NAVAL POSTGRADUATE SCHOOL

Monterey, California

PROBLEMS IN MODELING NAVIES

by

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SEPTEMBER 1988

Prepared for:

Naval Postgraduate School
Monterey CA 93943

Strategic Concepts Branch (OP-603)
Office of the Chief of
Naval Operations
Washington, DC 20350

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

The work reported herein was supported by the Strategic Concepts Branch, Office of the Chief of Naval Operations, and in part by the Naval Postgraduate School Research Council and funded by the Naval Postgraduate School Research Council.

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

- **1a REPORT SECURITY CLASSIFICATION:**
- **1b RESTRICTIVE MARKINGS:**
- **2a. SECURITY CLASSIFICATION AUTHORITY:** UNCLASSIFIED
- **2b DECLASSIFICATION / DOWNGRADING SCHEDULE:**
- **3 DISTRIBUTION / AVAILABILITY OF REPORT:**
- **4 PERFORMING ORGANIZATION REPORT NUMBER(S):** NPS-56-88-022
- **5 MONITORING ORGANIZATION REPORT NUMBER(S):**
- **6a NAME OF PERFORMING ORGANIZATION:** Naval Postgraduate School
- **6b OFFICE SYMBOL (If applicable):** 56Ch
- **7a NAME OF MONITORING ORGANIZATION:** Naval Postgraduate School
- **6c ADDRESS (City, State, and ZIP Code):** Monterey, CA 93943-5100
- **7b. ADDRESS (City, State, and ZIP Code):** Monterey, CA 93943
- **8a NAME OF FUNDING SPONSORING ORGANIZATION:** Strategic Concepts Branch
- **8b OFFICE SYMBOL (If applicable):** OP-603
- **9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:** O&MN, direct funding
- **8c. ADDRESS (City, State, and ZIP Code):** Office of the Chief of Naval Operations, Washington, DC 20350
- **10. SOURCE OF FUNDING NUMBERS:** PROGRAM ELEMENT NO | PROJECT NO | TASK NO | WORK UNIT ACCESSION NO
- **11 TITLE (Include Security Classification):** Problems in Modeling Navies
- **12 PERSONAL AUTHOR(S):** Ralph N. Channell
- **13a TYPE OF REPORT:** Final Report
- **13b TIME COVERED:** FROM Mar 88 TO Jul 88
- **14. DATE OF REPORT (Year, Month, Day):** 88 September 22
- **15 PAGE COUNT:** 37
- **16 SUPPLEMENTARY NOTATION:** Earlier drafts presented at the "Thinking Red in Wargaming" Workshop sponsored by the National Defense University, and at the 56th Military Operations Research Society Symposium, June 1988.
- **17 COSATI CODES:** FIELD | GROUP | SUB-GROUP
- **18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number):** Wargaming; RAND Strategy Assessment System (RSAS); Strategy; Naval Postgraduate School; Simulations; Naval Models

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

Paper discusses problems encountered in modeling naval warfare with emphasis on the RAND Strategy Assessment System (RSAS) as installed at the Naval Postgraduate School. Paper points out that there are unique modeling problems for naval warfare, that the RSAS work is attempting to solve these problems, but that more work needs to be done. ~~Paper~~ includes details on RSAS naval models, and recommends improvements to these models as well as RSAS approach to naval warfare.

- **20 DISTRIBUTION / AVAILABILITY OF ABSTRACT:** ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS
- **21 ABSTRACT SECURITY CLASSIFICATION:** UNCLASSIFIED
- **22a NAME OF RESPONSIBLE INDIVIDUAL:** Ralph Norman Channell
- **22b TELEPHONE (Include Area Code):** (408) 646-2409/2521
- **22c OFFICE SYMBOL:** 56Ch

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 1986—606-24

UNCLASSIFIED

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ACKNOWLEDGMENTS

The author is indebted to Drs. Paul Davis, William Schwabe, Bruce Bennett, John Schrader, and the other members of the RAND Strategy Assessment Center for their guidance, instruction and forbearance in acquainting me with the intricacies of the RAND Strategy Assessment System (RSAS). Much of the technical detail in this study is drawn from papers produced by them and their colleagues. Commander James J. Tritten, USN, Chairman of the National Security Affairs Department at the Naval Postgraduate School is the force behind the acquisition and installation of the RSAS at the Naval Postgraduate School, and has read and commented upon the early draft of this paper.

