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USING MULTIATTRIBUTE UTILITY THEORY FOR COMPARING MILITARY CAPABILITIES OF TWO COUNTRIES (U).

by

Dale E. Hays

March 1985

Thesis Advisor: Robert E. Looney

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Using Multiattribute Utility Theory For Comparing Military Capabilities of Two Countries (U)

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(U) This thesis uses Multiattribute Utility theory for development of a methodology to compare the military capabilities of two countries. The hypothesis is that this method is a more accurate and complete measure of the countries' relative military balance than mere order of battle comparisons. The use of expert judgment to assess the qualitative differences that exist among military hardware and among "soft" varibles such as political resolve, morale, and personnel proficiency allow for these differences to be quantified.

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TABLE OF CONTENTS (U)

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I. INTRODUCTION (U)

(U) Many studies which concern the application of Multiattribute Utility (MAU) theory have been conducted and have covered a wide range of social, business, government, medical, and military areas of interest. Topics studied, to name only a few, include matters such as selecting a computer system that best suits a company's needs, locating the best construction site for a nuclear power generating plant, determining optimal test and treatment strategies for strep throat and rhuematic fever, and choosing the optimum naval aircraft mix necessary to conduct specific missions under differing tactical situations. From these various studies it has been shown that MAU theory is an extremely versatile method of providing a decision maker the optimum course of action to select from among several alternatives. However, rather than determining the optimal solution to a given problem the purpose of this thesis is to develope a straitforward methodology based on MAU theory for comparing two countries' military capabilities relative to each other to aid in determining their individual success of achieving a designated objective during a specified hostile engagement. An engagement between selected naval forces of the People's Republic of China and the Socialist Republic of Vietnam in a dispute over the sovereignty of the Spratly Islands will serve as the case situation to test the methodology.

(U) The rationale for using MAU theory to make comparisons of a country's military capability is a result of the inadequacy of other techniques to account for significant yet difficult to quantify components

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of military balance in a comprehensive and easily understood manner. Baugh [Ref. 1] lists three general measures for assessing strategic balance which are also applicable to conventional armaments; simple counts of weapons and their characteristics, composite measures or figures of merit, and outcome or effects measures. The later two types use complicated mathematical techniques like factor analysis or computer simulations and tend to yield results which are not well understood by the average analyst or results the derivation of which are quite confusing. The first type of measure, listings of a country's weapons inventory commonly referred to as order of battle, has long been the primary means of comparing military balances and usually serves as a basis upon which other techniques are formulated. The MAU approach taken here relies heavily on order of battle comparison but improves upon this simple technique.

(U) In order of battle comparisons totals for various military assets are tabulated and the country with the greatest number of assets is considered to have the advantage. This technique has serious shortcommings. Since qualitative differences exist among individual weapons and among countries' capabilities to use the weapons these differences cannot be guaged by order of battle comparisons alone. [Ref. 2] Evaluations about "soft" variables that are critical to overall capability comparison such as operator competence, the tactical situation, military morale, logistics, and maintenance and intelligence proficiency are also not reflected in order of battle tables. Multiattribute Utility theory allows for these qualitative differences and variables to be quantified

[redacted]

ously developed methodology these expert generated data can be aggregated to compute overall utility scores.

(U) The hypothesis of this thesis is that comparisons of the MAU scores of two countries is a more accurate and complete measure of their relative military balance than mere order of battle comparisons. While assessing the quality of the MAU methodology presented here against more complex techniques is beyond the scope of this thesis it is certainly a simpler and more comprehensible measure. Also, the methodology is flexible enough to be rapidly applied to a large number of pairs of countries with a fraction of the cost and research effort required for development of more detailed measures.

(U) Chapter II briefly explains utility theory and focuses on those topics which are pertinent to the development of a MAU methodology. Chapter II outlines the general methodology used to apply MAU theory to military capability comparisons. Chapter IV is the heart of this thesis as it applies the methodology of Chapter III to a possible real world situation in a step-by-step process and analyzes the results of the methodology. Chapter V presents conclusions and recommendations for future studies.

II. MULTIATTRIBUTE UTILITY THEORY (U)

A. (U) BACKGROUND

(U) Classical utility theory has been recognized since the eighteenth century and has been used in one fashion or another by economists, mathematicians, statisticians, and psychologists. The fundamental theorem of utility has to do with axioms for preferences which guarantee, in a formal mathematical sense, the ability to assign a number (utility) to each alternative so that, for any two alternatives, one is preferred to the other if and only if the utility of the first is greater than the utility of the second. Thus, utility is simply a personal measure of liking something and provides a means of quantifying subjective judgments. Multiattribute Utility (MAU) theory is an extension of this fundamental theorem in that each alternative is viewed as a multiple factor or multiple attribute entity. The utility of a whole can then be expressed as the sum of utilities of its parts. [Ref. 3]

(U) Utility theory has gained greater recognition and use since the mid-fifties with the advent of decision analysis and its acceptance by decision makers who could no longer singularly and intuitively deal with the myriad of details in a complex decision situation. Decision analysis is a general technology for imposing logical structure on the reasoning that underlies any specific decision. It is comprised of several methods many of which use quantitative expressions of the subjective judgments of experts. [Ref. 4] Multiattribute Utility theory has enhanced decision analysis methods since most important decisions today involve choosing among alternatives which have various characteristics. The alternative finally selected depends on the preferences that are attached to the values of the alternatives' characteristics.

(U) The principle concept of MAU theory is simple and can be easily explained by reviewing previously proposed models and procedures. Newman [Ref. 5] has identified three basic steps necessary to apply MAU theory. First, the decision problem is broken up into little pieces (attributes) along natural lines depending on the nature of the task. Second, separate judgments are made about each of the component pieces. Generally, there are two such judgments, numerical judgments about the importance of each attribute relative to each other and numerical judgements about the worth or "utility" of each attribute to each of the competing decision alternatives. Finally, these separate judgments are aggregated using some formal algebraic rule.

(U) Utility theory in its totality covers many separate topics and can become quite involved. The objective here is to consider only those theoretical topics pertinent to an understanding of the methodology developed in Chapter III. This methodology is organized according to the three basic steps listed above. Even with this limitation many of the significant topics concerning MAU theory will be addressed.

B. (U) ATTRIBUTE SELECTION

(U) The initial step in any MAU theory application is to decompose the problem situation or object of evaluation into its relevant dimensions by use of a hierarchial structure. The dimensions at the lowest hierarchial level must be measurable attributes or indicators for intangible attributes of the situation or object. Exactly how to construct this hierarchy is a ture, analytical study, and causual empiricism as approaches for constructing a hierarchy. These approaches provide a decision maker with only a cursory structure. To construct a complete hierarchy the decision maker will usally seek the opinions of experts or other informed people.

(U) Much has been said in the literature about the degree of decomposition and the independence assumptions necessary to identify a set of attributes. In fact, most of the usefulness of MAU applications relies on assumptions of independence between attributes. [Ref. 7] The primary independence assumption required for selection of attributes is that of value or utility independence. Attribute Xi is defined to be utility independent of the other attributes if the preference order for lotteries on Xi does not depend on fixed levels of the other attributes. [Ref. 8] And if preference orders for other attributes do not depend on a fixed level of Xi then the set of attributes is said to have mutual independent utility. These are strong assumptions when one has to make judgments about attributes of a complex structure knowing that there are in actuality very few aspects of any situation that are not interdependent. Even so, Edwards [Ref. 9] notes that these assumptions do not have to be strictly adhered to since modest error in these judgments will still make little difference to the ultimate number of attributes and even less difference to later rank ordering of the attributes.

(U) It is not practical or possible to establish a step-by-step procedure that leads to a meaningful set of attributes. Excellent guidance for selecting attributes is presented by Keeney and Raiffa. It is important that the set of attributes be complete, so that it covers all the important in the analysis; decomposable, so that aspects of the evaluation process can be simplified by breaking it down into parts; nonredundant, so that double counting of impacts is avoided; and minimal, so that the problem dimension is kept as small as possible. [Ref. 10] Overall, the best rule of thumb is to stop the selection of more attributes and thus the hiearchial decomposition when the attributes can no longer be operationalized i.e., reliably measured on any scale or subjectively considered.

C. (U) PREFERENCE AND FUNCTIONS

(U) Once the alternatives of a problem have been identified and a total listing of the attributes has been selected the final outcome of whichever alternative is chosen by a decision maker may or may not be apparent. This forces a choice under certainty or uncertainty. If the decision maker is able to specify with complete certainty the outcome associated with each alternative, then the decision is said to be riskless. A decision is said to be risky if the decision maker is uncertain as to the consequences associated with each alternative but is able to express this uncertainty in the form of probability distributions over the possible consequences of each alternative. [Ref. 11] A utility function provides a complete description of the decision maker's attitude toward risk over the range of all the possible consequences of the problem under analysis. [Ref. 12] A value function describes a decision maker's tradeoffs between alternatives when the outcomes are known. Value functions will be discussed first.

