives." The seminar was attended by 25 participants, including representatives from eight countries including Great Britain. Saaty decided to use AHP to determine what Britain's course of action should be with regard to the Falklands.[1]

Regarding the invasion of the Falkland Islands by Argentine forces, the international group of executives identified three possible courses of action, costs and benefits for Britain:[2]

Courses of Action:

1. Do nothing; allow Argentina to keep the islands.
2. Send the fleet and force Argentina to reopen negotiations.
3. Send the fleet and retake the islands.

Benefits:

1. Save the islanders' lives
2. Save Thatcher's career
3. British national prestige
4. Peace
5. No casualties
6. Hold islands
7. Teach Argentina a lesson
8. Maintain options

Costs:

1. Political costs
2. Fuel and maintenance costs
3. Argentine sovereignty
4. Possible war
5. Casualties and ammunition
6. Potential for naval defeat

On the basis of the above, two hierarchies were constructed, as presented in Appendix I. One hierarchy depicts benefits as the primary criteria and the second one depicts costs as the primary criteria. A synthesis of ratios for each of the hierarchies produced the results in Figure 3:[3]

FIGURE 3

BENEFIT-TO-COST RATIOS FOR FALKLAND ISLANDS

Options:	Benefits:	Costs:	Benefit -to Cost Ratio
Do nothing	.307	.141	.307 ÷ .141 = 2.18
Send fleet - negotiate	.375	.221	.375 ÷ .221 = 1.70
Send fleet - retake isl.	.318	.638	.318 ÷ .638 = 0.50

The highest benefit-to-cost ratio, 2.18, is associated with the option of doing nothing. Yet, the British fleet was already steaming toward the Falkland Islands. Saaty and Alexander give two possible explanations for Great Britain's decision. The first is that Britain failed to take a sufficiently long range view, failing to recognize the relationship of benefits to costs. This explanation would be consistent with short sighted tactical decisions made by British as well. For example, putting troops ashore at San Carlos and exposing them to the harsh environment with minimal sustainability, only to have them wait for over one week for the arrival of the 5th Infantry Brigade to reinforce them. Another short sighted decision was 2nd Battalion Parachute Regiment's maneuver to Fitzroy without considering requirements for reinforcement and sustainability. The last example of Britain's short sightedness was the relatively unprotected landing at Bluff Cove by elements of the 5th Infantry Brigade, causing casualties to the 1st Battalion Welsh Guards.

The second explanation offered for the disparity between model and actual outcome is that his analysis failed to sufficiently account for a sense of responsibility of Britain to the Falkland Islanders. Accordingly, he could have given a higher weight to the option of expelling Argentinians from the island. It seems hindsight is always perfect and had Saaty's

seminar performed the analysis even one month later, the participants might have been more aware of the nationalistic fervor this situation had created in Britain.

This case shows how AHP can be very simply and easily applied to a very complex problem of conflict resolution at the national level. However, as is true with all analysis, the outcome is only as good as the analysis that produced it.

The second case used to illustrate the application of AHP to a complicated national security problem is the 1980 Iran Hostage Rescue Operation. According to Saaty and Alexander, the military experts' assessment that there was a medium chance for success in the operation inevitably led to President Carter's decision to execute the operation, given his objectives and those of his advisors.[4] The case describes the rescue attempt as a complicated plan involving joint assets, a long flight, a night landing in the desert, transfer by land to Tehran, removing the hostages from the Embassy and returning to safety. The Go, No-Go decision of that operation was analyzed using both AHP and Multi-Attribute Utility (MAU). The hierarchy used in AHP is reproduced at Appendix II.

Under AHP, the process favored the Go decision (.69) over the No-Go decision (.31). Sensitivity analysis identified the dominance of the factor of Carter's political life in the rescue mission decision. Barring any clearly existing jeopardy to the lives of the hostages, greater emphasis on the hostages' lives versus Carter's political life would have tilted the recommendation in favor of a No-Go decision.[5]

When analyzed using MAU, the expected utility of Go (.7319) exceeded the expected utility of No-Go (.6540). Additionally, under a low likelihood of success the No-Go alternative was dominant, while a medium to high likelihood of success favored the Go alternative.[6] Thus, the two methods produced the same basic recommendation.

Three shortcomings of MAU are discussed by Saaty and Alexander. The first is that the decision maker is required to quantify all attributes of a decision prior to constructing utilities. The second is that the decision maker must decide on probability levels. Lastly, the model assumes the decision maker is always consistent.

On the other hand, Saaty and Alexander found AHP to be considerably easier, especially for the non-technical decision maker. One only has to understand the rating scale and the arrangement of judgments. Additionally, I would add that the ease with which sensitivity analysis can be performed on *Expert Choice* adds an invaluable capability to the decision making process that uses this methodology.

CHAPTER IV

THE ANALYTIC HIERARCHY PROCESS (AHP) AND THE COMMANDER'S ESTIMATE OF THE SITUATION (CES)

When following the procedures for a Commander's Estimate of the Situation as described in NWP 11 (Rev. F), the heart of the analysis is the decision matrix, a dynamic analysis performed to determine the probable effect of each enemy capability on the success of each own course of action. A brief review of this methodology is helpful here:

1. Decide on a Measure of Effectiveness (MOE) that satisfies the following criteria:

   a. criteria for success
   b. basis for comparing the courses of action under consideration
   c. focuses on the physical objective and lends itself to prediction

2. Predict outcomes for each interaction of Own Course of Action (OCA) and Enemy Capability (EC) using the Measure(s) of Effectiveness. Outcomes are normally plotted in matrix format as in Figure 2, below:

FIGURE 2

CES DECISION MATRIX

	EC #1	EC #2	EC #3
OCA #1	Outcome OCA 1/EC 1	Outcome OCA 1/EC2	Outcome OCA 1/EC 3
OCA #2	Outcome OCA 2/EC 1	Outcome OCA 2/EC 2	Outcome OCA 2/EC 3
OCA #3	Outcome OCA 3/EC 1	Outcome OCA 3/EC 2	Outcome OCA 3/EC3

3. Interpret the results of the analysis.[1]

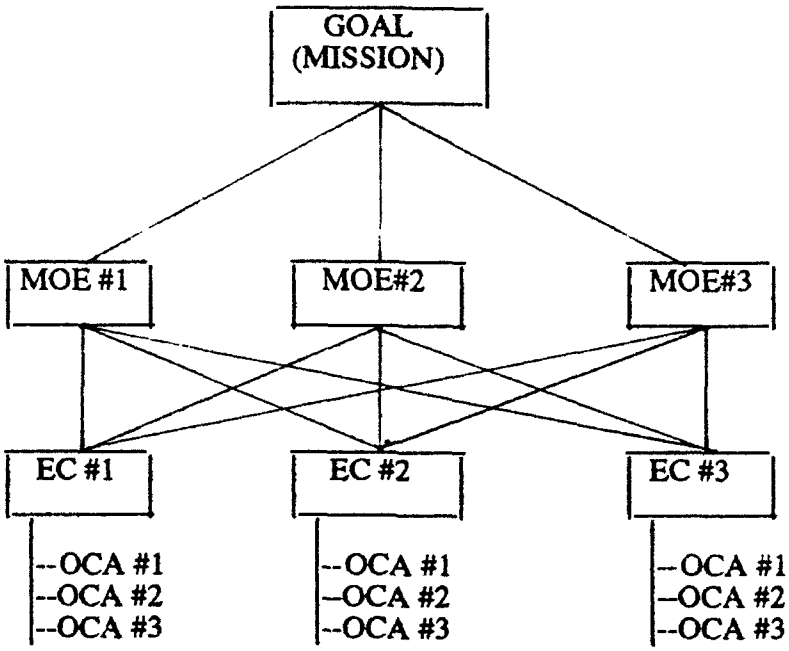
Following this analysis, the decision maker reviews the advantages and disadvantages of each retained course of action, perhaps in light of principles of war such as mass, simplicity or maneuver. Also, each course of action receives a final check for suitability, feasibility and acceptability prior to weighing the merits of each course of action and selecting one. In this manner, the decision maker has ultimately compared the courses of action against one another, in view of how each is predicted to perform across the range of enemy capabilities.

The Analytic Hierarchy Process allows for pairwise comparisons of Own Courses of Action *relative to a specific enemy capability.* For example, the decision maker would use the Ratio Scale to indicate the degree to which OCA #1 was preferred to OCA #2 against EC #1. In doing so, the decision maker would intuitively consider principles of war and relevant measures of effectiveness. Pairwise comparisons can be made on the basis of importance, preference or likelihood. Abstractions, uncertainty and intangibles can all be considered in these comparisons without overwhelming the decision maker.

Assuming a hierarchy is constructed with own courses of action as alternatives or outcomes, the decision maker would follow a path from the mission (goal) to courses of action (alternatives) in Figure 4. First, the MOE's would be compared against one another relative to the mission. For example, if the mission is to maintain a foothold on the peninsula, MOE #1 is the control of a major seaport and MOE #2 is the number of U.S. casualties, then the pairwise comparison would be something like the following: "Relative to the mission of maintaining a foothold on the peninsula, how important is control of the major seaport to the number of U.S. casualties?" In other words, the decision maker determines priorities for each of the MOEs. Next, pairwise comparisons would be made for each enemy capability relative to the measures of effectiveness. Finally, the courses of action would be compared against one another relative to an enemy capability. The basic analysis ends with a synthesis of all weights to arrive at composite weights for each of the courses of action.

FIGURE 4

CES HIERARCHY



One primary advantage of the use of *Expert Choice* is that sensitivity analysis can easily be performed on the outcome. In the above example, the decision maker could determine how sensitive the composite weights of the courses of action are to the judgments (weights) given to the measures of effectiveness. Or, the decision maker could determine how sensitive the courses of action are to the judgments (weights) given to the enemy capabilities. This ability to perform sensitivity analysis on an operational level decision involving an array of abstractions, uncertainties and intangibles, with only a few keystrokes on a laptop computer, far exceeds the information available to the decision maker using the traditional format of the Commander's Estimate of the Situation.

An additional advantage of the Analytic Hierarchy Process over the traditional Commander's Estimate of the Situation is that it allows for group input to the process, without that group reaching consensus on the recommended course of action. For example,

in the hierarchy above, a commander could insert a level of players between the goal and the measures of effectiveness. The players could be a joint staff (J-1, J-2, J-3, etc.) or component commanders (air, ground, surface, etc.) Each player would then perform his or her own judgments regarding measures of effectiveness, enemy capabilities and courses of action.

Typically, a group can reach consensus regarding MOEs, ECs and OCAs to retain, even if they can not agree upon which should be given a higher priority. The commander would determine, through pairwise comparison of the players, what weight each player's judgments should receive. If the commander was faced with an ad hoc staff, each player might be given equal weight. Conversely, if the commander favored the judgment of one player over the others, through either experience or mission, then that player's judgments might be given greater priority over the others. Ultimately, composite weights are obtained for each Own Course of Action, however they are influenced by the judgments of the players.