This study was originally produced to support presentations assessing problems in modeling navies as encountered while using the RSAS, which were given at a workshop sponsored by the National Defense University on "Thinking Red in Wargaming" and the 56th Military Operations Research Society Symposium, both in June 1988. Sections of the study tend to emphasize the Red side of naval warfare due to the forum for which the paper was originally intended.

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Part I

INTRODUCTION

1. Problems in Modeling Navies. Why are navies difficult to model? Are they more difficult to model than land forces? Are there unique aspects of navies that require a different approach? The disposition of navies is broad, covering large ocean areas, they are very mobile, and they carry to a great extent, their own capabilities, dependent upon their particular task organization. Thus, they provide an operating force that is in many respects unique to warfare. Detection and tracking play a crucial role in naval warfare due to the expanse of the ocean, the techniques of evading detection, the use and limits of weather, varying characteristics of ocean basins and layers, sophisticated electronic warfare (EW) techniques, and the use of space. In addition, the crucial role of the exchange of information is important, to include message communications, data links, and voice circuits. Chance plays an important element in many aspects of naval warfare, and efforts are constantly in progress to diminish the element of chance so that rational choices can be made. It seems reasonable, therefore, that in order to conduct more creditable analysis, the use of deterministic models is more appropriate than is the use of stochastic ones. Strike and hit problems require a different approach in naval warfare due to the changing ship dispositions, the makeup of a battle group, changing characteristics of the sea and the weather. There are aircraft to be reckoned with as well as long, medium, and short range missiles, close in weapons systems, EW, etc.. Further complicating the

problem, naval units operate in the air, on the surface, and in the water, each with its unique and differing physical mediums.

2. RSAS as a Solution. RAND Corporation has developed the RAND Strategy Assessment System (RSAS), essentially as an aid to performing net assessment, and modeling national security systems from the level of the National Command Authority (NCA) to the operating forces for both the U.S./NATO and the USSR/Warsaw Pact sides. The RSAS release as of the time of this analysis is 3.0, and is the one that supports the discussion in this paper.

RAND has included two differing NCA models for both the Blue and Red sides to play the political-military aspects at the higher levels, and the equivalent of war plans on the military levels to control the military units simulated. Various options of the war plans are available, and user analysts can write their own if desired, using the relatively easy to understand RAND-ABEL programming language. In developing the RSAS, RAND has given priority to the strategic and central European models, which are the best developed at this stage. Some emphasis has been given to the capability to handle other theaters such as the AFNORTH, AFSOUTH, Southwest Asia, and Korean areas. More recently, RAND has started to expand and improve the naval models. SSBN activity and open ocean ASW were included as part of the earlier strategic effort, and these aspects of naval warfare are being improved. The capability to carry out attacks by and against surface battle groups, SAG's, and with long range shore base strike aircraft, as well as the beginnings of mine warfare, have all been recently added to the system. Amphibious warfare can be played to a very limited degree, but further refinement is required.

The RSAS is impressive. It is complex, but it runs on a relatively simple Sun workstation using the UNIX operating system. The directory structure is both broad and deep, but it has a logical hierarchical organization. The RSAS has default values for standard situations, and sample scenarios that can be run with a minimum of effort. The system is complex, but the ease in using it improves with each new release. As an analytic tool it appears to have great promise. Almost any parameter can be modified to meet analytic needs, if the best assessment output value does not seem to be realistic. The RSAS objects when a gross misassessment is made, such as "airlifting" battle groups, requiring a certain amount of intellectual honesty on the part of the analyst.

As noted above, RAND has recently increased its effort on the naval models, and has cited the following primary issue areas for detailed study: ASW, ASUW, AAW, Mine Warfare,and Amphibious Warfare. With regard to improving naval engagements, RAND has proposed the following areas: Naval Postures, Naval Tasks, Engagements, Naval Strikes, the Naval Commander, and War Plans.