(U) Because the value of the outcome is known under conditions of certainty the theory of conjoint measurement additivity is applicable.

nectedness and transitivity. Connectedness requires for any two outcomes Xi and Xj, either Xi is not preferred to Xj, Xj is not preferred to Xi, or the decision maker is indifferent between the two outcomes. Transitivity means that for any three outcomes, Xi, Xj, and Xk, if Xi is not preferred to Xj, and Xj is not preferred to Xk, then Xi is not preferred to Xk. When both of these assumptions are satisfied, preferences are said to be weakly ordered. [Ref. 14] For a finite set of outcomes, the weak ordering property alone is sufficient to guarantee the existence of some value function V such that, for any X and Y, X is not preferred to Y if and only if V(X) is not preferred to V(Y). [Ref. 14]

(U) Another assumption, monotonicity, is related to the concept of mutual utility independence and is necessary when three or more attributes are involved. For this assumption, let (x1, x2,..., xn) be the attribute vector describing the outcome X. Let Y be any subset of these attributes and let Z be the vector of the remaining attributes, so that X = (Y,Z). If Yi and Yj are any two values of the Y attributes and Zi and Zj are any two values of the Z attributes, then (Yi,Zi) is not preferred to (Yj,Zi) if and only if (Yi,Zj) is not preferred to (Yj,Zj). [Ref. 15] While this assumption may appear to be quite involved, it essentially states that preference increases with any increase in quantity. [Ref. 16] This is a very intuitive assumption and the literature repeatedly states that it is difficult to imagine situations where this assumption does not hold.

(U) When weak ordering and monotonicity are satisfied then there will exist constituent functions V1, V2,..., Vn such that, for any two outcomes or equal to V(Xj), where

$$V(X) = V1(x1) + V2(x2) + . . . + Vn(xn)$$

Thus, conjoint theories provide axiom systems guaranteeing the existence of an interval scale additive function. [Ref. 17] This function can be rewritten in the form,

$$V(X) = V(x1, x2,\ldots, xi,\ldots,xn) = \sum_{i=1}^{n} vi(xi)$$

where xi denotes the value of outcome X = (x1, x2,..., xi,..., xn) in the i-th attribute and vi is the function over the different states (values) of the i-th attribute. [Ref. 18]

(U) Recall in risky decision making the decision maker chooses not between outcomes but between probability distributions of outcomes. Let (A1, A2,..., Am) be a set of alternatives and let (X1, X2,..., Xn) be the set of possible consequences of those alternatives. Then for each alternative Ai there is an associated probability distribution of outcomes (p1i,X1; p2i,X2;..., pni,Xn). Given that alternative Xi is selected, outcome X1 will occur with probability p1i, and so on.

(U) A number of procedures for choosing between probability distributions of outcomes have been proposed, but the expected utility principle has dominated normative discussions of the risky choice problem. According to this principle there exists a utility function U defined on outcomes such that: (a) for any two outcomes Xi and Xj, Xi is not preferred to Xj if and only if U(Xi) is less than or equal to U(Xj) and, (b) for any two alternatives Ai and Aj, Ai is not preferred to Aj if and only if EU(Ai) is than or equal to (EA(Aj). U(Xi) denotes the utility of outcome Xi and EU(Ai) denotes the expected utility associated with alternative Ai where, however, the expected utility principle alone does not guarantee the existence of an additive utility function. [Ref. 19]

(U) Strong assumptions about the joint probability distributions of the outcomes and the decision maker's preference for these probabilities have to be made to ensure the existence of any type of utility function. But if these assumptions can be met, then the additive utility function is represented by,

$$U(x1,x2,\ldots,xj,\ldots,xm) = \sum_{j=1}^{m} pj \sum_{i=1}^{n} ui(xij)$$

where X = (x1, x2,...,xj,...,xm) is a risky alternative for which the outcome xj is received if event Ej occurs, pj is the probability of this event, xij is the state of the i-th attribute of outcome xj, ui is the utility function over the i-th attribute, and U is the expected utility for the risky alternative X. [Ref. 20]

(U) The value and utility functions above are one dimensional or single attribute functions. Multidimensional functions assume a decision maker can accurately, consistently, and simultaneously express his preferences for many outcomes over the whole range of attributes. This is not a reasonable assumption to make. But with the hierarcial decomposition involved in MAU approaches an analyst can obtain a series of separate preferences from the decision maker based on the one dimensional functions. Analyzing the results of these functions leads to an assessment of a multi-dimensional function and thus to an assessment of the decision problem as a whole. From the single attribute functions above the worth of each outcome associated with a certain alternative, and thus the worth of the alternative, is determined by simply summing the results of each function for each attribute.

than the additive form. Multiplicative and quasi-additive functions are the two most popular representations in this regard. Since only additive evaluations are used in this thesis there is no need to dwell on the derivation of other representations. Besides, whenever the monotonicity assumption is satisfied, additive evaluation will provide an excellent approximation to overall value and implies that the distinction between additive and non-additive evaluation is trivial from a practical standpoint. As in the case of utility independence and attribute selection, it has been argued that additive evaluation models do not significantly effect the assessment of the functions relating each attribute to overall value or the specification of weighting factors for the attributes. [Ref. 21]

(U) Since different values or amounts of the attributes can influence the outcome of the alternatives and thus the worth of the alternatives for solving the decision problem there is a need to estimate the degree of each attribute's influence on each alternative. No matter if a value or utility function is being considered it is reasonable to assume that both V and U are bounded by some limits. Thus, it is convenient to scale V or U and each of the single attribute, one dimensional functions. For an additive value function, the inclusion of this scalling factor gives the form

$$V(x1,\ x2, \ldots,\ xn) = V(X) = \sum_{i=1}^{n} \lambda i vi(xi)$$

where V and vi are certain positions on an arbitray scale and the sum of all λi's equals the upperbound of the scale. [Ref. 22] These scale values are called weights and the procedures for estimating these weights will be discussed in the next section.

only the riskless case. As mentioned, there is a great deal of debate in the literature about how best to assign probabilities to outcomes and then how to determine a decision maker's preference for the different probabilities. The discussion is still largely theoretical and what work has been done under risky conditions is statistical in nature or involves methods that generally lie outside the scope of utility theory. Even though most decisions are of a risky nature with the outcomes not being certain, the results of riskless studies have proved to be fairly representative of reality. [Ref. 23] For these reasons, only decision under certainity will be considered from this point.

D. (U) PREFERENCE AND WEIGHTS

(U) The previous sections have provided the theoretical basis for using riskless, additive value functions with linear single attribute values. This section, which actually is not in the domain of utility theory, concerns estimating importance weights of the attributes. Since obtaining these estimates is the most difficult task of any MAU application a discussion of MAU theory is not complete without consideration of this topic. There are two general approaches to importance weight estimation: indirect holistic estimation and direct subjective estimation and direct subjective estimation. [Ref. 24]

(U) The common defining characteristic of indirect holistic procedures to weighting is their reliance on holistic evaluations of complex choice alternatives. Such approaches often require numerous holistic judgments and utilize specific statistical tools for analyzing covariance structure, such as multiple regression and analysis of variance. The weights are the relative desirability of acts or objects are inherently subjective [Ref. 26], direct subjective procedures will be used to obtain the weights of the attributes relative to each other and the weights of each attribute in determining the overall worth of an alternative.

(U) The purpose of any direct subjective estimation strategy for defining weights is to create a ratio scale for the importance of the attributes that have been selected. There are numerous subjective procedures for obtaining importance weights that use well known techniques prominent in the psychophysics and general psychological scaling literature. However, there is no strong evidence about which procedure produces a more accurate estimate of weights in additive, riskless multiattribute functions. [Ref. 27] The two general types of direct subjective estimations used in Chapter III are ranking and fractionation. As noted, one procedure is just as useful as another for determining weights and this is especially true for ranking techniques. The ranking techniques used in Chapter III are self explanatory and will not be discussed further.

(U) The logic of fractionation is based on the assumption that a decision maker (judge) is capable of directly perceiving and reporting the ratio between two subjective magnitudes. Here, magnitude means the amount of an attribute possessed by an alternative. In one form of fractionation, the judge is presented with two alternatives and instructed to report the subjective ratio between them with respect to the designated attribute. Methods which use this approach are referred to as direct-estimate methods. [Ref. 28] The two direct-estimate methods used in Chapter III are the additive rating scale method and the constant sum method.

and worst outcomes of the different values or amounts of a specific attribute. Within each attribute a judge assigns arbitrary values of 100 and 0 to the best and worst outcomes respectively. Then for each attribute the judge assigns numerical values to all outcomes intermediate in value to the best and worst. These numerical assessments should accurately reflect the value differences within each attribute. For each possible intermediate outcome on an attribute, the judge assess a number between 0 and 100 which reflects the subjective value (ratio) of the outcome in question relative to the worst and best outcomes on that attribute. [Ref. 29]

(U) In the constant sum method the alternatives are simply the two objects of evaluation to be compared. Using procedures borrowed from the method of paired comparison the judge independently assess the magnitude of each attribute with respect to the alternatives. In most applications of this method the judge divides 100 points between the alternatives with respect to the magnitude of the attribute in question in terms of absolute ratios. [Ref. 30]

III. MILITARY CAPABILITY COMPARISON METHODOLOGY (U)

(U) The MAU methodology developed in this chapter is adapted from procedures described by Edwards [Ref. 31], Fischer [Ref. 32], Sherwin and Laurance [Ref. 33], and Bouchard [Ref. 34]. As mentioned, this methodology assumes decision under certainty and uses an additive function and weighted linear averages to aggregate subjective judgments. Even though "true" utility functions properly refer to decisions made under risky conditions, the term utility will be used throughout to refer to the results of the value function simply for continuity purposes; despite convention. These results or utilities reflect the worth of an attribute to mission success or the overall military worth of a weapon or platform operating in certain conditions. The methodology consists of 10 steps for an analyst to perform.