The Commander could then quickly perform sensitivity analysis to determine the degree to which the weight given to the players effects the outcome. Or, the Commander can review the synthesis of each player's judgments in order to ascertain the priorities given to each element. Should the commander concur, in general terms, with the soundness of an individual player's judgments, then that player might receive additional weight. This process will become clearer in Chapter V.

CHAPTER V

THE ANALYTIC HIERARCHY PROCESS AND CONFLICT RESOLUTION - OPERATIONAL LEVEL DECISION MAKING

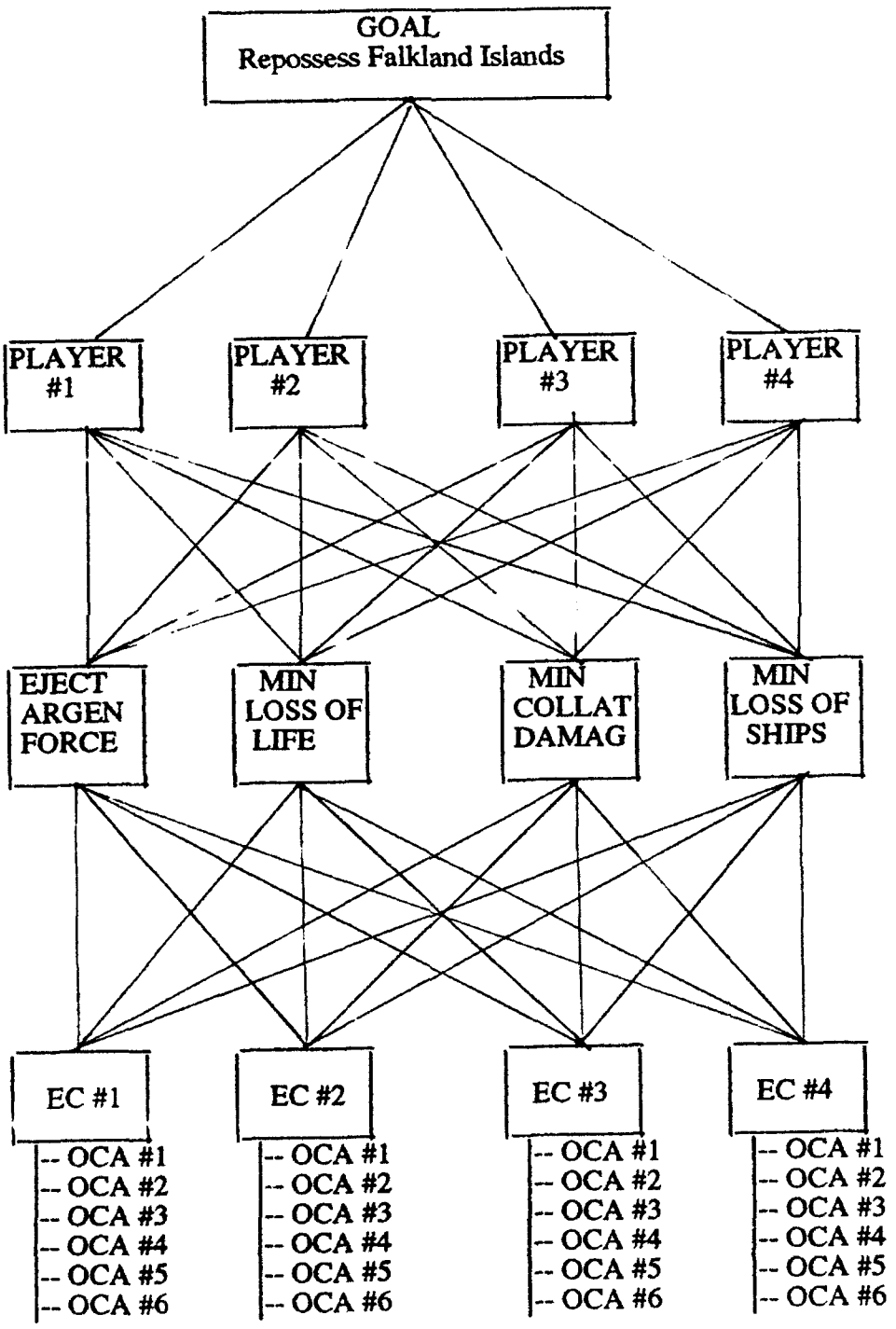
In this chapter AHP will be applied to operational level decision making using a case developed from the Falklands War. Additionally, the planning will include a group of four players that could represent either a joint staff or component commanders. The group was temporally placed in mid-May 1982 in the role of British planners. Their decision is where to make an amphibious assault on the Falkland Islands in order to seize control of Port Stanley and repossess the islands.

The background given to the group to frame the problem and attempt to provide the British mindset is provided in the Background, Situation and partial Commander's Estimate of the Situation at Appendix III. The estimate stops at the point of analyzing opposing courses of action, because it is at that point where the Analytic Hierarchy Process is applied, versus the traditional decision matrix. *Expert Choice* was used to run the model. The hierarchy was constructed to include four players, four measures of effectiveness, four enemy capabilities and six courses of action, arranged in five tiers. The completed hierarchy is depicted in Figure 4. The hierarchy as seen after insertion in the *Expert Choice* format is provided at Appendix IV.

The players were asked to make judgments at each level of the hierarchy using the Player's Worksheet and Ratio Scale also included at Appendix III. One player had difficulty expressing judgments using a numerical ratio that involved integers and reciprocals. A second player had difficulty with the wording used to weight two elements relative to a parent node (i.e. two enemy capabilities relative to a MOE). Both of these difficulties could have been alleviated by using the Pairwise Comparison Worksheets available in later versions of *Expert Choice*. A sample worksheet is provided at Appendix V, and has been annotated to approximate actual judgments that were entered to weight the players.

FIGURE 4

FALKLAND ISLANDS HIERARCHY - CASE STUDY



Once all judgments had been entered in Expert Choice, a synthesis of all the weights was performed to compute the composite weights of each alternative and arrive at an initial solution. Performing these computations manually exceeds the mathematical capability of most military officers and would be entirely too cumbersome to be of value in crisis action planning. Indeed, without friendly computer software to perform the computations and sensitivity analysis, AHP loses most of its appeal for the operational planner. This is probably evident to most by viewing the synthesis for this case study that is provided at Appendix VI.

The bottom line provided by the synthesis is the composite weights for each alternative. These weights are provided at Appendix VII and is reproduced in Table 5, below:

TABLE 5

COMPOSITE WEIGHTS FOR COURSES OF ACTION

OCA #	DESCRIPTION	WEIGHT
2	Attack at San Carlos; maneuver to seize Stanley	0.299
3	Attack at Bluff Cove; maneuver to seize Stanley	0.267
4	Attack at Cow Bay; maneuver to seize Stanley	0.150
1	Attack at Stevelly Bay; mass & sustain	0.135
5	Attack at Berkeley Sound; seize Port Stanley	0.096
6	Attack and Seize Port Stanley	0.052

Over and above the written guidance that the players were provided, they were given three assumptions: 1) They did not have air superiority, 2) Expediency was critical (politically and militarily) and 3) The prime conflict experienced by the British decision makers was between the Navy's desire for a protected anchorage and the desire by the ground forces to limit lines of communication and mobility once they were on the ground.

Sensitivity analysis was first conducted to determine the degree that the weight of the players influenced the outcome. (Regrettably, I lacked the graphics capability to print

these graphs for the reader.) The results indicated the following sensitivities:

- For player #1: OCA #1 is favored if the player's weight is increased to .48 or greater.

- For player #2: OCA #3 is favored if the player's weight is increased to .68 or greater.

- For player #3: OCA #4 is favored if the player's weight is increased to .55 or greater.

- For player #4: OCA #3 is favored if player's weight is decreased to .12 or less.

This analysis indicates that OCA #2 (San Carlos) is truly a synthesis of the judgments of all four players. The high composite weight given to OCA #3 (Bluff Cove) is largely due to the preference for that alternative by player #2. Given that this player already received a weight of .502, it would not be a substantial increase to raise the weight to .68 and tilt the outcome in favor of OCA #3 (Bluff Cove).

Another example of the type of information that sensitivity analysis provided is the sensitivity of the composite weights for courses of action to the weights each player gave to the measures of effectiveness. For example:

Player #1: Favors OCA #2, regardless of priorities of MOE

Player #2 Favors OCA #3 if Ejection of Argentine forces is $\leq .25$
Favors OCA #3 if Minimize loss of British life is $\leq .25$
Favors OCA #3 if Minimize collateral damage is $\geq .42$
Favors OCA #3 if Minimize damage to ships is $\geq .12$

Another example of sensitivity analysis is the effect of the weights given to enemy capabilities upon composite weights for courses of action. For Player #2, with regard to the MOE of ejecting Argentine forces:

OCA #3 is preferred if EC #1 is $\geq .40$
OCA #3 is preferred if EC #2 is $\geq .18$
OCA #3 is preferred if EC #3 is $\geq .36$
OCA #2 is preferred regardless of the priority given to EC #4

Upon reviewing the individual player's worksheets and the synthesis, it became apparent that there were two problems faced by the players in entering judgments. First, using the numerical ratio was difficult for some and may have detracted from the process. Secondly, when evaluating enemy capabilities against measures of effectiveness, Player #2 took a worse case approach and Player #4 took a best case approach. This disparity, as well as the difficulty of turning verbal judgments into numbers, could have been eliminated if comparison sheets like the one at Appendix V had been used.

The weighting awarded to the players may be of interest. Weights were determined based only on the consistency factors of the players. For example, the judgments entered by Player #2 were extremely consistent (< .10), while the judgments entered by Player #1 were extremely inconsistent (> .70). Player #1 also exhibited the greatest difficulty with the verbal judgments, which probably contributed to that player's inconsistency. Giving players a higher weight based on their consistency only says their decisions are consistent, not that they're operationally or tactically sound. A commander could award higher weight to a component commander who has the greatest role to play in executing the course of action, or to the staff member whose judgment he or she most respects.

Of interest is that the group's recommendation is consistent with the actual action taken by the British. This may be because of the attempt to frame the case in the British perspective. Had this framework not been provided, the Bluff Cove option may have fared even better than it did.

CHAPTER VI

CONCLUSIONS

The Analytic Hierarchy Process, when used with *Expert Choice,* enhances national security decision making -- particularly at the operational level. E. S. Quade lists the following pitfalls and limitations in systems analysis and policy planning:[1]

Under emphasis on problem formulation
Inflexibility in the face of evidence
Adherence to cherished beliefs
Parochialism
Communication failure
Over concentration of the model
Excessive attention to detail
Neglect of the question
Incorrect use of the model
Disregard of the limitations
Concentration on statistical uncertainty
Inattention to uncertainties
Use of side issues as criteria
Substitution of the model for the decision maker
Neglect of the subjective elements
Failure to reappraise the work

The ability to formulate the problem is essential to any form of decision making and the use of AHP or *Expert Choice* does not alleviate that requirement. Someone with an ability to think logically, spatially and decompose an element is needed to formulate the hierarchy. However, this is not a difficult process that requires extraordinary genius. Likewise, use of AHP and *Expert Choice* does not prevent an overemphasis on the model itself or on the solution. People must still employ that necessary step of the Rational Decision Process called interpretation of results.