Some of the primary difficulties in the RSAS with regard to modeling navies include command and control, and launching attacks. Currently, there are difficulties in simulating the naval command and control structure, especially for the Red side. There are difficulties also in carrying out attacks from both the Red and Blue sides. One cannot currently direct the carrier battle group to carry out a standard attack against Red surface groups without descending into the minutia of numbers and weapons. Also, a coordinated Red attack is difficult to set up and carry out against a Blue carrier battle group. Some units do not have the proper weapons entered into the data base to conduct attacks of which they are capable. Sensor systems are modeled, but on a very rudimentary basis.

3. <u>Red-side Simulation in Games</u>. Certain key questions on naval warfare have been posed with regard to Red-side war gaming and simulation. While this paper cannot respond fully to these major issues, the applicability of the RSAS to assist in evaluation can be commented upon. With regard to the deployment of Red naval forces in advance of the commencement of the land war battle, the RSAS can be programmed to model runs for the case of predeployment of naval units, and to model runs involving naval deployment simultaneous with the start of the land battle. Assessments can then be made regarding the differing effect upon the overall war. One difference that comes to mind would be the advance warning accruing to the Blue side as a result of Red predeployment, with the resulting advantage in readiness for Blue. With regard to the initial use of tactical nuclear weapons at sea, this can be played out by the RSAS with differing responses by both sides. Once a series of control plans has been written, it is a matter of an hour or two to run out the full global game, or theater if desired, to gain insights into the problems and likely results. There are multipliers in the RSAS which permit allowing for the quality of readiness and training for units to the level played, and for each side. While this aspect of the model is better

developed for the air/land battle, work is in progress to add it to the naval models. Logistics and maintenance are admittedly not thoroughly played in the RSAS. Further refinement is needed, but the RSAS is a strategy system, and not every phase of warfare can be played fully. For naval engagement interactions, the RSAS has several models to simulate detection, attrition, and BDA, generally in an indexed and aggregated way. The outcomes can be changed by modifying various parameters to reflect the judgment of experienced naval officers and defense analysts. Details on these models are included elsewhere in this paper. The RSAS handles the Red concept of combined arms very well for the air/land battle, to a lesser extent for the sea battle. Less clear, as it is in the real world, is the issue of command and control of warfare in the open ocean. RAND has proposed a "naval commander" concept to deal with such issues as when battle groups will engage, when long range air attacks will be made, and how submarines will be controlled in the open ocean. Such models must be as close to the real world as possible for best simulation, and for proper student research and education. The Naval Postgraduate School intends to participate in addressing these issues.

Part II

NAVAL WARFARE

1. Soviet Naval Warfare. The emphasis in Soviet warfare is certainly on combined arms warfare, and one of the primary missions of the Soviet Navy is to support the advance of the ground forces by the several means available to it. It is also true that the Soviet Navy has missions that do not function primarily in support of the ground forces. There is the strategic nuclear mission, which is, of course, part of a combined arms approach to nuclear warfare, but where do open ocean missions fit in? Why are Soviet ships deployed to the Mediterranean, the Indian Ocean, and the South China Sea. Why do submarines and other ships foray out into the open ocean? If we think that the Soviet Navy will fit neatly and solely into the mission of supporting shore forces (aside from the strategic nuclear mission), we are ignoring both the history of Soviet naval operations and current fleet deployments. It certainly appears that there are unique aspects of Soviet naval warfare that require their own separate modeling in gaming and simulation. (For additional analysis on this point, see Captain Jim Amerault's study on the problems involved in modeling US and Soviet naval asymmetries.)

2. The Northern Flank. This paper will not address the air-land battle on the central front, this having been covered in great detail many times over, by other author-analysts, but the naval aspect of the flanks is important to both sides and should be carefully considered. The case in the northern front is of great