(U) Step 1. Identify the situation and forces. The analyst, for whatever purpose, first selects the two countries to be compared. Care must be taken to completely define the political and military situation with emphasis placed on the selection of combat operations (ground, naval, or air) relevant to hostilities that could occur. The analyst then should identify the single most important strategic objective a country would have to obtain to determine success or failure in the event of hostilities.

(U) Next, the analyst should identify the specific missions which must be effectively accomplished to achieve the strategic objective. These missions should be divided into three categories: (1) essential, support, those missions which make a substantial contribution to the performance of a country's combat forces, and (3) dependent, those missions which cannot be performed without prior accomplishment of the essential missions.

(U) The analyst then collects order of battle information on the two countries. The primary weapons or platforms to consider are those that perform the essential missions. Just because a country has a certain number of assets does not mean they are all operational or able to be deployed. Reviewing appropriate intelligence estimates will provide the analyst with a more accurate list of the weapons that are likely to become engaged in hostilities given the situation. Only these weapons and platforms need be compared.

(U) Step 2. Identify the attributes. Now the analyst solicits the judgments of informed persons to identify the technical (tangible) and nontechnical (intangible) characteristics of the two countries' military capabilities. Depending on real world constraints like time or geographic location the analyst can use one of several means to obtain these judgments. Group discussions, delphi techniques, and questionnairs are examples. Of these, questionnaires may well be the most practical technique. If questionnaires are used, it is recommended that a separate questionnaire be used for this step. Another questionnaire can be used for the remaining steps.

(U) Step 3. Weight the technical attributes. Once the attributes have been identified the judge's next task is to rank the attributes in order of importance for each country. This rank ordering is necessary so the attributes can be rated by importance preserving ratios. To do this, the judges start by assigning the least important attribute an importance of 10. Then they consider the next-least-important attribute. The judges determine how much more important is it than the least important and assign it a number that reflects that ratio. The judges continue on up the list, checking each set of implied ratios as each new judgment is made. Thus, if an attribute is assigned a weight of 20, while another is assigned a weight of 80, it means that the attribute with the 20 is one-fourth as important as the attribute assigned the 80. The judges may want to revise previous judgments to make them consistent with later ones, and this is acceptable.

(U) Once the results from all of the judges are collected the analyst should normalize the ratio data. This is done by summing all the importance weights and dividing the total for each attribute by the sum. This converts the importance weights into numbers that, mathematically, are rather like probabilities. Further normalization of results can be done in later steps depending on the desired magnitude of the final score. Notationally, let (X) represent the weapon systems or platforms that are being compared, let (i) represent the various technical attributes, and let (Ki) represent the normalized importance ratio for each attribute.

(U) Step 4. Scale the technical attributes for each weapon system or platform. This step involves using the additive rating scale method and has as its basis a fairly strong assumption. The assumption is that there is a linear relationship between the range of values for an attribute and the worth of that attribute in the overall capability of the weapon or platform. The analyst must be extremely clear in the instructions to the judges for completing this step so they will know exactly what is expected of them.

(U) The analyst instructs the judges to specify to themselves what the least desirable and most desirable values of each attribute should be. These values are arbitrarily assigned values of 0 and 100, respectively. Then, for each attribute and each weapon or platform a judge assigns a number from 0 to 100 which reflects the amount of the attribute he thinks the weapon or platform has. For example, if a judge thinks that the least desirable speed of a frigate is 0 knots and the most desirable speed is 40 knots then, for this judge, 0 knots is assigned a value of 0 and 40 knots is assigned a value of 100. If a frigate under consideration has a speed of 20 knots then this judge would assign the speed attribute a value of 50.

(U) For each weapon or platform the analyst simply averages the values assigned to each of the attributes. Let this value be represented notationally by Ui(Xi).

(U) <u>Step 5</u>. Calculate technical attribute utilities. This step is purely computational for the analyst and involves combining all the factors from above with an additive function to find the "utility" or military worth, U(X), of a weapon or platform based soley on its technical attributes. Thus,

$$U(X) = \sum_{i=1}^{n} [Ki \times Ui(Xi)]$$

(U) <u>Step 6</u>. Weight the nontechnical attributes. This step is performed in the same manner as Step 3 except the nontechnical attributes are considered. It should be emphasized to the judges that the importance rankings and ratios are determined separately for the two countries. So, two sets of weights are needed, one with respect to one country and another with respect to the other country. Notationally, let (j) represent the nontechnical attributes and let (Kj) represent the normalized importance ratio for each attribute.

(U) Step 7. Scale the nontechnical attributes. The judges scale the strengths and weaknesses of the two countries relative to each other for each of the nontechnical attributes. These judgments are obtained by asking the judges to split 100 points between the two countries for each of the attributes. Using a simple version of the constant sum method the total points for each attribute are then averaged by the analyst to find the scaled ratio. Let this ratio be represented by (Vj).

(U) Step 8. Calculate nontechnical attribute utilities. This step is similar to Step 5. The nontechnical attribute factors from Steps 6 and 7 are combined again using an additive function to find the "utility" of nontechnical attributes for enhancing the military capabilities of a country. This utility score (Vc) is calculated by the expression,

$$(Vc) = \sum_{j=1}^{n} [kj \times Vj]$$

(U) Step 9. Integrate technical and nontechnical attributes. The purpose of this step is for the judges to assess the relative importance of the technical attributes versus the nontechnical attributes for each country. Unlike Step 7, the two countries are not compared in this regard.

(U) The analyst instructs the judges to first split 100 points between the two categories of attributes for one country and then likewise for the other country. The averages of these comparisons result in four relative importance values:

Kt(c1) = weight of technical attributes for country 1

Kn(c1) = weight of nontechnical attributes for country 1

Kt(c2) = weight of technical attributes for country 2

Kn(c2) = weight of nontechnical attributes for country 2

(U) <u>Step 10</u>. Calculate overall MAU scores. For each weapon or platform, the analyst combines its technical attribute utility score, U(X), with the nontechnical attribute utility score, V(c), of the country possessing that weapon or platform. But first the analyst must multiply U(X) and V(c) by the respective relative importance weights found in Step 9. This results in a MAU score, MAU(X), for each weapon or platform. Thus,

$$MAU(U) = (Kt(c1)) \times U(X)) + (kn(c1)) \times (V(c1))$$

where the equation finds the MAU score of a weapon or platform owned by country 1.

(U) Lastly, the analyst multiplies MAU(X) by the number of weapons or platforms of each country likely to become engaged in hostilities. Comparisons of similar weapons or platforms can be made at this point. By summing these results an overall MAU score for each country is found.

(U) Because the utility value of each weapon or platform is measured in terms of its contribution to the performance of missions essential for achieving the strategic objective of the situation being considered, aggregate numbers of diverse weapons and platforms can be compared to assess the relative military capabilities of the two countries. Since the nontechnical attributes have been factored in to assess this balance a much more accurate and comprehensive comparison can be made. Also, since these scores are derived with respect to a certain situation the effects of simply comparing numerical totals for each type of weapon or platform, as used in order of battle comparisons, are reduced.

IV. APPLICATION OF THE METHODOLOGY (U)

A. (U) SPECIFIC APPROACH AND ASSUMPTIONS

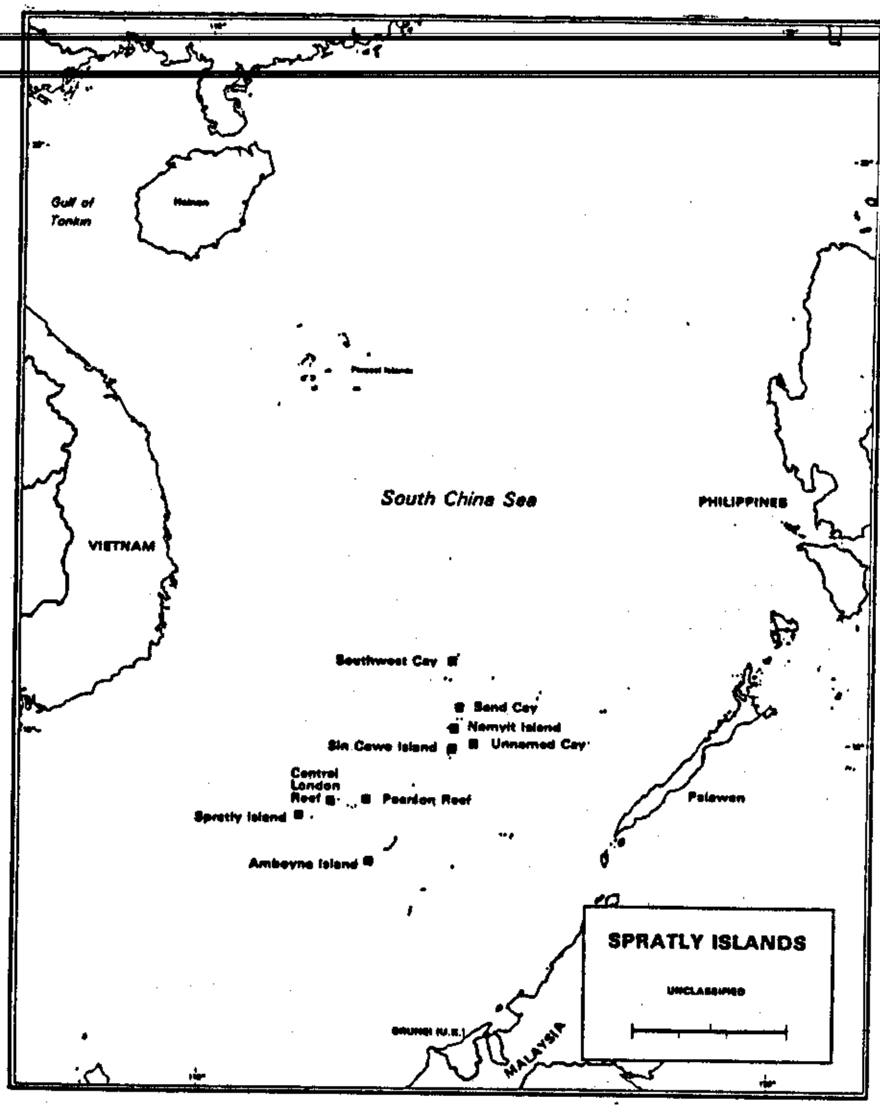
(U) A procedure not mentioned in the previous chapter but nevertheless vital for the application of any MAU methodology is the selection of experts or judges. The quality of the results of a study relies on the quality of the experts. Naturally, analysts would like to have the best judges possible to become involved in their study and just as naturally this is not usually the case. Accessability of the judges to the analyst effects the smooth running of a research effort. To avoid poor response rates or untimely responses to questionnaires an analyst should select judges that are readily accessable but still knowledgeable about the topic to be studied. For these reasons, the specific approach for applying the military capabilities comparison methodology was to select ten judges from the staff, faculty, and student body of the Naval Postgraduate School who were very familiar with China and Vietnam.