AHP as employed by *Expert Choice* does ameliorate, or at least diminish, many of the pitfalls above. When a group is allowed to insert individual judgments parochialism is vastly diminished, as are communication problems. Inflexibility and adherence to cherished beliefs are also minimized. The real value of AHP and *Expert Choice* is in the treatment of

subjective criteria and uncertainty. The evaluator is able to evaluate subjective criteria on a relative and qualitative basis, versus an absolute or quantitative basis. Through the graphs provided in sensitivity analysis, the decision maker is able to bound uncertainty.

Ultimately though, as with any other methodology, there is only one decision maker. No where is this more true than in military decision making, where standards of accountability placed upon a commander exceed a simple legal responsibility. Thus, the decision maker must not fall into the trap that is indicated in one of the pitfalls above, in which the model replaces decision making. The process described in this paper is intended to *enhance* decision making, not replace it.

APPENDIX I

BENEFITS AND COSTS HIERARCHIES FOR THE FALKLAND ISLANDS CRISIS

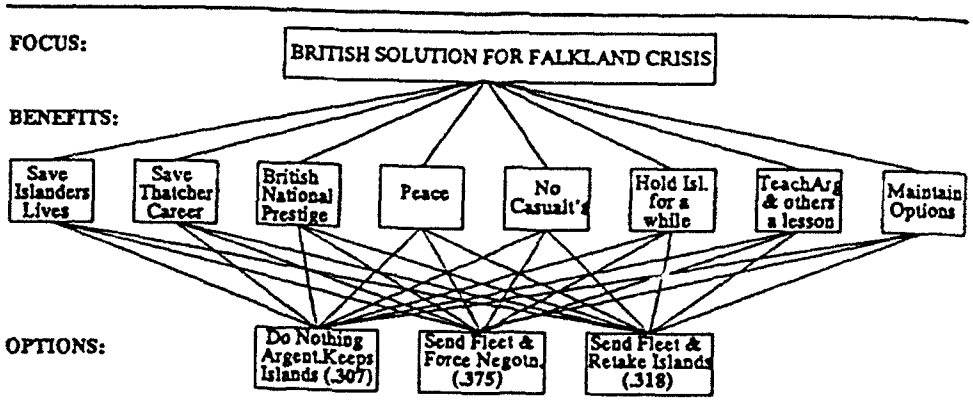
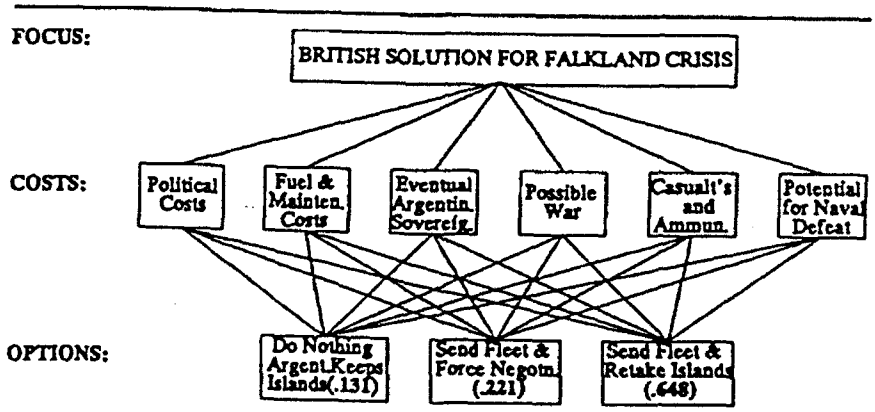


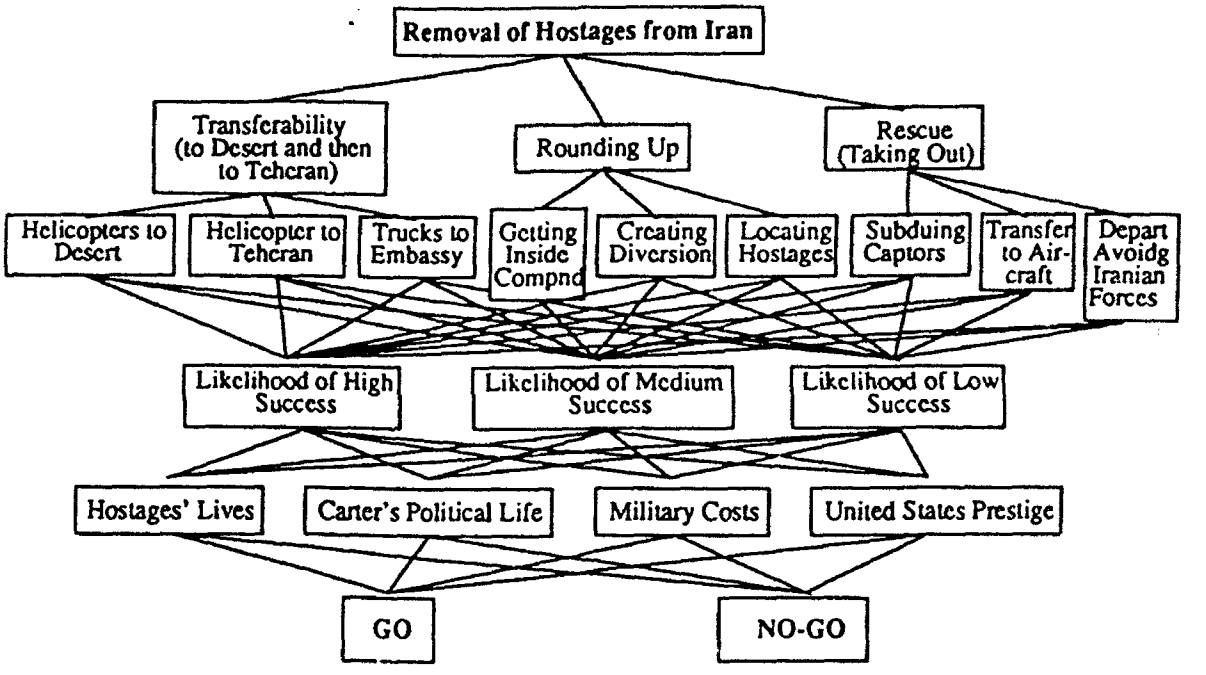
Figure 5.2
Costs of the British Solution for the Falkland Crisis



Source: Thomas L. Saaty and Joyce M. Alexander. Conflict Resolution (New York: Praeger Publishers, 1989, p. 68.

APPENDIX II

HIERARCHY OF THE IRANIAN HOSTAGE RESCUE MISSION



Source: Thomas L. Saaty and Joyce M. Alexander. Conflict Resolution (New York: Praeger Publishers, 1989, p. 125.

APPENDIX III

BRITISH AMPHIBIOUS ASSAULT OF THE FALKLAND ISLANDS OPERATIONAL LEVEL DECISION MAKING CASE STUDY

BACKGROUND TO THE CONFLICT.

- Sovereignty of the Falkland Islands has long been the subject of diplomatic dispute between Britain and Argentina. The Islands' 2,000 British residents reject Argentina's claims to sovereignty. They are administered as a British territory with a local Governor. The islands are the primary source of wool for Great Britain and occupy a strategic location in the South Atlantic.

- East Falkland Island, with the capital of Port Stanley, is 465 miles from the Argentine coast, West Falkland is 350 miles from the Argentine coast.

- Control of the Falkland Islands has become a national cause in Argentina which is plagued by military threats from Chile, high inflation and other economic ills.

- Britain, too, has been plagued by economic ills forcing Parliament to place its naval forces on the chopping block.

CURRENT SITUATION

- On 2 April 1982, the Argentine military junta sent troops to invade the Falkland Islands, overwhelming the garrison of 84 British Royal Marines stationed there. Current Argentine troop strength in the Falklands is estimated at just over 10,000.

- The Argentine invasion ignited a nationalistic fervor in Britain, resulting in the dispatch of nearly two-thirds of the Royal Navy and 25,000 sailors, marines, soldiers and airmen.

- The overarching political aim is the repossession of the Falklands and the self-determination of British citizens.

- On 30 April, Britain declared the 200 mile radius of the Falkland Islands to be a Total Exclusion Zone (TEZ) in which any Argentine ships or aircraft would be subject to attack.

- The war at sea began 1 May and the destroyer *Sheffield* hit by an air launched Exocet missile on 4 May. 20 lives were lost and 24 sailors were injured. The ship sank 10 May. Britain has failed to achieve air superiority and the capability of the Argentines to launch Exocets from both surface and air platforms create a constant threat. The sinking of the *Sheffield*, combined with harassment by the Argentine air forces, stirs concern among the British populace.

- As is true in most democracies, the British are eager for a quick victory and have deployed significant forces to achive it. Yet, also at the forefront is concern for loss of life, damage to the islands and protection of the British capital ships.

- It is mid-May and planning is underway for the invasion. The attached partial Commander's Estimate of the Situation outlines the considerations. What is the best Course of Action for the British with regard to a landing?

Source: Harry D. Train, II, "An Analysis of the Falkland/Malvinas Islands Campaign," Naval War College Review (Newport, R.I.), Winter 1988, pp.33-50.

Source: Martin Middlebrook, Task Force: The Falklands War, 1982 (New York: Viking Penguin, Inc, Rev. ed., 1988).

1. MISSION. To seize the Falkland Islands and eject Argentinian military forces in order to regain possession of the islands.

2. THE SITUATION AND COURSES OF ACTION.

A. Considerations Affecting Courses of Action.

(1) Characteristics of Area of Operations

(a) Military Geography. Falkland Islands comprised of two islands (East and West) separated by Falkland Sound. Jagged coastline, together with the sound, provide variety of protected and unprotected anchorages suitable for amphibious landings. Anchorages represent suitable and likely areas for mining. Birdwood Bank, 150-200 NM south of islands is a shallow water area, unsuitable for submarine operations.

(b) Topography. Rugged, exposed terrain with significant increase in elevation from coastal area. Impedes mobility of ground forces.

(c) Hydrography/Oceanography. (Actual conditions unknown -- assume moderate sea state, minimal effect of tide and current for landing.)

(d) Climate and Weather. Cool marine with strong winds and frequent rains. Temperature range 34° - 44° F. Likely effects are reduced visability, impediment to ground mobility and decreased individual comfort and performance. Potential for visability to cloak movement, as well.

(e) Transportation. (Actual conditions unknown -- assume paved coastal roadway and few dirt inland roadways.)

(2) Relative Combat Power.

(a) Own (British) Forces.