interest because of the dangers in yielding control of this important maritime related flank to Soviet control. If the Soviets attain control of Norway, they would have relatively easy access to the North Atlantic and vital NATO shipping lanes. Ocean surveillance and ASW from Iceland would become hazardous and control of the Norwegian Sea would be lost. If the Soviets march through Finnmark down the difficult terrain of northern Norway, or through the Finnish wedge, they can either use the sea flank to their advantage, or face the possibility of being cut off by NATO operations at sea. The RSAS models the northern and southern flanks using a node network concept called the S-Land model that is different than the more massive model of the central front. (Part VI of the Tritten & Channell technical report on the RAND Strategy Assessment System at the Naval Postgraduate School contains an overview of the "Secondary Land and Other Theater Models".) As noted in a recent RAND study by Pat Allen and Barry Wilson, the "Secondary Land Theater Model" gives emphasis to key discrete events and the details of road networks, and relegates the modeling of continuous processes such as attrition in a particular battle zone to a lower visibility level. The emphasis is on the battle in military terms rather than sliding pistons and Lanchester equations. The S-Land model also depends heavily on rules rather than algorithms alone for modeling various decisions and adjudications, attempting to distinguish among different types of battles, and depending heavily on the RAND-ABEL programming language. Norway, Sweden, Finland, and the Baltic Islands (Bornholm and Zealand) are well modeled, Iceland is being developed.

The actual movement of forces is along the LOC's where adjudication is made with respect to the strength of the opposing forces, the type of terrain, and the air situation. Coastal control is also considered in the model. At the nodes, which are important towns, airfields, harbors, etc., adjudication is made dependent upon the opposing ground forces, the air situation, and the issue of coastal control. Amphibious and/or airborne forces can be inserted, with attrition exacted upon landing and, to a certain extent, enroute. Data can be called up which indicates the degree of control and forces remaining, to include some information about the status of naval forces. Unfortunately, there is no real naval warfare going on, other than what can be described as strategic ASW. Carriers can be directed to the area, and their aircraft can be sent to support the shore forces, but there are no NATO amphibious ships, and the concept of an amphibious landing force is difficult to implement. The war at sea beyond the coastal zone, other than the theater support for the Red side, has not yet been implemented. These deficiencies have been recognized, however, and RAND has plans to overcome them in the RSAS. Another problem for the analyst is that the S-Land nodes and arcs are in numbers, not place names, making them cumbersome to use and understand. Real names should be used wherever possible, and command or area abbreviations should be changed to those that are commonly used and understood throughout NATO (e.g., NEUR should be AFNORTH).

The Red northern fleet is currently played as individual units under the Northwestern TVD, which is awkward and should be reworked. The Northern Fleet with its surface, air and submarine forces should have a war plan of its own, operating under the appropriate TVD. Using the present RSAS structure, it is awkward to look for the required naval air and naval infantry, while attempting to sort these out from other air and the frontal forces. In the real world, Soviet naval forces have their own command and control structure; therefore, they should have their own structures in gaming.

3. The Southern Flank. In the Mediterranean, the situation is even more sea oriented, with the Soviet naval forces permanently deployed on a year round basis, and presenting a constant threat to the Sixth Fleet/Striking Force South. The S-Land model for this area is not as well developed as it is for the North, concentrating primarily on Turkey and Greece, although Italy and Yugoslavia are under development. The RSAS naval war in the Mediterranean currently more or less runs on its own, naval engagements are scripted (by direction), or are ordered by a control plan or through the RSAS "force window". If an analyst wants a naval war in AFSOUTH that has a semblance of reality, each side must be told what to do. The war at sea in the Mediterranean requires much more work, and efforts must be made to integrate it with the air/land battle ashore. (RAND and the National Defense University have recently completed a study on AFSOUTH, but more effort is required regarding integrating the land and sea wars.)

4. The Far East. The Far East is a diverse area with its great expanses of ocean, complex naval commands, deployed fleets, and

varied detection and locating capabilities. Here also, the ocean areas modeled in the RSAS are too large, and are not placed properly for naval warfare. Open ocean reconnaissance by Bear aircraft cannot be accomplished, there are no amphibious units, air wing attack is cumbersome, and it is difficult to move MPA about. Basing is not permitted, e.g., in areas where MPA is currently deployed in the real world (Diego Garcia). Realistic naval war plans need to be written for both sides, and the naval forces must be made capable of interfacing with the war ashore, especially in complex situations such as will occur in the ocean areas around Japan and Korea.