(U) The number of judges, ten, was arbitrarily chosen. There is no "required" number of judges for conducting a MAU study. Previous studies have used as few as three judges and more than fifty with between eight through fifteen being common for most studies. Thus, ten judges is an adequate number to ensure variability to the questionnaire responses. The judges were selected based on their experience, position, and knowledge. The group of judges included two staff officers, four faculty members, and four student naval officers.

(U) Some judges expressed concern about their ability to rate technical attributes for some of the classes of ships under consideration. The judges were instructed that if they were not certain about some of their responses they did not have to provide a numerical judgment. Failure to respond did not effect the calculations for utility scores since the weighted averages for the particular attribute was found by dividing the total number of importance points by the number of judges that did respond.

B. (U) THE SITUATION AND FORCES INVOLVED

(U) The vast expanse of reefs, shoals, sand bars, cays, and islands south of MacClesfield Bank and west of Palawan Island in the South China Sea is referred to by many names. English-speaking mariners often call the entire area the Spratly Islands [Fig. 1] and this name has become accepted for the area in the West. For more than twenty years, the Spratly Islands have been the focus of competing claims by the People's Republic of China (PRC), the Government on Taiwan, the Socialist Republic of Vietnam (SRV), the Republic of the Philippines, and Malaysia. Though the islands consist of less than one square mile of ocean, the possibility of important oil and gas reserves provides significant reason for these persistent claims. [Ref. 35] States exercising sovereignty over the islands may claim sovereign rights to vast resources under the exclusive economic zone legal regime or continental shelf concept. [Ref. 36] Also, the islands' proximity to major sea lanes increases the strategic military advantage of the contry that controls the area.



(UNCLASSIFIED)

(U) Figure 1 The Spratly Islands

C. (U) SELECTION OF ATTRIBUTES

(U) To identify the technical and nontechnical attributes of the PRC and SRV naval forces involved in the situation an Attribute Selection questionnaire, shown in Appendix A, was administered to the judges. Lists of suggested attributes were provided for the judges to choose from or they could list attributes of their own choosing. The suggested lists were prepared by reviewing previous MAU studies that compared naval capabilities [Refs. 43 and 44] and by asking Operations Research specialists what typical performance factors are considered when modeling naval engagements.

(U) Aggregating the results of the Attribute Selection questionnaire determined the attributes to be used for subsequent weighting and scaling. The attributes finally selected are listed in Table 4. Efforts were made to include the preferences of all judges but the final lists were prepared with the objective of determining the commonality of all the responses. An attribute from the suggested list was dropped if none of the judges considered it to be important. Based on written feedback from the judges some attributes were redefined to better fit the scenario or they were

Table 4

(U) The Attributes

(UNCLASSIFIED)

Technical Attributes	Nontechnical Attributes
MANEUVERABILITY	POLITICAL RESOLVE/WILL
DISPLACEMENT	MORALE
COMMUNICATIONS	INTELLIGENCE CAPABILITY
SURVIVABILITY	TACTICS EMPLOYMENT CAPABILITY
QUIETNESS	MAINTENANCE CAPABILITY
TYPE OF ARMAMENT	
WEAPON RANGE	
WEAPON ACCUARACY	
NO. OF LAUNCHERS, MOUNTS, BARRELS	
RELOAD OR MAGAZINE CAPABILITY	
AIR SEARCH RADAR	
SURFACE SEARCH RADAR	
FIRE CONTROL SYSTEM	
ESM/ECM	
SONAR	

(U) Once the attributes were determined a weights and scaling questionnaire, Appendix B, was used to gather the necessary information for calculation of overall MAU scores for selected naval units of the PRC and SRV. The questionnaire is quite lengthy but the format was selected to ensure that a complete and comprehensive set of data was obtained from the judges. Some ship characteristic data taken from Reference 45 was included as a reference the judges could use to maintain consistency in the scaling process. Normalization of the data by simply dividing a given number by the sum of all such numbers was done at various steps to provide a final MAU score that was a decimal fraction. Due to round off error, a few totals for the normalized scores do not sum exactly to one.

(U) The tables presented in this section were prepared in the manner described in Chapter III beginning with Step 3. Table 5 lists the (Ki) weight values which were multiplied by the Ui(Xi) scale values shown in Table 6 and summed to find the U(X) technical attribute utilities for each ship class as presented in Table 7. In Table 6 the low scale values given to many ship classes for the air search radar attribute is due to some judges assigning values based on the assumption that most surface search radars do have a limited air search capability. Likewise, the due to their mine countermeasures capability. Table 8 lists the (Kj) weights which were multiplied by the relative (Vj) scale values shown in Table 9 and summed to find the V(c) nontechnical attribute utilities for each country as presented in Table 10.

(U) Table 11 shows the relative importance of the technical versus the nontechnical attributes for each county. These values were multiplied by the respective utilities and summed to find the MAU score for each ship class as shown in Table 12. Finally, the MAU score for a particular ship class was multiplied by the number of ships in the order of battle. Table 13 shows overall MAU scores which can then be used for capability comparison purposes.

Table 5

(U) Technical Attribute Weights (Ki)

(UNCLASSIFIED)

Attribute	Total Weight Points PRC	Total Weight Points SRV	Normalized Weight PRC	Normalized Weight SRV
MANEUVERABILITY	539	557	.0707	.0710
DISPLACEMENT	400	404	.0525	.0515
COMMUNICATIONS	600	626	.0787	.0798
SURVIVABILITY	570	538	.0748	.0798
QUIETNESS	214	267	.0281	.0340
TYPE OF ARMAMENT	815	772	.1069	.0984
WEAPON RANGE	712	662	.0934	.0844
WEAPON ACCURACY	666	657	.0873	.0837
NO. LAUNCHERS	441	431	.0578	.0549
RELOAD/MAG CAP	384	356	.0504	.0454
AS RADAR	336	277	.0441	.0353
SS RADAR	715	683	.0938	.0871
FC SYSTEM	503	635	.0660	.0809
ESM/ECM	499	441	.0654	.0562
SONAR	231	540	.0303	.0688
Totals	7625	7846	1.002	1.000

Table 6

(U) Average Scale Values of the Technical Attributes
For Each Ship Class [Ui(Xi)]

(UNCLASSIFIED)