Strength	Composition	Location
3rd Commando Brigade, Royal Marines (7,300) (light w/ min. mobility; SOF capability)	3 - Commando Battalions 1 - Artillary Regiment (18 x 105 mm) 1 - Air Defense (12 Rapier) 2 - Parachute Battalions (from 5th Infy Bdge) Special Boat Squadron (SOF) Special Air Service (SOF) Misc. Combat Service Support	At sea off Falkland Isl.
Surface Forces (ASUW; NGFS; ASW; transport -- min. AAW)	2 Carriers, 7 Destroyers, 15 Frigates, 2 Ldg. Platform Dock, 6 Landing Ship Logistics, 1 Helo Support Ship, Misc. replenish. & hospital ships	At sea off Falkland Isl

Strength	Composition	Location
Submarine Forces	5 Nuclear 1 Diesel	At sea off Falkland Isl.
Aviation Assets (some lift; min. fighter/strike; min. early warning)	3 - Harrier Sqdr 1+ - Chinook Sqdr (22) 5 - Sea King Sqdr (4 stripped of ASW) 2 - Wessex 5 Sqdr	At sea off Falkland Isl.
STUFT (Ships Taken Up From Trade)	2 liners, 7 ferries, 2 containers, 3 freighters, Misc support vessels	At sea off Falkland Isl.

(b) Enemy (Argentinian) Forces

Strength	Composition	Location
7,200 - primarily defensive; limited mobility	5 - Regiments 1 - Marine Battalion 1 - Artillary Battalion (30 x105 mm, 4 x155 mm) Helo unit (primarily CAS with some lift) Misc. support units	At and around Port Stanley
600 - primarily defensive	Elements of 2 regts 3 x 105 mm guns Elements of AA Btn. Air Force Elements	Goose Green
1200 - primarily defensive; recon.	1 - regiment Engineer Company	Fox Bay
1200 - primarily defensive; recon.	1 - regiment Engineer Company	Port Howard
120 personnel	Naval air personnel	Pebble Island
65 aircraft	Strike/Fighter Mix	Patagonia and Teirra de Fugo
12 aircraft	Strike/Fighter Mix	Rio Grande
17 aircraft	Tankers/Recon	Patagonia and Tierra de Fugo
Surface Forces	1 Carrier, 1 Amphib. Landing Ship, 5 destroyers, Misc. fast boats and support	At sea off Falkland Isl.
Submarine Forces	2 diesel subs	At sea off Falkland Isl.

(c) Friendly forces. None

(d) Reinforcements.

Strength	Composition	Location
5th Infantry Brigade (3,200) - Light; No para capability Can be inserted from the sea	1 - Btn. Scots Guard 1 - Btn. Welsh Guard 2 - Rifle Infy Btn. Arty Battery (6 x 105 mm) Air Sqdr (6 gazelle, 3 Scout)	Enroute on *Queen Elizabeth II* - EDA is 30 May

(e) Logistics Factors.

a. Own. Long SLOC to Ascension Island (3258 NM). Limited logistics and sustainability.

b. Enemy. Must reprovision by sea or air from Argentine mainland. Limited sustainment through TEZ.

(f) Time and Space Factors.

a. Own. Primary forces within 24 hours of Falkland Islands. EDA of Ground reinforcements 30 May.

b. Enemy. Forces largely constrained to current defensive positions by geography. Limited mobility.

(g) Combat Efficiency.

a. Own. High state of readiness, high morale, ground forces eager to land.

b. Enemy. Questionable proficiency and training. Morale of conscripts low. Suspect inadequate food and clothing for conscripts. U.S. trained officers. Air forces exhibit high proficiency.

(3) Own Forces.

(a) Strengths. Amphibious assault capability. Naval gunfire support. ASW/ASUW capability. Night vision. Morale and readiness.

(b) Weaknesses. Early warning. Tactical loadout for amphib. assault. Ground mobility. Intelligence. Lines of communication.

(4) Enemy Forces.

(a) Strengths. Strike warfare. Night vision. Intelligence. Defensive position.

(b) Weaknesses. Ground mobility. Reinforcements. Sustainment. Proficiency, training and morale.

B. Enemy Capabilities.

(1) EC #1. Defend Stanley with existing forces.

(2) EC #2. Reinforce Stanley from the sea, with the two regiments from the West Falklands.

(3) EC #3. Attack British ground forces during landing, using both air and ground assets.

(4) EC #4. Attack British ground forces during landing using air assets only.

C. Own Courses of Action.

(1) OCA #1. Attack at Stevelly Bay (W. Falkland). Build landing strip for logistics sustainment and additional tactical aircraft for air superiority. Prepare for second amphibious assault on E. Falkland.

(2) OCA #2. Attack at San Carlos, cross island to seize Port Stanley.

(3) OCA #3. Attack at Bluff cove, maneuver to seize Port Stanley.

(4) OCA #4. Attack at Cow Bay, maneuver to seize Port Stanley.

(5) OCA #5. Attack at Berkeley Sound, seize Port Stanley.

(6) OCA #6. Attack and seize Port Stanley.

3. ANALYSIS OF OPPOSING COURSES OF ACTION.

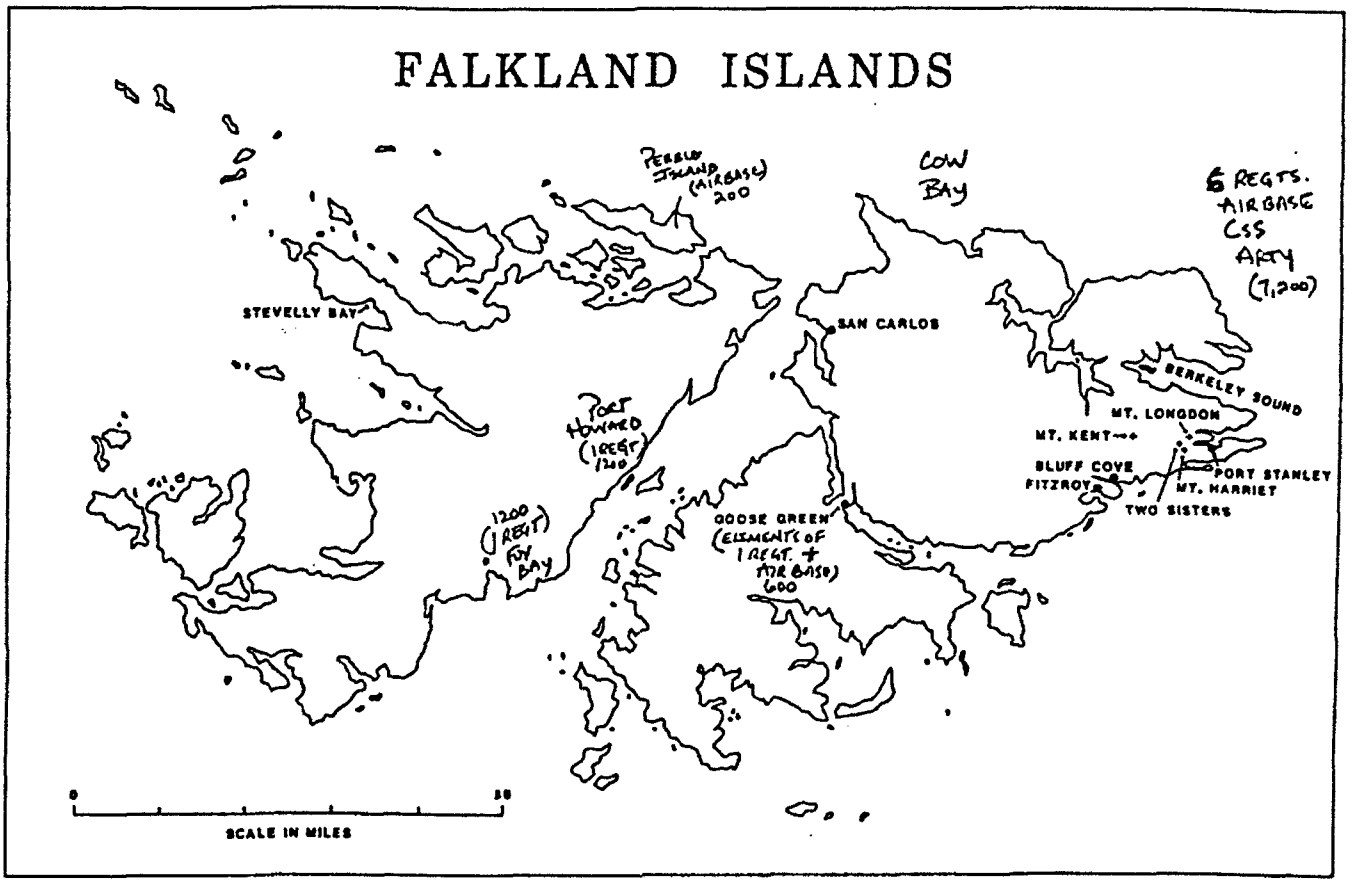
(See Chapter V and Appendix IV)

Sources: Harry D. Train, II, "An Analysis of the Falkland/Malvinas Islands Campaign," Naval War College Review (Newport, R.I.), Winter 1988, pp. 33-50.

Martin Middlebrook, Task Force: The Falklands War, 1982 (New York: Viking Penguin, Inc, Rev. ed., 1988).

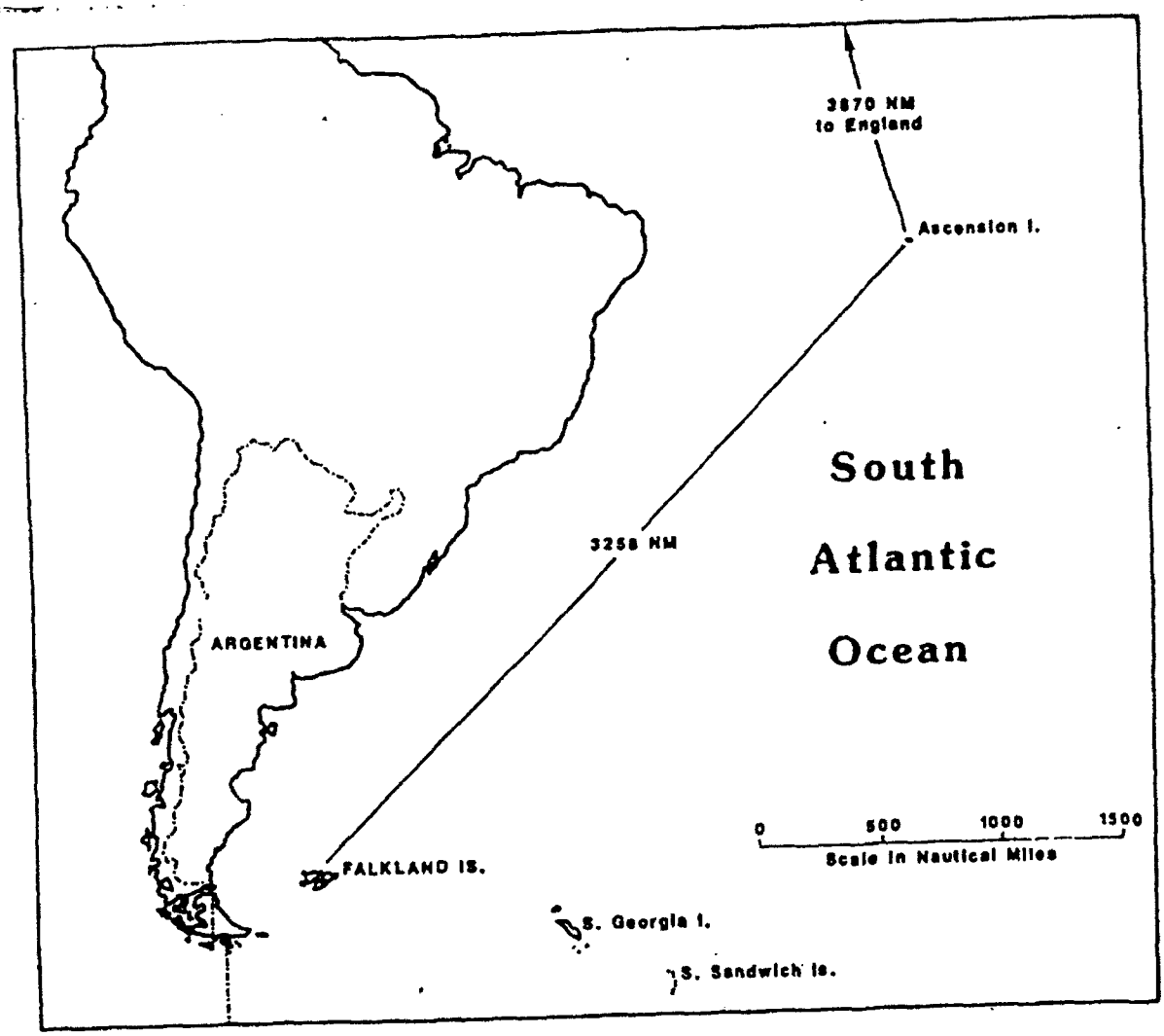
Max Hastings and Simon Jenkins, The Battle for the Falklands (New York: W. W. Norton & Co., 1983).