5. Naval Models in General. In conducting analysis and games with the RSAS, a high level simulation, the analyst does not want to be forced down into the "grass" and become lost in the details of individual ships and weapons. Instead, broad concepts of task force and fleet operations should be pursued. The RSAS has just recently acquired the capability to conduct warfare at sea, including Blue and Red attacks against opposing battle groups, as well as limited mine warfare, and more realistic ASW scenarios. However, carrier air wings are treated as a series of administrative units (individual squadrons), and not as an operationally integrated group. The RSAS wants to know how many aircraft and specific kinds of weapons for air wing strikes. This information should be built into the RSAS using standard air wing tactics, so that all that is needed is the order to attack, the target, and the general level of the size or intensity of the strike.

With regard to detection and location problems, the RSAS models make some allowances for these problems in conducting attacks against battle groups; however, the factors are rough, and do not permit playing effectively one of the most important aspects of naval warfare. Ground truth, or perfect intelligence, is basically given to both sides. This makes a tremendous difference to the naval battle in which locational information is so vitally important. Work is in progress, at least with the naval models, regarding the availability of information on the opposing forces. This is a complex problem that needs more work - some means must be developed to filter the information.

Another problem is the way that weather is played. While this is understandably an extremely difficult case, it is not really played at all in the RSAS with regard to locating units, conducting strikes, and carrying out operations at sea.

Still another problem is the conduct of ASW operations. The RSAS treats ASW engagements as an expansion of a one-on-one engagement between a Los Angeles SSN vs a C/V/D type. Even the MPA, surface detection, and kill/counter-kill operations are essentially derived from the basic index of a 688 vs a C/V/D. Not only does this present some difficulties in extrapolating the results for a number of surface ships, what happens when there are literally dozens of submarines and/or surface ships in the large sea areas? Fixed detection systems are played to a certain extent, but these need to be refined into more precise capabilities.

One of the basic problems regarding naval modeling in the RSAS is the use of large sea areas. This is not a serious problem in certain restricted areas such as the Barents, or possibly the Norwegian Sea, but the entire northeast Atlantic being treated as one sea area results in gross aggregations that are unrealistic when one considers the action likely to take place there. Even the Mediterranean, which is divided into three areas by the RSAS, ignores the ASW problems presented by the several sea basins, and would have been better divided at least into these basins. The use of large sea areas means that space assets, long range reconnaissance, and fixed surveillance systems cannot be simulated very effectively. There are obviously limits to the amount of locational detail that can be maintained without slowing the RSAS down excessively. Some sort of grid system that would not require precise locations, within some 100 NM or so, and would keep track of group locations rather than individual ships, would seem appropriate.

Part III

RSAS DETAILS

1. Introduction. The Tritten & Channell report on the RSAS at the Naval Postgraduate School contains a summary of earlier versions of the RSAS, and identifies shortfalls in the RSAS maritime structure. Some of these shortfalls have been rectified, but for others, the problem has been identified, and work is in progress or in planning. As noted previously, the RSAS version considered in this paper is release 3.0.

2. The RAND-ABEL Language. RAND-ABEL for those not familiar with it, is a strongly typed procedural language that compiles into "C", and runs on the UNIX operating system. The latest description is in the first revision to The RAND-ABEL Programming Language Reference Manual by N. Z. Shapiro, et al, of the RAND RSAS team. The language was developed by the RSAS analysts for the RSAS when it was realized that there was not a language suitable for RSAS use. Goals for the language included being reasonably understandable by military and civilian defense analysts and gamers who might not necessarily be programmers, rapid in execution, and portable across a range of minicomputers and powerful micro's. Lastly, the language had to support the special requirements of the RSAS, such as co-routines, tabular data, and the creation of complex simulations by groups of developers. RAND-ABEL is a derivative of, and a somewhat simplified version of ROSIE, and runs faster than that earlier language. It should be noted, however, that RAND-ABEL is a pro-

cedural language, and does not have an inference engine. It is very suitable for representing knowledge in the form of "if-then-else" statements, but it does not have the inferencing capabilities of , e.g., LISP, PROLOG, or ROSIE. Since RAND-ABLE is a strongly typed language, properties of identifiers can be tested for statement validity, and many errors can be detected early. Probably the most novel feature of the language is the table statement, which can be used for both defining iterative processes and creating decision tables. Functions or statements can be called several times by each line of the table, and each column can be matched with function parameters or statement variables. The decision table uses conditions in the columns followed by the action to be taken, and will stop the iteration when the conditions are met. The primary advantage of the table is that it is readily understandable by the strategic analysts who should be the primary users of the language.