SHIP CLASS	Attribute (see key next page) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<u>PRC SHIPS</u>															
ROMEO SS	51	48	78	44	63	54	54	47	71	48	4	39	39	33	37
LUDA DD	77	61	63	64	44	65	59	48	66	59	28	57	53	47	42
JIANGHU FF	71	51	54	46	42	66	52	54	60	53	27	49	50	38	38
JIANGNAN FF	70	45	50	42	40	46	39	46	47	49	9	45	41	7	31
RIGA FF	72	51	55	52	42	60	48	53	52	57	52	60	55	45	37
ETORUFU PGF	61	47	50	39	40	37	48	43	36	30	3	43	23	0	30
HOUKU PTG	66	33	49	32	38	52	47	47	21	24	4	53	47	0	0
OSA I PTG	81	48	49	43	40	67	53	54	45	40	4	54	51	0	0
HAINAN PCS	70	43	50	45	39	44	33	45	44	36	2	40	28	0	31
KRONSHTADT	53	38	45	40	35	44	32	42	31	27	2	8	18	0	29
HUCHUAN PTH	82	30	48	29	41	36	30	40	21	17	2	44	19	0	2
P-4 PT	77	29	46	28	41	38	29	43	31	19	2	40	22	0	0
P-6 PT	70	35	49	33	39	40	38	44	21	17	4	39	23	0	0
HUZHOU PC	67	35	48	36	38	35	39	42	21	24	2	38	17	0	0
HAIKOU PC	58	31	37	27	36	21	25	34	21	23	2	37	16	0	0
SHANGHAI PC	62	36	52	31	39	44	26	35	41	35	2	41	17	0	0
LST 511	42	61	50	54	28	23	29	33	30	19	1	27	14	0	0
LSM 1	45	39	54	53	30	27	29	32	33	23	1	39	14	0	0
YULIANG LSM	40	45	55	42	28	19	20	32	16	14	1	41	13	0	0
T-43 MSF	50	42	55	36	31	40	30	33	39	27	1	42	12	10	20
<u>SRV SHIPS</u>															
PETYA FFL	71	47	57	42	39	46	39	46	45	45	14	50	50	3	33
SAVAGE PG	59	56	56	44	43	43	35	48	45	42	51	53	38	0	46
BARNEGAT PGF	62	59	52	50	41	54	54	53	35	35	58	60	47	0	0
KOMAR PTG	67	32	45	30	45	48	49	47	27	19	3	43	58	0	0
OSA II PTG	69	52	52	44	37	61	53	52	34	25	1	49	55	2	0
SHERSHEN PT	73	38	45	36	36	61	37	48	27	30	2	37	41	0	0
P-4 PTL	78	30	42	35	36	35	25	39	27	21	2	36	15	0	0
P-6 PTL	76	35	42	36	30	36	29	40	27	20	2	36	16	0	0
PGM-59 PC	48	38	40	35	44	32	29	29	33	28	3	43	15	0	0
SHANGHAI PC	62	39	51	32	36	36	27	29	25	23	1	34	15	0	0
173 FT PC	50	28	47	32	38	30	27	24	21	27	1	40	26	0	0
PGM 83 PB	40	25	20	24	35	19	21	20	12	11	0	4	4	0	0
PO-2 PB	43	26	44	26	39	14	17	21	13	11	0	26	4	0	0
POLUCHAT PB	55	35	42	33	34	19	26	22	18	19	0	36	9	0	0

(U) Average Scale Values of the Technical Attributes
For Each Ship Class [Ui(Xi)]
(continued)

(UNCLASSIFIED)

SWIFT MK2 PB	56	29	45	33	33	28	22	25	30	24	0	34	16	0	0
ZHUK PB	74	36	44	29	32	18	19	21	22	15	0	22	5	0	0
S.O. 1 PCS	67	32	46	32	31	34	30	23	31	34	3	35	12	0	0
YURKA MSF	50	45	47	38	36	28	21	23	21	19	0	39	25	4	0
K-8 MSF	35	15	28	20	33	15	16	26	14	11	0	5	6	1	0
ADMIRABLE PCS	47	56	45	42	28	27	26	39	30	28	2	37	12	0	0
LST 1	36	57	46	50	26	21	23	26	17	21	1	9	14	0	0
POLNOCHNY LSM	53	43	58	44	25	33	28	32	22	28	1	34	19	0	0
LCU 501	37	30	25	31	27	20	20	21	25	23	1	9	4	0	0
LCU 1466	32	32	37	30	28	25	20	22	30	25	1	24	15	0	0

Key to Attribute Description

1. Maneuverability
2. Displacement
3. Communications
4. Survivability
5. Quietness
6. Type of Armament
7. Weapon Range
8. Weapon Accuracy
9. No. of Launchers, Mounts, Barrels
10. Reload or Magazine Capability
11. Air Search Radar
12. Surface Search Radar
13. Fir Control System
14. ESM/ECM
15. Sonar

Table 7

(U) Technical Attribute Utilities For Each Ship Class
[U(X)]

(UNCLASSIFIED)

Ship Class	Technical Attribute Utility	
PRC Ships		
ROMEO SS	48.46	(.065)
LUDA DD	57.49	(.077)
JIANGHU FF	52.06	(.069)
JIANGNAN FF	42.00	(.056)
RIGA FF	54.18	(.072)
ETORUFU PGF	37.46	(.050)
HOUKU PTG	38.44	(.051)
OSA I PTG	56.50	(.062)
HAINAN PCS	38.30	(.051)
KRONSHADT PCS	30.68	(.041)
HUCHUAN PTH	32.22	(.043)
P-4 PT	27.10	(.036)
P-6 PT	33.30	(.044)
HUZHOU PC	32.36	(.043)
HAIKOU PC	25.58	(.034)
SHANGHAI I PC	33.16	(.044)
LST 511	30.11	(.040)
LSM 1	30.36	(.041)
YULIANG LSM	26.52	(.044)
Total PRC	749.52	(.988)
SRV Ships		
PETYA FFL	43.73	(.062)
SAVAGE PG	44.26	(.063)
BARNEGAT PGF	45.31	(.065)
KOMAR PTG	36.93	(.057)
OSA II PTG	42.70	(.061)
SHERSHEN PT	37.02	(.057)
P-4 PT	29.73	(.042)
P-6 PT	27.11	(.039)
PGM-59 PC	28.63	(.041)
SHANGHI PC	28.77	(.041)
173 FT PC	29.74	(.042)
PGM 83 PB	15.71	(.022)
PO-2 PB	19.38	(.028)
POLUCHAT PB	24.10	(.034)

(U) Technical Attribute Utilities For Each Ship Class
[U(X)]
(continued)

(UNCLASSIFIED)

SWIFT MK2 PB	23.63	(.034)
ZHUK PB	23.04	(.033)
S.O. 1 PCS	33.75	(.048)
YURKA MSF	27.56	(.039)
K-8 MSF	15.23	(.022)
U.S. ADMIRABLE PCS	32.21	(.046)
LST-1	23.50	(.033)
POLNOCHNY LSM	29.77	(.042)
LCU 501	18.18	(.026)
LCU 1466	21.99	(.031)
Total SRV	701.98	(1.004)

Table 8

(U) Nontechnical Attribute Weights (KJ)

(UNCLASSIFIED)

Attribute	Total Weight Points PRC	Total Weight Points SRV	Normalized Weight PRC	Normalized Weight SRV
MORALE	247	345	.1293	.1591
MAINTENANCE	324	272	.1695	.1255
POLITICAL RESOLVE	450	570	.2355	.2629
TACTICS EMPLOYMENT	479	575	.2507	.2652
INTELLIGENCE	411	406	.2151	.1873
Totals	1911	2168	1.000	1.000

Table 9

(U) Average Scale Values Of The Nontechnical Attributes For Each Country Relative To The Other (VJ)

(UNCLASSIFIED)

Attribute	Scale Value PRC	Scale Value SRV
MORALE	47 (.19)	53 (.21)
MAINTENANCE	55 (.23)	45 (.18)
POLITICAL RESOLVE	45 (.19)	55 (.21)
TACTICS EMPLOYMENT	45 (.19)	55 (.21)
INTELLIGENCE	51 (.21)	49 (.19)
Totals	243(1.01)	257(1.00)

Table 10

(U) Nontechnical Attribute Utilities For Each Country
[V(C)]

(UNCLASSIFIED)

Attribute	Utility	
	PRC	SRV
MORALE	11609 (.025)	18285 (.033)
MAINTENANCE	17820 (.038)	12240 (.023)
POLITICAL RESOLVE	20250 (.045)	31350 (.055)
TACTICS EMPLOYMENT	21555 (.048)	31625 (.056)
INTELLIGENCE	20961 (.050)	19894 (.036)
Totals	92195 (.206)	113094 (.203)

Table 11

(U) Attribute Relative Importance Values

(UNCLASSIFIED)

Country	Attribute Importance Value	
	Technical	Nontechnical
PRC	50 [Kt(c1)]	50 [Kn(c1)]
SRV	49 [Kt(c2)]	51 [Kn(c1)]

Table 12

(U) MAU Score For Each Ship Class MAU(X)

(UNCLASSIFIED)

Ship Class	U(x)	x	Kt	+	V(c)	x	Kn	=	MAU(X)
PRC Ships									
ROMEO SS	.065		.5		.206		.5		.136
LUDA DD	.077		.5		.206		.5		.142
JIANGHU FF	.069		.5		.206		.5		.138
JIANGNAN FF	.056		.5		.206		.5		.131
RIGA FF	.072		.5		.206		.5		.139
ETORUFU PGF	.050		.5		.206		.5		.128
HOUKU PTG	.051		.5		.206		.5		.129
OSA I PTG	.062		.5		.206		.5		.134
HAINAN PCS	.051		.5		.206		.5		.129
KRONSHTADT PCS	.041		.5		.206		.5		.124
HUCHUAN PTH	.043		.5		.206		.5		.125
P-4 PTL	.036		.5		.206		.5		.121
P-6 PTL	.044		.5		.206		.5		.125
HUZHOU PC	.043		.5		.206		.5		.125
HAIKOU PC	.034		.5		.206		.5		.120
SHANGHAI PC	.044		.5		.206		.5		.125
LST 511	.040		.5		.206		.5		.123
LSM 1	.041		.5		.206		.5		.124
YULIANG LSM	.035		.5		.206		.5		.121
T-43 MSF	.044		.5		.206		.5		.125
SRV Ships									
PETYA FFL	.062		.49		.203		.51		.134
SAVAGE PG	.063		.49		.203		.51		.134
BARNEGAT PGF	.065		.49		.203		.51		.135
KOMAR PTG	.057		.49		.203		.51		.131
OSA II PTG	.061		.49		.203		.51		.133
SHERSHEN PT	.053		.49		.203		.51		.130
P-4 PT	.042		.49		.203		.51		.124
P-6 PT	.039		.49		.203		.51		.123
PGM-59	.041		.49		.203		.51		.124
SHANGHAI PC	.041		.49		.203		.51		.124
173 FT PC	.042		.49		.203		.51		.124
PGM 83 PB	.022		.49		.203		.51		.114
PO-2 PB	.028		.49		.203		.51		.117
POLUCHAT PB	.034		.49		.203		.51		.120
SWIFT MK2 PB	.034		.49		.203		.51		.120
ZHUK PB	.033		.49		.203		.51		.120
S.O. 1 PCS	.048		.49		.203		.51		.127