Lawrence Freedman and Virginia Gamba Stonehouse, Signals of War: The Falklands Conflict of 1982 (Princeton, N.J.: Princeton University Press, 1991).

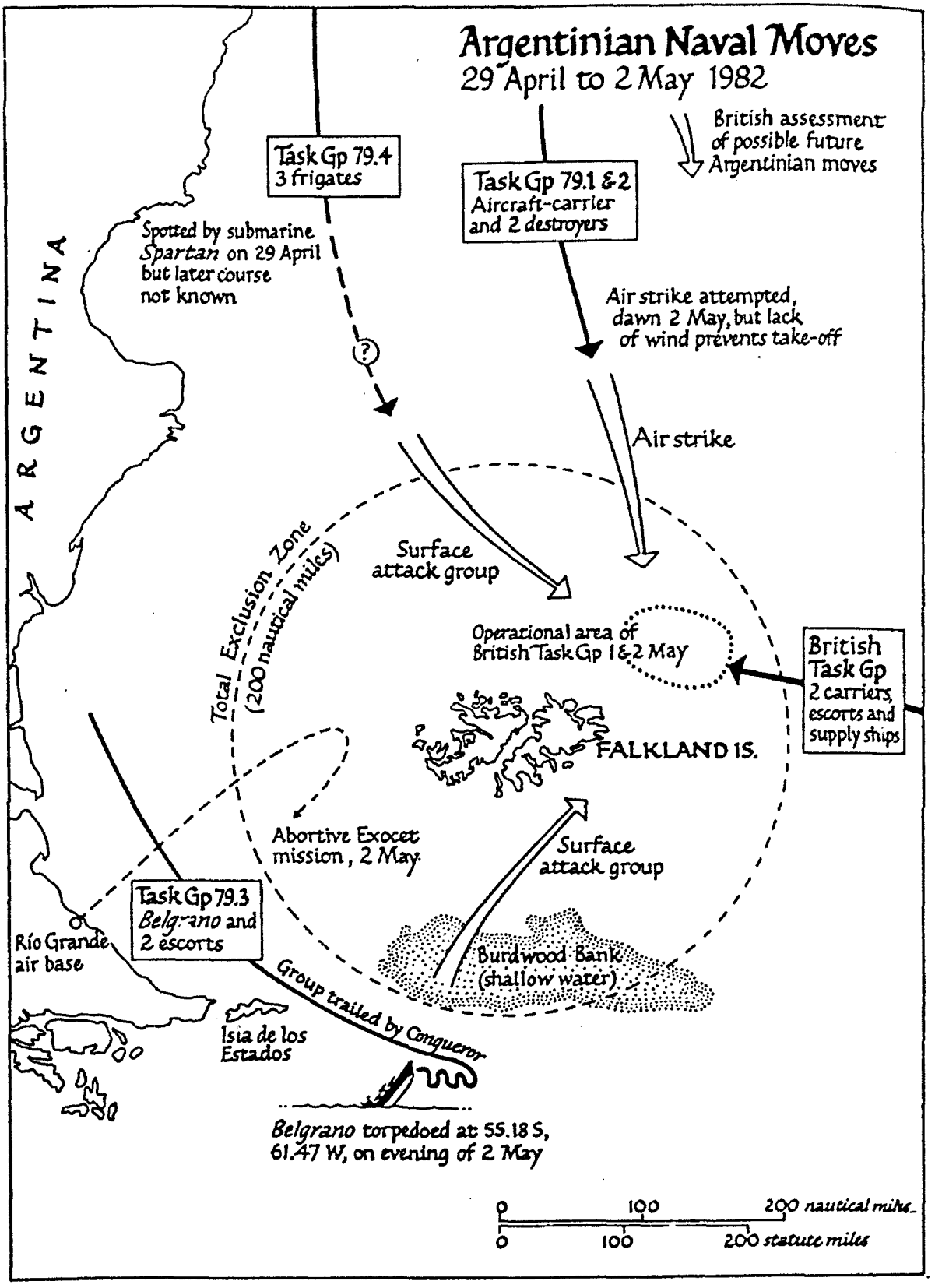


Source (map): Harry D. Train, II, "An Analysis of the Falkland/Malvinas Islands Campaign," Naval War College Review (Newport, R.I.), Winter 1988, p. 44.

Source (troop strength): Martin Middlebrook, Task Force: The Falklands War, 1982 (New York: Viking Penguin, Inc, Rev. ed., 1988), p. 197.



Source: Harry D. Train, II, "An Analysis of the Falkland/Malvinas Islands Campaign," Naval War College Review (Newport, R.I.), Winter 1988, p. 37.



Source: Martin Middlebrook, Task Force: The Falklands War, 1982 (New York: Viking Penguin, Inc, Rev. ed., 1988), p. 144.

PLAYERS' WORKSHEET

1. With regard to the goal (repossession of the Falkland Islands), how important is _____ to _____?

	Eject Argent	Min. loss life	Min. col dam.	Min. ship loss
Eject Argent				
Min. loss of life				
Min. coll. damage				
Min. ship losses				

For the next four questions, consider the following Enemy Capabilities (EC):

#1: Defend Stanley with existing forces
#2 Reinforce Stanley with forces from West Falkland
#3 Attack British landing forces from ground and air
#4 Attack British landing forces from air only

2. With regard to the ejection of Argentine forces how preferrable is EC___ to EC ___?

	EC #1	EC #2	EC #3	EC #4
EC #1				
EC #2				
EC #3				
EC #4				

3. With regard to minimizing the loss of British lives, how preferrable is EC___ to EC ___?

	EC #1	EC #2	EC #3	EC #4
EC #1				
EC #2				
EC #3				
EC #4				

4. With regard to minimizing collateral damage, how preferrable is EC ___ to EC ___?

	EC #1	EC #2	EC #3	EC #4
EC #1				
EC #2				
EC #3				
EC #4				

5. With regard to minimizing the loss of Royal Navy ships, how preferrable is EC ___ to EC ___?

	EC #1	EC #2	EC #3	EC #4
EC #1				
EC #2				
EC #3				
EC #4				

The following are abbreviated descriptions of Own Courses of Action (OCA) to be considered in the following four questions:

OCA #1: Stevelly Bay	OCA #4: Cow Bay
OCA #2: San Carlos	OCA #5: Berkeley Sound
OCA #3: Bluff Cove	OCA #6: Port Stanley

6. With regard to EC #1, how preferrable is OCA ___ to OCA ___ ?

	OCA #1	OCA #2	OCA #3	OCA #4	OCA #5	OCA #6
OCA #1						
OCA #2						
OCA #3						
OCA #4						
OCA #5						
OCA #6						

7. With regard to EC #2, how preferrable is OCA ___ to OCA ___?

	OCA #1	OCA #2	OCA #3	OCA #4	OCA #5	OCA #6
OCA #1						
OCA #2						
OCA #3						
OCA #4						
OCA #5						
OCA #6						

8. With regard to EC #3, how preferrable is OCA ___ to OCA ___?

	OCA #1	OCA #2	OCA #3	OCA #4	OCA #5	OCA #6
OCA #1						
OCA #2						
OCA #3						
OCA #4						
OCA #5						
OCA #6						

9. With regard to EC #4, how preferrable is OCA ___ to OCA ___?

	OCA #1	OCA #2	OCA #3	OCA #4	OCA #5	OCA #6
OCA #1						
OCA #2						
OCA #3						
OCA #4						
OCA #5						
OCA #6						

THE RATIO SCALE

Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement strongly favor one activity over another
5	Essential or strong importance	Experience and judgement strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two judgements	When compromise is needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*.	