A sample RAND-ABEL table, this one for decisions is:

```
[comment: anything between the brackets is comment and will not
    be executed.]

Decision Table      [Unique name for table]
    input-          input-      / output-        output-
    variable-A      variable-B  / variable-x     variable-y
    ==========      ==========  / ==========     ==========.
    value-A-1       value-B-1     value-X-1      value-Y-2
    value-A-1       value-B-2     value-X-2      value-Y-3
    value-A-2       value-B-1     value-X-3      value-Y-4
    --              ++            value-X-4      value-Y-5
 [End Table].
```

The decision table reads "if input-variable-A is value-A-1 and input-variable-B is value-B-1 then output-variable-X is value-X-1 and output-variable-Y is value-Y-2". The first row that sets all variables true on the left of "/" sets the values to the right of "/", and the program exits from the table. "--" and "++" are "don't cares", returning "true".

Another notable feature of the language is the "declaration by example". All identifiers are declared by giving examples of their use, usually by an assignment statement that declares a variable, then gives the example. Thus, the identifier can be declared without cluttering up the code with a data type - useful when non-programmers are trying to read the code. The language also has a built-in set of functions to handle coprocesses and a data dictionary for ease in coordinating external data references among the modules being developed by different teams of analysts. This data dictionary describes the contents and attributes of the data set to be used in common by all the RAND-ABEL modules, and in the RSAS is known as the World Situation Data Set (WSDS). The coprocess arrangement allows two or more processes to run independently and asynchronously, and will permit the creation of an hierarchy, such as in a military command structure, as demonstrated by the RSAS decision models. The language also permits easy use of output to log files with simple statements regarding "log" or "print".

Currently, the RAND-ABEL translator is used as an aid in producing syntactically correct rules, and to produce compilable "C" code for incorporation into the executable model. The RSAS also has an interpreter feature. The analytic war plans can be copied into the analyst's interpretive file, modified as desired, run for debugging, and then run as part of the standard events. The RSAS will run these special files instead of the comparable baseline files.

3. <u>System</u> <u>Software</u>. The RSAS system software is complex and evolving. The best current description is contained in a discussion paper prepared by Paul Davis and H. Edward Hall earlier this year. Considerations for the system software design include: Hierarchical agents or players as natural objects/modules; two distinct types of decision modeling - National Command Levels (NCL's) with strategic outlook, and Analytic War Plans (AWP's) as building block scripts for operational commands; wakeup rules for both scheduled and unscheduled action; lookaheads with imperfect information; variable resolution time steps; flexibility; and reproducible as well as understandable results. As noted above, a combination of "C" and RAND-ABEL is used for speed on the one hand, and understanding and analyst accessibility on the other. The principle software entities include the Agents (Force, Red, Blue, Green, Control), and the Data Bases (in "C" and ABEL). Other entities run in the background, and include the system monitor and the tools for analyst communication and analysis.

The control agent is key to the analytic efforts of using the RSAS, and can be used in a number of different modes of varying complexity. Probably the easiest mode is the scenario generator with the user scheduling events using the menus from the data editors, and the control agent passing instructions to the other agents at the appropriate times. More complicated is the actual writing of a control plan in RAND-ABEL similar to an AWP, with its sleeps, moves, wakeups, etc.. This plan is usually interpreted for speed and debugging, permitting the collection of the desired events in one place. Somewhere in between is the

"Order" mode, in which instructions are given to the "force window" for immediate execution.

The various tools that can be called to assist the analyst include the Interpreter for changing RAND-ABEL interactively, the Data Editor for viewing and changing RAND-ABEL variables, the Hierarchy Tool for monitoring and changing control flow, the Cross-referencing Tool for finding definitions and ranges of variables, the Logging Tool for providing variable resolution reports, the Walking Menu Tool for viewing relevant parts of the RAND-ABEL code, the "C" Menu Tool (CMENT) to interface into Force-C (CAMPER), and the Graphics Tool for constructing and displaying various types of charts and graphs.