(U) MAU Score For Each Ship Class MAU(X)
(continued)

(UNCLASSIFIED)

~~YURKA MSF~~	~~.039~~	~~.49~~	~~.203~~	~~.51~~	~~.123~~
~~K-8 MSF~~	~~.022~~	~~.49~~	~~.203~~	~~.51~~	~~.114~~
ADMIRABLE PCS	.046	.49	.203	.51	.126
LST 1	.033	.49	.203	.51	.120
POLNOCHNY LSM	.042	.49	.203	.51	.124
LCU 501	.026	.49	.203	.51	.116
LCU 1466	.031	.49	.203	.51	.119

V. CONCLUSION AND RECOMMENDATIONS (U)

(U) The .05 increase over the order of battle ratio provided the PRC in the MAU study is not significant enough to effect any previous intelligence assessments about the outcome of the proposed scenario. Although the balance of forces remains in favor of the PRC, the MAU comparison more accurately reflects the actual military balance of the PRC and the SRV naval forces that were considered. Primarily the study shows that intelligence estimates should not give the PRC any greater advantage over the SRV in their mutual desire to control the South China Sea. It was shown that the SRV is just as capable and determined as the PRC, if not more so, to initate, support, and adequately conduct offensive naval operations to back up their claims and objectives in the South China Sea. These determinations can not be made simply by reviewing order of battle information.

(U) Several problems with the MAU methodology were encountered in the application to the test situation or were expressed by the judges and are the basis for recommendations for future similar studies. For the selection of attributes, it was felt that, if possible, a group discussion among the judges would have led to a better defined list of attributes. The lack of interaction between the judges placed a greater responsibility on the researcher to sort out interdependencies and discrepancies of the individual responses to the Attribute Selection Questionnaire. This introduced an additional subjectivity that may have had substantial effect of the final results. To reduce this possible clarify their responses and determine if they were consistent with the responses of other judges. Therefore, group discussions, or possibly the use of delphi techniques, should be used to make the attribute selection process less susceptible to prejudices of the analysts.

(U) Use of a questionnaire for the individual weighting and scaling of the attributes does not require any interaction between the judges since the numerical responses can be aggregated without adding extra subjectivity. However, feedback from the judges indicated that filling out the questionnaire was quite demanding. It was suggested that a questionnaire wherein the judges could rate types of ship classes rather than the many different classes that were considered would have been easier and just as adequate. But this would cause extrapolation from the results by the researcher to specific ship classes. This procedure would also inject analyst subjectivity into the problem. Also, the method by which an analyst could make the extrapolations is not clear and the literature does not provide any guidelines as to how this procedure might be performed. Use of cluster analysis or other similar techniques for the extrapolation of general responses to specific military platforms and weapons needs to be investigated. However, the format of the questionnaire seems to be the most efficient and adequate method to obtain the detailed information an analyst needs to implement the methodology.

(U) Since the procedure used in the methodology for integrating the technical and nontechnical attributes resulted in an even importance split between the two sets of attributes for both countries, this procedure requires some refinement so more accurate numerical assessments can be capabilities comparison is that the nontechnical attributes are considered in the computation of utility scores. It was not clearly shown that the intangible variables were included in a manner that ensured an accurate representation of their influence on the ability of a country to use their military forces. Alternative methods for integrating technical and nontechnical attributes should be tested. A statistical method which does not involve the averaging of individual responses is one consideration.

(U) Several judges expressed concern that the scope of the test study was too large. It was suggested that if a smaller number of ship classes were considered then the judges' responses would have been more consistent and meaningful. These doubts are probably based on the relative unfamiliarity of the judges with some of the smaller classes of ships. This may be a valid point when other countries' military forces are being compared under differing tactical situations. But when considering the test scenario used in this thesis one can not ignore the PRC or SRV resolve to use even the least capable of ships to support their naval initiatives. One solution to these concerns, which has been previously mentioned, is to get the most knowledgeable judges available to participate in the MAU study since the quality of the results depends heavily on the quality of the judges. Another solution is to develope scenarios that succinctly and comprehensively define the forces to be studied. Efforts should be made to keep the total number of forces to be considered as small as possible. Probably the best solution is to limit comparison to only a few of the major essential combat forces but this approach large number of different types of weapons and platforms.

(U) One last possible problem, which is due to the format of the Weights and Scaling Questionnaire, deserves mention. The ship classes for each country were arbitrarily presented in a manner where the larger, and usually more capable, classes were listed first for consideration. The results of the study showed a general declining trend in the utilities of the ships as they were presented. Even though it was expected that the larger classes of ships should receive a higher utility score than the smaller classes it is possible that the presentation of the ships in the questionnaire in a top down fashion did indeed help to reenforce this general observation. Questionnaires should be constructed so that formats can not influence results. Random order presentations of platforms and weapons should alleviate any undue bias.

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

NC4(38)
2 January 1985

From: Curricular Officer, National Security and Intelligence Programs (Code 38)
To:

Subj: DISTRIBUTION OF MULTIATTRIBUTE UTILITY THEORY AND MILITARY CAPABILITIES QUESTIONNAIRE.

Encl: (1) Attribute Selection Questionnaire

1. This questionnaire is part of a student research project designed to measure the military capabilities of two specified countries relative to each other. The methodology to be used is derived from Multiattribute Utility theory. The results of this questionnaire will be incorporated into a thesis being prepared by LT Dale E. Hays to satisfy the degree requirement in the Naval Intelligence curriculum. You have been asked to respond to this questionnaire because of your position, experience, and knowledge. Thus, each response to the questionnaire becomes very important to this research effort.

2. Enclosure (1) is the first section of a two part questionnaire. Part Two will be separately provided once the results of Part One are aggregated. This first part addresses the initial step in applying Multiattribute Utility Methodology; the identification and selection of attributes.

3. Your participation in this research effort is most appreciated.

D. N. SCHUETZ

MULTIATTIBUTE UTILITY THEORY AND MILITARY CAPABILITIES

COMPARISON QUESTIONNAIRE

PART ONE

ATTRIBUTE SELECTION QUESTIONNAIRE

Gentlemen,

The hypothesis of my thesis is that comparison of the Multiattribute Utility (MAU) scores of two countries is a more accurate and complete measure of their relative military balance than mere order of battle comparisons. The purpose of this questionnaire is to collect raw data to test this hypothesis. An engagement between selected naval units of the PRC and the SRV in a dispute over the sovereignty of the Spratly Islands serves as the case situation. I am attempting to evaluate the overall military worth of these ships based on judgments about the value of tangible and intangible characteristics of the forces.

Three basic steps will be used in the MAU application. First, the decision problem will be decomposed along natural lines according to various value characteristics called attributes. Second, separate judgments will be made about each of the attributes. Finally, these separate judgments will be aggregated using a formal algebraic rule and this is used as an aid for the comparison. These steps will serve as the basis of a methodology for comparing relative military balances.

~~Some decomposition of the problem has already been~~ done due primarily to assumptions necessary for specification of the situation and forces involved and for preparation of the questionnaire. Since the situation to be tested involves PRC and SRV naval units in a dispute near the Spratly Islands, a limited at-sea engagement with little or no submarine activity and no land based air participation is envisioned. After reviewing intelligence estimates on the operational capabilities of PRC and SRV naval forces a list of those ships likely to become engaged in such hostilities has been prepared and will be provided if desired.

Also, the attributes have already been separated into tangible and intangible categories. The tangible attributes are classified as technical attributes and have been divided into categories reflecting the basic type of attribute to be considered. The intangible attributes are classified as nontechnical attributes with some explanatory remarks added for clarification. For purposes here, an attribute is defined as any characteristic of a ship which has relevance to adequacy of performance of the ship in the conduct of missions. Your responses to this part of the questionnaire will be compared with others to select a complete list of attributes.

Lists of suggested technical and nontechnical attributes are provided. You are asked to circle the attributes you think are necessary to consider to determine the military worth of naval forces operating under the given scenario. Please feel free to write in any attribute you may wish to include. For guidance, the set of attributes you chose should be complete, so that it covers all important aspects of the situation; operational, so that individual characteristics of the set can be easily quantified or judgmentally scaled; nonredundant, so that double counting of impacts can be avoided; and minimal, so that the dimensions of the situation are kept as small as possible for practical and meaningful analysis. Judgments about the relative importance of the attributes are not necessary at this time.

Thank you,

TECHNICAL ATTRIBUTES

CIRCLE YOUR PREFERENCES OR WRITE IN CHOICES OF YOUR OWN.