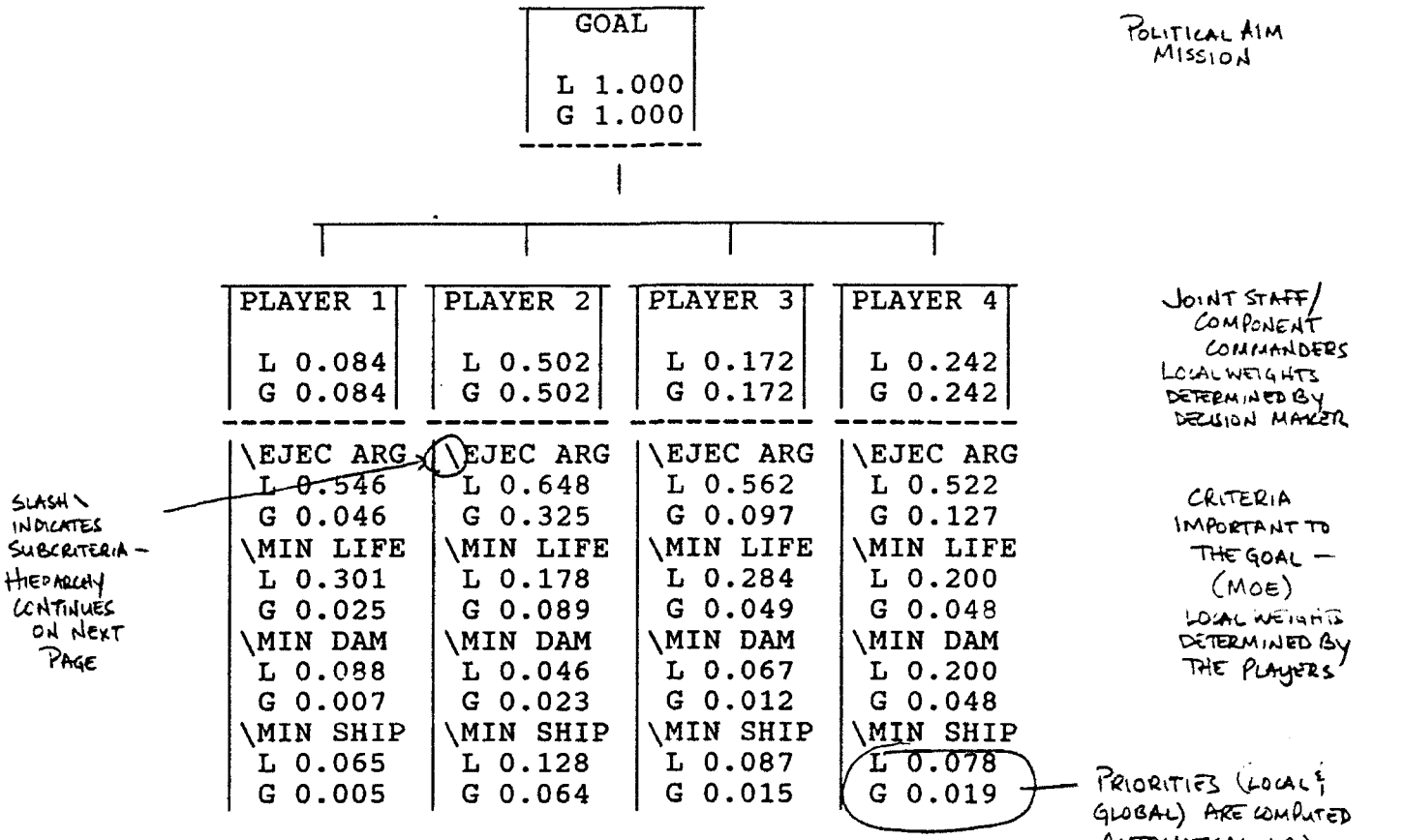
Source: Thomas L. Saaty and Joyce M. Alexander. Conflict Resolution. (New York: Praeger Publishers, 1989), p. 16.

APPENDIX IV

EXPERT CHOICE HIERARCHY

CASE STUDY

REPOSSESS FALKLANDS

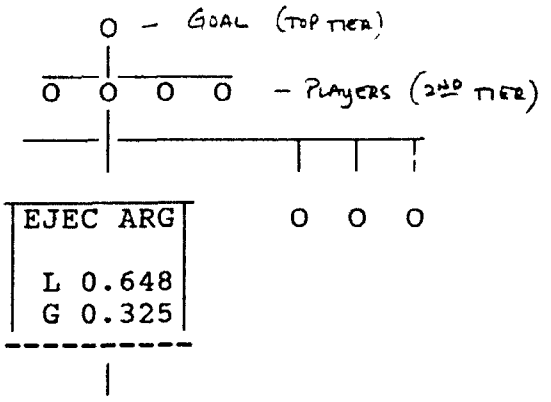


EJEC ARG --- EJECT ARGENTINIAN FORCES
MIN DAM --- MINIMIZE COLLATERAL DAMAGE
MIN LIFE --- MINIMIZE LOSS OF BRITISH LIFE
MIN SHIP --- MINIMAL DAMAGE & LOSS TO ROYAL NAVY SHIPS
PLAYER 1 --- COMPONENT COMMANDER
PLAYER 2 --- COMPONENT COMMANDER
PLAYER 3 --- COMPONENT COMMANDER
PLAYER 4 --- COMPONENT COMMANDER

DEFINES ABBREVIATIONS USED IN HIERARCHY

L --- LOCAL PRIORITY: PRIORITY RELATIVE TO PARENT
G --- GLOBAL PRIORITY: PRIORITY RELATIVE TO GOAL

THIS DISPLAY DEPICTS THE CONTINUATION OF THE HIERARCHY UNDER THE CRITERIA "EJECT ARG" FOR PLAYER #2



EJEC ARG
L 0.648
G 0.325

PLAYER #3 JUDGED EC #3 TO BE THE MOST IMPORTANT RELATIVE TO EJECTING THE ARGENT. FORCES

EC #1	EC #2	EC #3	EC #4
L 0.120	L 0.231	L 0.582	L 0.066
G 0.039	G 0.075	G 0.189	G 0.022
-OCA #1	-OCA #1	-OCA #1	-OCA #1
L 0.033	L 0.049	L 0.106	L 0.101
G 0.001	G 0.004	G 0.020	G 0.002
-OCA #2	-OCA #2	-OCA #2	-OCA #2
L 0.117	L 0.226	L 0.398	L 0.346
G 0.005	G 0.017	G 0.075	G 0.007
-OCA #3	-OCA #3	-OCA #3	-OCA #3
L 0.446	L 0.455	L 0.250	L 0.331
G 0.017	G 0.034	G 0.047	G 0.007
-OCA #4	-OCA #4	-OCA #4	-OCA #4
L 0.096	L 0.145	L 0.161	L 0.136
G 0.004	G 0.011	G 0.030	G 0.003
-OCA #5	-OCA #5	-OCA #5	-OCA #5
L 0.249	L 0.078	L 0.048	L 0.049
G 0.010	G 0.006	G 0.009	G 0.001
-OCA #6	-OCA #6	-OCA #6	-OCA #6
L 0.058	L 0.047	L 0.038	L 0.037
G 0.002	G 0.004	G 0.007	G 0.001

ENEMY CAPABILITIES (SUBCRITERIA) LOCAL WEIGHTS BASED ON JUDGEMENTS ENTERED BY PLAYERS RELATIVE TO REPOSSESSION OF FALKLANDS & MOE OF EJECT ARGENT. FORCES

INDICATES THAT IF THE ENEMY CHOOSES EC #3, PLAYER 2 PREFERS OCA #2.

(IF THE ARGENTINIANS ATTACK THE AMPHIBIOUS ASSAULT W/ AIR & GROUND FORCES, PLAYER #2 WOULD PREFER TO MAKE HIS ASSAULT AT THE PROTECTED ANCHORAGE OF SAN CARLOS)

EC #1 --- DEFEND STANEY WITH EXISTING FORCES
EC #2 --- REINFORCE STANLEY FROM WEST FALKLANDS
EC #3 --- ATTACK BRITISH AMPHIB LANDING WITH AIR AND GROUND ASSETS
EC #4 --- ATTACK BRITISH AMHIB LANDING WITH AIR ASSETS ONLY
EJEC ARG --- EJECT ARGENTINIAN FORCES
OCA #1 --- ATTACK AT STEVELLY BAY - MASS FORCES & ACHIEVE AIR SUPERIORITY
OCA #2 --- ATTACK AT SAN CARLOS, CROSS ISLAND TO SEIZE STANLEY
OCA #3 --- ATTACK AT BLUFF COVE, MANEUVER TO SEIZE PORT STANLEY
OCA #4 --- ATTACK AT COW BAY, MANEUVER TO SEIZE PORT STANLEY
OCA #5 --- ATTACK AT BERKELEY SOUND, SEIZE PORT STANLEY
OCA #6 --- ATTACK AND SEIZE PORT STANLEY

L --- LOCAL PRIORITY: PRIORITY RELATIVE TO PARENT
G --- GLOBAL PRIORITY: PRIORITY RELATIVE TO GOAL

DEFINES ABBREVIATIONS USED IN PRECEEDING HIERARCHY

APPENDIX V

EXPERT CHOICE PAIRWISE COMPARISONS

CASE STUDY

Compare elements with respect to GOAL

Comparisons made at node: 0

Circle one judgement for each comparison

1	PLAYER 1	9 8 7 6 5 4 3 2 1 2 3 (4) 5 6 7 8 9	PLAYER 2
2	PLAYER 1	9 8 7 6 5 4 3 2 1 2 (3) 4 5 6 7 8 9	PLAYER 3
3	PLAYER 1	9 8 7 6 5 4 3 2 1 2 (3) 4 5 6 7 8 9	PLAYER 4
4	PLAYER 2	9 8 7 6 5 4 (3) 2 1 2 3 4 5 6 7 8 9	PLAYER 3
5	PLAYER 2	9 8 7 6 5 4 (3) 2 1 2 3 4 5 6 7 8 9	PLAYER 4
6	PLAYER 3	9 8 7 6 5 4 3 2 1 (2) 3 4 5 6 7 8 9	PLAYER 4

1 EQUALLY 3 MODERATELY 5 STRONGLY 7 VERY STRONGLY 9 EXTREMELY

PLAYER 1 --- COMPONENT COMMANDER
PLAYER 2 --- COMPONENT COMMANDER
PLAYER 3 --- COMPONENT COMMANDER
PLAYER 4 --- COMPONENT COMMANDER

THIS IS A SAMPLE RATING SHEET FROM EXPERT CHOICE THAT CAN BE USED TO INDICATE JUDGEMENTS. OPERATOR (PLANNER) CAN THEN INPUT THE JUDGEMENTS INTO THE MODEL.

THE JUDGEMENTS CIRCLED APPROXIMATE THOSE SELECTED TO WEIGHT PLAYERS 1-4 IN THIS CASE STUDY.

APPENDIX VI

EXPERT CHOICE SYNTHESIS OF JUDEGEMENTS

CASE STUDY

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
PLAYER 2 =0.502				
· Highest Priority Player	EJEC ARG =0.325			
	· Highest Priority MOE for Player #2	EC #3 =0.189		
		· Priorities of ECs under top MOE	OCA #2 =0.075	Priorities of OCAs under each EC
			OCA #3 =0.047	
			OCA #4 =0.030	
			OCA #1 =0.020	
			OCA #5 =0.009	
			OCA #6 =0.007	
		EC #2 =0.075		
			OCA #3 =0.034	
			OCA #2 =0.017	
			OCA #4 =0.011	
			OCA #5 =0.006	
			OCA #1 =0.004	
			OCA #6 =0.004	
		EC #1 =0.039		
			OCA #3 =0.017	
			OCA #5 =0.010	
			OCA #2 =0.005	
			OCA #4 =0.004	
			OCA #6 =0.002	
			OCA #1 =0.001	
		EC #4 =0.022		
			OCA #2 =0.007	
			OCA #3 =0.007	

This Page (and the next nine Pages) is a synthesis of the judgements entered in order to arrive at a composite weight for each OCA.

The synthesis is sorted by Priorities... Player, MOE, EC & OCA.

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
	.	.	OCA #4 =0.003	
	.	.	OCA #1 =0.002	
	.	.	OCA #5 =0.001	
	.	.	OCA #6 .80E-03	
	MIN LIFE =0.089			
	. SECOND	EC #4 =0.045		
	. HIGHEST	.	OCA #2 =0.015	
	. PRIORITY MOE	.	OCA #3 =0.015	
	. FOR PLAYER	.	OCA #4 =0.006	
	. #2	.	OCA #1 =0.005	
	.	.	OCA #5 =0.002	
	.	.	OCA #6 =0.002	
	.	EC #1 =0.027		
	.	.	OCA #3 =0.012	
	.	.	OCA #5 =0.007	
	.	.	OCA #2 =0.003	
	.	.	OCA #4 =0.003	
	.	.	OCA #6 =0.002	
	.	.	OCA #1 .91E-03	
	.	EC #3 =0.010		
	.	.	OCA #2 =0.004	
	.	.	OCA #3 =0.003	
	.	.	OCA #4 =0.002	
	.	.	OCA #1 =0.001	
	.	.	OCA #5 .50E-03	
	.	.	OCA #6 .39E-03	
	.	EC #2 =0.007		
	.	.	OCA #3 =0.003	
	.	.	OCA #2 =0.002	
	.	.	OCA #4 =0.001	
	.	.	OCA #5 .55E-03	
	.	.	OCA #1 .34E-03	
	.	.	OCA #6 .33E-03	
	MIN SHIP =0.064			
	.	EC #1 =0.034		
	.	.	OCA #3 =0.015	
	.	.	OCA #5 =0.009	
	.	.	OCA #2 =0.004	
	.	.	OCA #4 =0.003	
	.	.	OCA #6 =0.002	
	.	.	OCA #1 =0.001	
	.	EC #2 =0.020		
	.	.	OCA #3 =0.009	
	.	.	OCA #2 =0.005	
	.	.	OCA #4 =0.003	
	.	.	OCA #5 =0.002	
	.	.	OCA #1 .98E-03	
	.	.	OCA #6 .93E-03	
	.	EC #4 =0.006		
	.	.	OCA #2 =0.002	
	.	.	OCA #3 =0.002	
	.	.	OCA #4 .83E-03	
	.	.	OCA #1 .61E-03	

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
	.	.	OCA #5 .30E-03	
	.	.	OCA #6 .22E-03	
	.	EC #3 =0.004		
	.	.	OCA #2 =0.002	
	.	.	OCA #3 .98E-03	
	.	.	OCA #4 .63E-03	
	.	.	OCA #1 .42E-03	
	.	.	OCA #5 .19E-03	
	.	.	OCA #6 .15E-03	
	MIN DAM =0.023			
	.	EC #1 =0.011		
	.	.	OCA #3 =0.005	
	.	.	OCA #5 =0.003	
	.	.	OCA #2 =0.001	
	.	.	OCA #4 =0.001	
	.	.	OCA #6 .66E-03	
	.	.	OCA #1 .38E-03	
	.	EC #2 =0.007		
	.	.	OCA #3 =0.003	
	.	.	OCA #2 =0.002	
	.	.	OCA #4 =0.001	
	.	.	OCA #5 .55E-03	
	.	.	OCA #1 .35E-03	
	.	.	OCA #6 .33E-03	
	.	EC #4 =0.003		
	.	.	OCA #2 .10E-02	
	.	.	OCA #3 .96E-03	
	.	.	OCA #4 .39E-03	
	.	.	OCA #1 .29E-03	
	.	.	OCA #5 .14E-03	
	.	.	OCA #6 .11E-03	
	.	EC #3 =0.002		
	.	.	OCA #2 .72E-03	
	.	.	OCA #3 .45E-03	
	.	.	OCA #4 .29E-03	
	.	.	OCA #1 .19E-03	
	.	.	OCA #5 .86E-04	
	.	.	OCA #6 .68E-04	
LAYER 4 =0.242				
2ND HIGHEST PRIORITY PLAYER	EJEC ARG =0.127			
	. TOP PRIORITY MOE FOR PLAYER #4	EC #1 =0.073		
	.	. TOP PRIORITY (MOST PREFERRED EC) FOR MOE	OCA #2 =0.035	
	.	.	OCA #3 =0.018	
	.	.	OCA #1 =0.009	
	.	.	OCA #6 =0.006	
	.	.	OCA #5 =0.003	
	.	.	OCA #4 =0.002	
	.	EC #2 =0.030		
	.	.	OCA #2 =0.011	
	.	.	OCA #1 =0.009	
	.	.	OCA #3 =0.005	
	.	.	OCA #4 =0.002	
	.	.	OCA #5 =0.001	

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	.	OCA #6 .77E-03	
.	.	EC #3 =0.015		
.	.	.	OCA #2 =0.006	
.	.	.	OCA #1 =0.004	
.	.	.	OCA #4 =0.002	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #6 .37E-03	
.	.	EC #4 =0.009		
.	.	.	OCA #2 =0.003	
.	.	.	OCA #1 =0.002	
.	.	.	OCA #6 =0.002	
.	.	.	OCA #5 .90E-03	
.	.	.	OCA #3 .54E-03	
.	.	.	OCA #4 .25E-03	
.	MIN LIFE =0.048			
.	.	EC #1 =0.029		
.	.	.	OCA #2 =0.014	
.	.	.	OCA #3 =0.007	
.	.	.	OCA #1 =0.004	
.	.	.	OCA #6 =0.002	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #4 .91E-03	
.	.	EC #2 =0.010		
.	.	.	OCA #2 =0.004	
.	.	.	OCA #1 =0.003	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #4 .61E-03	
.	.	.	OCA #5 .39E-03	
.	.	.	OCA #6 .25E-03	
.	.	EC #4 =0.006		
.	.	.	OCA #2 =0.002	
.	.	.	OCA #1 =0.002	
.	.	.	OCA #6 =0.001	
.	.	.	OCA #5 .64E-03	
.	.	.	OCA #3 .38E-03	
.	.	.	OCA #4 .18E-03	
.	.	EC #3 =0.003		
.	.	.	OCA #2 =0.001	
.	.	.	OCA #1 .82E-03	
.	.	.	OCA #4 .36E-03	
.	.	.	OCA #3 .33E-03	
.	.	.	OCA #5 .27E-03	
.	.	.	OCA #6 .80E-04	
.	MIN DAM =0.048			
.	.	EC #4 =0.027		
.	.	.	OCA #2 =0.010	
.	.	.	OCA #1 =0.007	
.	.	.	OCA #6 =0.005	
.	.	.	OCA #5 =0.003	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #4 .75E-03	
.	.	EC #3 =0.012		

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	.	OCA #2 =0.005	
.	.	.	OCA #1 =0.003	
.	.	.	OCA #4 =0.001	
.	.	.	OCA #3 =0.001	
.	.	.	OCA #5 .10E-02	
.	.	.	OCA #6 .30E-03	
.	.	EC #2 =0.006		
.	.	.	OCA #2 =0.002	
.	.	.	OCA #1 =0.002	
.	.	.	OCA #3 =0.001	
.	.	.	OCA #4 .40E-03	
.	.	.	OCA #5 .26E-03	
.	.	.	OCA #6 .16E-03	
.	.	EC #1 =0.004		
.	.	.	OCA #2 =0.002	
.	.	.	OCA #3 .87E-03	
.	.	.	OCA #1 .45E-03	
.	.	.	OCA #6 .27E-03	
.	.	.	OCA #5 .15E-03	
.	.	.	OCA #4 .11E-03	
.	MIN SHIP =0.019			
.	.	EC #1 =0.009		
.	.	.	OCA #2 =0.004	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #1 =0.001	
.	.	.	OCA #6 .67E-03	
.	.	.	OCA #5 .36E-03	
.	.	.	OCA #4 .27E-03	
.	.	EC #2 =0.008		
.	.	.	OCA #2 =0.003	
.	.	.	OCA #1 =0.002	
.	.	.	OCA #3 =0.001	
.	.	.	OCA #4 .48E-03	
.	.	.	OCA #5 .31E-03	
.	.	.	OCA #6 .20E-03	
.	.	EC #4 =0.002		
.	.	.	OCA #2 .65E-03	
.	.	.	OCA #1 .43E-03	
.	.	.	OCA #6 .32E-03	
.	.	.	OCA #5 .17E-03	
.	.	.	OCA #3 .10E-03	
.	.	.	OCA #4 .49E-04	
.	.	EC #3 .85E-03		
.	.	.	OCA #2 .36E-03	
.	.	.	OCA #1 .22E-03	
.	.	.	OCA #4 .96E-04	
.	.	.	OCA #3 .89E-04	
.	.	.	OCA #5 .70E-04	
.	.	.	OCA #6 .21E-04	
PLAYER 3 =0.172				
.	EJEC ARG =0.097			
.	.	EC #4 =0.055		
.	.	.	OCA #4 =0.023	

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	.	OCA #2 =0.014	
.	.	.	OCA #5 =0.008	
.	.	.	OCA #3 =0.005	
.	.	.	OCA #1 =0.003	
.	.	.	OCA #6 =0.001	
.	.	EC #3 =0.025		
.	.	.	OCA #4 =0.011	
.	.	.	OCA #2 =0.006	
.	.	.	OCA #1 =0.004	
.	.	.	OCA #5 =0.003	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #6 .48E-03	
.	.	EC #2 =0.011		
.	.	.	OCA #4 =0.006	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #2 =0.002	
.	.	.	OCA #5 .96E-03	
.	.	.	OCA #1 .62E-03	
.	.	.	OCA #6 .20E-03	
.	.	EC #1 =0.005		
.	.	.	OCA #3 =0.003	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #4 .84E-03	
.	.	.	OCA #2 .43E-03	
.	.	.	OCA #1 .27E-03	
.	.	.	OCA #6 .96E-04	
.	MIN LIFE =0.049			
.	.	EC #1 =0.026		
.	.	.	OCA #3 =0.013	
.	.	.	OCA #5 =0.005	
.	.	.	OCA #4 =0.004	
.	.	.	OCA #2 =0.002	
.	.	.	OCA #1 =0.001	
.	.	.	OCA #6 .47E-03	
.	.	EC #2 =0.015		
.	.	.	OCA #4 =0.007	
.	.	.	OCA #3 =0.003	
.	.	.	OCA #2 =0.002	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #1 .81E-03	
.	.	.	OCA #6 .26E-03	
.	.	EC #3 =0.005		
.	.	.	OCA #4 =0.002	
.	.	.	OCA #2 =0.001	
.	.	.	OCA #1 .77E-03	
.	.	.	OCA #5 .53E-03	
.	.	.	OCA #3 .35E-03	
.	.	.	OCA #6 .10E-03	
.	.	EC #4 =0.002		
.	.	.	OCA #4 =0.001	
.	.	.	OCA #2 .60E-03	
.	.	.	OCA #5 .36E-03	
.	.	.	OCA #3 .21E-03	