Ship Characteristics

Speed

Range or endurance

Command, control, and communications

Seaworthiness

Survivability (Damage Control)

____

____

____

____

Unique Submarine Characteristics

Submerged endurance

Quietness

Maximum Depth

____

____

____

____

Armament Characteristics

Type of armament (missiles, guns, asw weapons, etc)

Weapon range

Warhead size

Accuracy or probability of a hit

Number of launchers, mounts, and barrels

Reload or magazine capability

<u>Sensor Capabilities</u>

Air search radar

Surface search radar

Fire control radar

ESM/ECM

Sonar

<u>Other Characteristics or Capabilities</u>

NONTECHNICAL ATTRIBUTES

CIRCLE YOUR PREFERENCES OR LIST OTHER CATEGORIES OF

INTANGIBLE ATTRIBUTES ON THE NEXT PAGE

Intelligence Capability

The capability to collect, analyze, and disseminate intelligence information.

Tactics Employment Capability

The capability to successfully employ developed tactics in hostile conditions. Includes quality of previous mission training exercises and command initiative.

Logistics Capability

The capabillity to replenish or replace items necessary to sustain the operational tempo.

Operator Competance

The ability of personnel to maximize the use of equipment and machinery that is functioning properly.

Maintenance Proficiency

The ability of personnel to maintain and repair mission essential systems.

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

NC4(38)
24 January 1985

(Unclassified upon removal of Enclosure (2))

From: Curricular Officer, National Security and Intelligence Programs, (Code 38)
To:

Subj: DISTRIBUTION OF MULTIATTRIBUTE UTILITY THEORY AND MILITARY CAPABILITIES COMPARISON QUESTIONNAIRE

Encl: (1) Weights and Scaling Questionnaire
(2) PRC and SRV Ship Characteristics Data Sheet

1. Enclosure (1) is the second part of a questionnaire being distributed for thesis research purposes by LT Dale E. Hays. This part of the questionnaire solicits your judgment about the relative capabilities of the naval forces of the PRC and the SRV. Since mathematical analysis will be applied to the results of this questionnaire each response becomes very important to this research effort.

2. Enclosure (2) is a classified listing of PRC and SRV ship characteristics. Please safeguard this enclosure appropriately.

3. Your participation in this research effort is most appreciated.

L. N. SCHUETZ

MULTIATTRIBUTE UTILITY THEORY AND MILITARY CAPABILITIES

COMPARISON QUESTIONNAIRE

PART TWO

WEIGHTS AND SCALING QUESTIONNNAIRE

Gentlemen,

In this questionnaire you will be asked to make several different subjective judgments. Generally, there will be two types of judgments to make, numerical judgments about the importance of each attribute relative to each other and numerical judgments about the worth of each attribute in determing the capability of the naval forces to successfully complete assigned missions. These numerical judgments are vital for the application of any Multiattribute Utility (MAU) methodology. Before discussing the attibutes to be considered, a quick review of the scenario is necessary.

An important naval objective of the PRC and the SRV is to obtain and maintain control of the South China Sea. The sovereignty of the Spratly Islands has been contested by both countries for several decades primarily due to the island group's strategic geographical location. Because other nations have expressed a military interest in some of the islands and the possibility of there being large oil deposits in the area, the dispute between the two countries has recently become more intense. Both the PRC and the SRV view control over the Spratly's as a significant indicator of prestige and as a stepping stone for future opportunities in the South China Sea. Thus, naval hostilities over the sovereignty of the Spratly Islands is a realistic likelihood.

The tactical scenario is a quick and small scale at-sea engagement between selelcted naval forces of the two countries. No third party intervention should be anticipated. Based on intelligence estimates only those classes of ships which can realistically be expected to participate in such an engagement are to be considered. The ships are assumed to be on station near the island chain at the start of hostilities. Submarine participation will consist of only Romeo class diesel submarines of the PRC's South Sea Fleet. Land based air activity will be limited with surveillance and reconnaissance the only assigned missions. Aircraft will not become involved in actual engagements. Therefore, any assumed aircraft participation should be taken into account when considering the intelligence collection capability of the two countries. Success or failure of the operation will be determined by the outcome of these two naval forces engaging one another with the victor able to land troops on several of the islands in the absence of any hostile opposition.

There was no mention of the number of each class of ships in the scenario. The scenario is used only to add meaning to the results of the basic comparison to be made. The objective here is to build a situation where the military interaction is strictly naval ships versus naval ships. In your judgments, do not worry about the number of units there are of a certain class of ship. Just consider the "worth" of that class of ship in a hypothetical engagement between the "worths" of oppossing classes ships.

The lists of attributes presented in the following sections were selected using the results of the first part of the questionnaire. Since some of the technical attributes listed in Part One were ambiguous, the less clear technical attributes for this part will be briefly defined. Maneuverability is based on speed and endurance and refers to the capability of a ship to be quickly and adequately repositioned. Displacement is easy to measure and, while not normally considered to contribute to the combat worth of a ship by itself, is an indicator of seaworthiness. Communications capability refers to the general type and sophistication of communications equipment and is fairly easy to assess. Here it also serves a basis to assess command and control capability. Survivability is difficult to measure, but for weighting and scaling purposes it refers to the vulnerability of a ship and its weapons or radar systems to withstand damage inflicted by oppossing forces. Quietness is also difficult to measure. It not only refers to sound propagated by submarines but also to the capability of ships and submarines to avoid detection from passive sonar.

The nontechnical attributes identified from Part One are listed below:

Political will/resolve

The determination of a country to carry out plans or initiatives, to back up threats, or to squarely meet aggressors.

Intelligence capability

The capability to collect, analyze, and disseminate technical, tactical, and political intelligence information.

Tactics employment capability

The capability to successfully employ developed tactics in hostile conditions. Includes quality of a country's naval doctrine, quality of command personnel, and operator training level.

Maintenance proficiency

The ability of personnel to maintain and repair mission essential equipment and the capability of supply organizations to ensure repair and replacement items are readily available.

The weighting and scaling methods used as a basis for developing this questionnaire are simplistic, more rigorous methods are available, but simplicity and ease of obtaining judgments are important for the MAU methodology I use in my thesis. The instructions for each section are straitforward. Some ship characteristic data (Enclosure 2) has been provided for you to use as a quick reference. Even though the data may not be complete it is your judgment that is valued over a compilation of data, particularly when the measure is difficult to quantify. Please feel free to give me feedback about the questionnaire.

Thank you,

A. The attributes

The technical attributes identified from an aggregation of the results of Part One are:

MANEUVERABILITY

DISPLACEMENT

COMMUNMICATIONS

SURVIVABILITY

QUIETNESS

TYPE OF ARMAMENT

WEAPON RANGE

WEAPON ACCURACY

NUMBER OF LAUNCHERS, MOUNT, BARRELS

RELOAD OR MAGAZINE CAPABILITY

AIR SEARCH RADAR

SURFACE SEARCH RADAR

FIRE CONTROL SYSTEM

ESM/ECM

SONAR

The nontechnical attributes identified from an aggregation of the results of Part One are:

POLITICAL WILL/RESOLVE

MORALE

INTELLIGENCE CAPABILITY

TACTICS EMPLOYMENT CAPABILITY

MAINTENANCE CAPABILITY

B. Ranking the technical attributes

Rank the technical attributes in order of importance for determining the military capabilities of ships for each of the countries. This rank ordering should simply be a list of the most important attribute (1) to the least important attribute (15). Write in your responses in the spaces below. You will be asked to judge the relative importance ratio (weight) in the next section.

PRC	WT	SRV	WT
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	
9.		9.	
10.		10.	
11.		11.	
12.		12.	
13.		13.	
14.		14.	
15.		15.	

C. Determining the weight of the attributes

In this section you will be rating the attributes in importance-preserving ratios or weights. To do this, start by assigning the least important attribute you identified in the previous section an importance of 10. Now consider the next-least-important attribute. How much more important (if at all) is it than the least? Assign it a number that reflects that ratio. Continue on up the list, checking each set of implied ratios as each new judgment is made. Thus, if an attribute is assigned a weight of 20, while another is assigned a weight of 80, it means that the attribute with the twenty is one-fourth as important as the attribute with the 80. By the time you reach the most important attribute, there will be many checks to perform. You may want to revise previous judgments to make them consistent with later ones and this is acceptable.

In the space provided in the previous section under the heading of **WT**, please mark your weight assessments of the technical attributes for each country.

D. Scaling the attributes

In this section you will be determining the worth of an attribute for a particular ship based upon how much of the attribute you think that ship has. The method used here is adapted from the additive rating scale method. First, you specify to yourself what the least desirable and most desirable values of each attribute should be. These values will then arbitrarily be assigned values of 0 and 100, respectively. Then for each attribute and each platform you assign a number from 0 to 100 which reflects the amount of the attribute you think a particular ship has. For example, if you think that the least desirable maximum speed of a frigate is 0 knots and the most desirable maximum speed of a frigate is 40 knots, then 0 kts is assigned a value of 0 and 40 knots is assigned a value of 100. Thus, if a particular frigate has a speed of 20 knots then you should assign the speed attribute for this ship a value of 50.

On the following pages are the classes of PRC and SRV ships to consider given the scenario. Listed under each ship class are the technical attributes. In the space provided beside each attribute please write the number from 0 to 100 which represents the amount of the attribute you think a ship has according to the end points you have established for each attribute.