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	.	OCA #1 .14E-03	
.	.	.	OCA #6 .57E-04	
.	MIN SHIP =0.015			
.	.	EC #1 =0.007		
.	.	.	OCA #3 =0.003	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #4 =0.001	
.	.	.	OCA #2 .54E-03	
.	.	.	OCA #1 .35E-03	
.	.	.	OCA #6 .12E-03	
.	.	EC #4 =0.003		
.	.	.	OCA #4 =0.001	
.	.	.	OCA #2 .84E-03	
.	.	.	OCA #5 .50E-03	
.	.	.	OCA #3 .30E-03	
.	.	.	OCA #1 .19E-03	
.	.	.	OCA #6 .80E-04	
.	.	EC #2 =0.003		
.	.	.	OCA #4 =0.001	
.	.	.	OCA #3 .56E-03	
.	.	.	OCA #2 .47E-03	
.	.	.	OCA #5 .25E-03	
.	.	.	OCA #1 .16E-03	
.	.	.	OCA #6 .53E-04	
.	.	EC #3 =0.002		
.	.	.	OCA #4 .80E-03	
.	.	.	OCA #2 .45E-03	
.	.	.	OCA #1 .27E-03	
.	.	.	OCA #5 .19E-03	
.	.	.	OCA #3 .13E-03	
.	.	.	OCA #6 .36E-04	
.	MIN DAM =0.012			
.	.	EC #1 =0.006		
.	.	.	OCA #3 =0.003	
.	.	.	OCA #5 =0.001	
.	.	.	OCA #4 .92E-03	
.	.	.	OCA #2 .47E-03	
.	.	.	OCA #1 .30E-03	
.	.	.	OCA #6 .11E-03	
.	.	EC #2 =0.003		
.	.	.	OCA #4 =0.002	
.	.	.	OCA #3 .64E-03	
.	.	.	OCA #2 .53E-03	
.	.	.	OCA #5 .28E-03	
.	.	.	OCA #1 .18E-03	
.	.	.	OCA #6 .60E-04	
.	.	EC #4 =0.001		
.	.	.	OCA #4 .54E-03	
.	.	.	OCA #2 .32E-03	
.	.	.	OCA #5 .19E-03	
.	.	.	OCA #3 .11E-03	
.	.	.	OCA #1 .73E-04	
.	.	.	OCA #6 .30E-04	

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	EC #3 .98E-03		
.	.	.	OCA #4 .42E-03	
.	.	.	OCA #2 .24E-03	
.	.	.	OCA #1 .14E-03	
.	.	.	OCA #5 .99E-04	
.	.	.	OCA #3 .66E-04	
.	.	.	OCA #6 .19E-04	
PLAYER 1 =0.084				
.	EJEC ARG =0.046			
.	.	EC #1 =0.027		
.	.	.	OCA #1 =0.014	
.	.	.	OCA #2 =0.006	
.	.	.	OCA #3 =0.004	
.	.	.	OCA #4 =0.002	
.	.	.	OCA #5 =0.002	
.	.	.	OCA #6 =0.001	
.	.	EC #2 =0.010		
.	.	.	OCA #1 =0.004	
.	.	.	OCA #2 =0.002	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #4 .65E-03	
.	.	.	OCA #5 .58E-03	
.	.	.	OCA #6 .42E-03	
.	.	EC #3 =0.005		
.	.	.	OCA #5 =0.002	
.	.	.	OCA #6 =0.002	
.	.	.	OCA #3 .56E-03	
.	.	.	OCA #2 .36E-03	
.	.	.	OCA #1 .22E-03	
.	.	.	OCA #4 .12E-03	
.	.	EC #4 =0.004		
.	.	.	OCA #6 =0.001	
.	.	.	OCA #3 .90E-03	
.	.	.	OCA #5 .74E-03	
.	.	.	OCA #2 .41E-03	
.	.	.	OCA #1 .20E-03	
.	.	.	OCA #4 .87E-04	
.	MIN LIFE =0.025			
.	.	EC #1 =0.016		
.	.	.	OCA #1 =0.008	
.	.	.	OCA #2 =0.003	
.	.	.	OCA #3 =0.002	
.	.	.	OCA #4 .98E-03	
.	.	.	OCA #5 .90E-03	
.	.	.	OCA #6 .58E-03	
.	.	EC #2 =0.007		
.	.	.	OCA #1 =0.003	
.	.	.	OCA #2 =0.002	
.	.	.	OCA #3 =0.001	
.	.	.	OCA #4 .44E-03	
.	.	.	OCA #5 .39E-03	
.	.	.	OCA #6 .28E-03	
.	.	EC #3 =0.002		

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
.	.	.	OCA #1 .31E-03	
.	.	.	OCA #2 .31E-03	
.	.	.	OCA #3 .31E-03	
.	.	.	OCA #4 .31E-03	
.	.	.	OCA #5 .31E-03	
.	.	.	OCA #6 .31E-03	
.	.	EC #4 =0.001		
.	.	.	OCA #1 .18E-03	
.	.	.	OCA #2 .18E-03	
.	.	.	OCA #3 .18E-03	
.	.	.	OCA #4 .18E-03	
.	.	.	OCA #5 .18E-03	
.	.	.	OCA #6 .18E-03	
.	MIN DAM =0.007			
.	.	EC #1 =0.005		
.	.	.	OCA #1 =0.002	
.	.	.	OCA #2 .97E-03	
.	.	.	OCA #3 .67E-03	
.	.	.	OCA #4 .30E-03	
.	.	.	OCA #5 .27E-03	
.	.	.	OCA #6 .18E-03	
.	.	EC #3 =0.001		
.	.	.	OCA #5 .48E-03	
.	.	.	OCA #6 .39E-03	
.	.	.	OCA #3 .14E-03	
.	.	.	OCA #2 .91E-04	
.	.	.	OCA #1 .55E-04	
.	.	.	OCA #4 .31E-04	
.	.	EC #2 .80E-03		
.	.	.	OCA #1 .36E-03	
.	.	.	OCA #2 .18E-03	
.	.	.	OCA #3 .13E-03	
.	.	.	OCA #4 .52E-04	
.	.	.	OCA #5 .47E-04	
.	.	.	OCA #6 .34E-04	
.	.	EC #4 .68E-03		
.	.	.	OCA #6 .24E-03	
.	.	.	OCA #3 .17E-03	
.	.	.	OCA #5 .14E-03	
.	.	.	OCA #2 .77E-04	
.	.	.	OCA #1 .37E-04	
.	.	.	OCA #4 .16E-04	
.	MIN SHIP =0.005			
.	.	EC #1 =0.004		
.	.	.	OCA #1 =0.002	
.	.	.	OCA #2 .73E-03	
.	.	.	OCA #3 .50E-03	
.	.	.	OCA #4 .23E-03	
.	.	.	OCA #5 .21E-03	
.	.	.	OCA #6 .13E-03	
.	.	EC #2 =0.001		
.	.	.	OCA #1 .54E-03	
.	.	.	OCA #2 .28E-03	

REPOSSESS FALKLANDS

Sorted Details for Synthesis of Leaf Nodes with respect to GOAL

LEVEL 1	LEVEL 2	LEVEL 3		LEVEL 4		LEVEL 5
.	.	.		OCA #3	.20E-03	
.	.	.		OCA #4	.79E-04	
.	.	.		OCA #5	.71E-04	
.	.	.		OCA #6	.52E-04	
.	.	EC #3	.39E-03			
.	.	.		OCA #5	.16E-03	
.	.	.		OCA #6	.13E-03	
.	.	.		OCA #3	.46E-04	
.	.	.		OCA #2	.30E-04	
.	.	.		OCA #1	.18E-04	
.	.	.		OCA #4	.10E-04	
.	.	EC #4	.24E-03			
.	.	.		OCA #6	.87E-04	
.	.	.		OCA #3	.60E-04	
.	.	.		OCA #5	.49E-04	
.	.	.		OCA #2	.27E-04	
.	.	.		OCA #1	.13E-04	
.	.	.		OCA #4	.58E-05	

APPENDIX VII

EXPERT CHOICE COMPOSITE WEIGHTS FOR ALTERNATIVES

CASE STUDY

REPOSSESS FALKLANDS

Synthesis of Leaf Nodes with respect to GOAL
CLOSED SYSTEM

OVERALL INCONSISTENCY INDEX = 0.06

OCA #2 0.299 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

OCA #3 0.267 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

OCA #4 0.150 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

OCA #1 0.135 XXXXXXXXXXXXXXXXXXXXXXXXXXXX

OCA #5 0.096 XXXXXXXXXXXXXXXXXXXX

OCA #6 0.052 XXXXXXXXXXX

OCA #1 --- ATTACK AT STEVELLY BAY - MASS FORCES & ACHIEVE AIR SUPERIORITY
OCA #2 --- ATTACK AT SAN CARLOS, CROSS ISLAND TO SEIZE STANLEY
OCA #3 --- ATTACK AT BLUFF COVE, MANEUVER TO SEIZE PORT STANLEY
OCA #4 --- ATTACK AT COW BAY, MANEUVER TO SEIZE PORT STANLEY
OCA #5 --- ATTACK AT BERKELEY SOUND, SEIZE PORT STANLEY
OCA #6 --- ATTACK AND SEIZE PORT STANLEY

FINAL PRODUCT of SYNTHESIS
COMPOSITE WEIGHTS OF ALL COURSES OF ACTION. OCA #2 (ATTACK AT SAN CARLOS) RECEIVED THE HIGHEST PRIORITY, WITH BLUFF COVE A CLOSE SECOND PLACE.

NOTES

Preface

1. Thomas L. Saaty, The Analytic Hierarchy Process rev. ed. (Pittsburgh: RWS Publications, 1988), p. ix.

2. *Expert Choice* a decision support software based on the Analytic Hierarchy Process licensed through Expert Choice, Inc., and Decision Support Software, Inc. 4922 Ellsworth Avenue, Pittsburgh, P.A. 15213 .

Chapter 2

1. For a more detailed description of the mathematical theory, see Thomas L. Saaty, The Analytic Hierarchy Process rev. ed. (Pittsburgh: RWS Publications, 1988).

2. Thomas L. Saaty and Joyce M. Alexander, Conflict Resolution (New York: Praeger Publishers, 1989), p. 13.

3. Stephen M. McBrien and D. S. Ensminger, An Introduction to Ratinal Decision Processes (Newport: Naval War College, 1991), p. 2-3.

4. Saaty and Alexander, p. 21.

5. Albert Madansky, "Uncertainty" in E. S. Quade and W. I. Boucher, ed. Systems Analysis and Policy Planning (New York: Elsevier Publishing Co., 1968), pp. 95-96.

Chapter 3

1. The reader is invited to see Saaty and Alexander, pp. 65-73, for a more complete account of the analysis performed at this seminar.

2. Saaty and Alexander, p. 67.

3. Saaty and Alexander, p. 70.

4. The interested reader is referred to Saaty and Alexander, pp. 123-138, or the original work, T. L. Saaty, L. G. Vargas and A. Barzilay, "High Level Decisions: A Lesson from the Iran Hostage Rescue Operation" Decision Sciences (April 1982), pp. 185-206.

5. Saaty and Alexander, p. 128.

6. Saaty and Alexander, p. 136.

Chapter 4

1. A more detailed description of this process is found in "Navy Operational Planning," Naval Warfare Publication 11 (Rev. F) (Washington: Chief of Naval Operations), pp. 2-13 to 2-15.

Chapter 6

1. E. S. Quade, "Pitfalls and Limitations" in E. S. Quade and W. I. Boucher, ed. Systems Analysis and Policy Planning (New York: Elsevier Publishing Co., 1968), p. 348.

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Hastings, Max and Jenkins, Simon. The Battle for the Falklands. New York: W.W. Norton & Co., 1983.

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McBrien, Stephen M. and Ensminger, D.S. An Introduction to Rational Decision Processes. Newport: Naval War College, 1991.

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