ROMEO SS — TYPE OF ARMAMENT________

MANEUVERABILITY ________	DISPLACEMENT ________
COMMUNICATIONS ________	SURVIVABILITY ________
QUIETNESS ________	WEAPON RANGE ________
FIRE CONTROL SYSTEM ________	WEAPON ACCURACY ________
AIR SEARCH RADAR ________	ESM/ECM ________
SURF SEARCH RADAR ________	SONAR ________
RELOAD/MAGAZINE CAPABILITY ________	NO OF LAUNCHER MOUNTS/BARRELS ________

LUDA DD — TYPE OF ARMAMENT________

MANEUVERABILITY ________	DISPLACEMENT ________
COMMUNICATIONS ________	SURVIVABILITY ________
QUIETNESS ________	WEAPON RANGE ________
FIRE CONTROL SYSTEM ________	WEAPON ACCURACY ________
AIR SEARCH RADAR ________	ESM/ECM ________
SURF SEARCH RADAR ________	SONAR ________
RELOAD/MAGAZINE CAPABILITY ________	NO OF LAUNCHER MOUNTS/BARRELS ________

JIANGHU FF — TYPE OF ARMAMENT________

MANEUVERABILITY ________	DISPLACEMENT ________
COMMUNICATIONS ________	SURVIVABILITY ________
QUIETNESS ________	WEAPON RANGE ________
FIRE CONTROL SYSTEM ________	WEAPON ACCURACY ________
AIR SEARCH RADAR ________	ESM/ECM ________
SURF SEARCH RADAR ________	SONAR ________
RELOAD/MAGAZINE CAPABILITY ________	NO OF LAUNCHER MOUNTS/BARRELS ________

JIANGNAN FF TYPE OF ARMAMENT__________

MANEUVERABILITY ____________ DISPLACEMENT ____________

COMMUNICATIONS ____________ SURVIVABILITY ____________

QUIETNESS ____________ WEAPON RANGE ____________

FIRE CONTROL SYSTEM____________ WEAPON ACCURACY____________

AIR SEARCH RADAR ____________ ESM/ECM ____________

SURF SEARCH RADAR ____________ SONAR ____________

RELOAD/MAGAZINE CAPABILITY ____________ NO OF LAUNCHER MOUNTS/BARRELS ____________

RIGA FF TYPE OF ARMAMENT__________

MANEUVERABILITY ____________ DISPLACEMENT ____________

COMMUNICATIONS ____________ SURVIVABILITY ____________

QUIETNESS ____________ WEAPON RANGE ____________

FIRE CONTROL SYSTEM____________ WEAPON ACCURACY____________

AIR SEARCH RADAR ____________ ESM/ECM ____________

SURF SEARCH RADAR ____________ SONAR ____________

RELOAD/MAGAZINE CAPABILITY ____________ NO OF LAUNCHER MOUNTS/BARRELS ____________

ETORUFU PGF TYPE OF ARMAMENT__________

MANEUVERABILITY ____________ DISPLACEMENT ____________

COMMUNICATIONS ____________ SURVIVABILITY ____________

QUIETNESS ____________ WEAPON RANGE ____________

FIRE CONTROL SYSTEM____________ WEAPON ACCURACY____________

AIR SEARCH RADAR ____________ ESM/ECM ____________

SURF SEARCH RADAR ____________ SONAR ____________

RELOAD/MAGAZINE CAPABILITY ____________ NO OF LAUNCHER MOUNTS/BARRELS ____________

HOUKU PTG TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

OSA I PTG TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

HAINAN PCS TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

KRONSHTADT PCS TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

HUCHUAN PT TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

PRC P-4 PT TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

PRC P-6 PT TYPE OF ARMAMENT__________

MANEUVERABILITY	__________	DISPLACEMENT	__________
COMMUNICATIONS	__________	SURVIVABILITY	__________
QUIETNESS	__________	WEAPON RANGE	__________
FIRE CONTROL SYSTEM	__________	WEAPON ACCURACY	__________
AIR SEARCH RADAR	__________	ESM/ECM	__________
SURF SEARCH RADAR	__________	SONAR	__________
RELOAD/MAGAZINE CAPABILITY	__________	NO OF LAUNCHER MOUNTS/BARRELS	__________

HUZHOU PC TYPE OF ARMAMENT__________

MANEUVERABILITY	__________	DISPLACEMENT	__________
COMMUNICATIONS	__________	SURVIVABILITY	__________
QUIETNESS	__________	WEAPON RANGE	__________
FIRE CONTROL SYSTEM	__________	WEAPON ACCURACY	__________
AIR SEARCH RADAR	__________	ESM/ECM	__________
SURF SEARCH RADAR	__________	SONAR	__________
RELOAD/MAGAZINE CAPABILITY	__________	NO OF LAUNCHER MOUNTS/BARRELS	__________

HAIKOU PC TYPE OF ARMAMENT__________

MANEUVERABILITY	__________	DISPLACEMENT	__________
COMMUNICATIONS	__________	SURVIVABILITY	__________
QUIETNESS	__________	WEAPON RANGE	__________
FIRE CONTROL SYSTEM	__________	WEAPON ACCURACY	__________
AIR SEARCH RADAR	__________	ESM/ECM	__________
SURF SEARCH RADAR	__________	SONAR	__________
RELOAD/MAGAZINE CAPABILITY	__________	NO OF LAUNCHER MOUNTS/BARRELS	__________

SHANGHAI PC TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

LST 511 TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

LSM-1 TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

YULIANG LSM TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

T-43 MSF TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

PETYA FFL

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

SAVAGE PG

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

BARNEGAT PGF

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

KOMAR PTG

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

OSA II PTG

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

SHERSHEN PT

TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

SRV P-4 PT — TYPE OF ARMAMENT ________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

SRV P-6 PT — TYPE OF ARMAMENT ________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

PGM-59 PC — TYPE OF ARMAMENT ________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

SHANGHAI PC TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

173 FT PC TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

PGM 83 PB TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

PO-2 PB TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
~~COMMUNICATIONS~~	________	~~SURVIVABILITY~~	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

POLUCHAT PB TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

SWIFT MK 2 PB TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

ZHUK PB TYPE OF ARMAMENT________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

S. O. 1 PCS TYPE OF ARMAMENT________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

YURKA MSF TYPE OF ARMAMENT________

MANEUVERABILITY		DISPLACEMENT	
COMMUNICATIONS		SURVIVABILITY	
QUIETNESS		WEAPON RANGE	
FIRE CONTROL SYSTEM		WEAPON ACCURACY	
AIR SEARCH RADAR		ESM/ECM	
SURF SEARCH RADAR		SONAR	
RELOAD/MAGAZINE CAPABILITY		NO OF LAUNCHER MOUNTS/BARRELS	

K-8 MSF — TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

U.S. ADMIRABLE PCS — TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

LST-1 — TYPE OF ARMAMENT ________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

POLNOCHNY LSM TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

LCU 501 TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

LCU 1466 TYPE OF ARMAMENT________

MANEUVERABILITY	________	DISPLACEMENT	________
COMMUNICATIONS	________	SURVIVABILITY	________
QUIETNESS	________	WEAPON RANGE	________
FIRE CONTROL SYSTEM	________	WEAPON ACCURACY	________
AIR SEARCH RADAR	________	ESM/ECM	________
SURF SEARCH RADAR	________	SONAR	________
RELOAD/MAGAZINE CAPABILITY	________	NO OF LAUNCHER MOUNTS/BARRELS	________

E. <u>Ranking and weighting the nontechnical attributes</u>

In this section you are to rank and weight the nontechnical attributes by the same procedure that was used for the technical attributes. Two sets of weights are needed, one for the PRC and one for the SRV. After a simple listing of the attributes from most important (1) to least important (5) is made you then determine the relative importance ratio or weight of the individual attributes. Again, assign your least important nontechnical attribute a value of 10 and then compare that attribute with the next-least-important attribute and so on. The nontechnical attributes are listed below in no particular order for your reference.

PRC	WT	SRV	WT
1. ________	____	1. ________	____
2. ________	____	2. ________	____
3. ________	____	3. ________	____
4. ________	____	4. ________	____
5. ________	____	5. ________	____

MORALE, MAINTENANCE CAPABILITY, POLITICAL RESOVE/WILL,

TACTICS EMPLOYMENT CAPABILITY, INTELLIGENCE CAPABILITY

F. Scaling the nontechnical attributes

The procedure used to scale the nontechnical attributes will be the constant sum method of paired comparisons. You are to determine the strengths and weaknesses of the PRC and the SRV <u>relative to each other</u> for each of the nontechnical attributes. This is a simple procedure. Split 100 points between the two countries ensuring that this point spread reflects the degree to which one country has the advantage over the other in each of the areas described by the attribute. For example, if you think the PRC has four times the political resolve than the SRV, assign the PRC 80 points and the SRV 20 points.

POLITICAL WILL/RESOLVE

PRC ____________________

SRV ____________________

MORALE

PRC ____________________

SRV ____________________

INTELLIGENCE CAPABILITY

PRC ____________________

SRV ____________________

TACTICS EMPOLYMENT CAPABILITY

PRC ____________________

SRV ____________________

MAINTENANCE CAPABILITY

PRC ____________________

SRV ____________________

G. <u>Integrate technical and nontechnical attributes</u>

In this last section you are to assess the relative importance of the technical attributes versus the non-technical attributes for each country. This step is similar to previous section except the two countries are not compared to each other. Simply split 100 points between the two categories of attributes for one country, again ensuring that the point spread reflects the categories relative importance, and then do the same for the other country.

PRC

Technical attributes ____________

Nontechnical attributes ____________

SRV

Technical attributes ____________

Nontechnical attributes ____________

THIS COMPLETES THE QUESTIONNAIRE. THANKS FOR YOUR HELP.

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