Currently (Release 3.0), the RSAS has some 150,000 lines each of ABEL and "C" code. The ABEL translates into about 450,000 lines of "C", for a total of around 600,000 lines of "C" code. RSAS operates on C/UNIX systems running Berkeley 4.2 UNIX, and requires 12 MB main memory, 60 MB virtual memory, and total disk size of 280 MB for storage.

There are, of course, problems in the RSAS software. There are some communications problems between the "C" and ABEL programs that degrade performance and require the future development of a "Force-server" approach, planned by RAND for RSAS 4.0. With its extreme flexibility, the RSAS can be enervating, especially to the beginner, because of the many options. Some narrower, tailored modes need to be identified and established as options. Most users will find that there are only certain sets of models of real interest to them, and will probably prefer that the other sets run in background in some sort of default mode acceptable to them. On the other hand, the monolithic Force-C program (CAMPER) limits flexibility in complexity and resolution. Much of the actual military modeling is executed in "C", requiring expertise in "C" (as well as the RSAS) to verify model details and/or to change programs. Most users, however, will probably be satisfied with a straightforward explanation of the algorithms, and the option of using either default variable settings or entering their own values. The RSAS is currently sadly lacking in such algorithm explanations, and the "C" code has not been released. The World Situation Data Set (WSDS) save and read procedures, vital to analysis, appear fragile and need work to make them more robust. Lastly, there are bugs in the models that will only become apparent as they are used in analytic efforts.

4. ASW Models. The only naval model played in some detail in the RSAS is the ASW one, and even that is very highly aggregated. Details are contained in a draft presentation by Dr. John Schrader of RAND concerning RSAS Naval Models, produced earlier this year. As noted above, the basis for ASW is the 688 class vs the C/V/Y/D. A baseline ASW factor is assigned to each ocean region, subregion and chokepoint that represents the number of days it would take a 688 to locate and destroy a C/V/Y/D in that region. The reciprocal of this figure then becomes the baseline daily kill rate, which can be changed by analysts if desired. Each ship type capable of ASW operations is assigned effectiveness and vulnerability parameters in terms of the reference attacker (the 688). Each potential target is assigned vulner-

ability and counterkill effectiveness in terms of the reference target type (C/V/Y/D). ASW task groups have their relative capabilities summed to determine attrition rates for each time period. Similarly, counterkill effectiveness is pooled and attrition distributed based upon individual relative vulnerabilities when more than one target is present. Details of ASW status can be called from the "Force Window" display menu using "asw-stat", and the appropriate sea region or chokepoint.

ASW attrition methodology in its simplified form is to determine initially the adjusted Blue kill rate and the Red counterkill rate for each individual unit. Then each unit is assigned a category, and two adjudications are made for each time period (6 hours), one for blue and one for red. The total killer ASW value is partitioned among the victims, the attrition rate is calculated, assigned and totaled, and adjustments are made for the time step of the adjudication period by the application of a heuristic that tends to kill more vulnerable units and those with more attrition and longer time in area first. Finally, the unit's attrition is calculated :

$$\text{partition\_attrition} * \frac{\text{unit share score}}{\text{total share scores for partition}}$$

Also, if a unit's Ps drops below 0.2, it is further decremented to 0.0, and adjudicated as sunk.

5. Sea Engagement Model. Attacks can be run using Blue carrier battle group air assets against Red groups, and by using Red shore or sea based air/missile assets. The best current description of these engagements is in the RSAS on-line documentation

under Force-C/A/Doc/naval. Attacking forces are characterized as a number of equivalent missiles, while defending forces are equated to the number of long and short range AAW weapons available, together with a calculated saturation level. Defensive weapons are aggregated for the force/group, and AAW capabilities are not reduced until units are actually adjudicated as sunk. The model has a limited capability to account for surveillance - onboard if air assets are present, offboard for queries to the space model for support. Initially, the entry price is determined using a table that takes into account factors such as the long range AAW weapons, size of the attack, and a number of other setable parameters. This entry price is subtracted from the number of attacking weapons, and the remainder of the weapons are engaged, up to the defender's saturation level. A fraction of the attacking weapons is killed first by the long range AAW weapons, then by the short range weapons, based upon setable parameters. The survivors plus those weapons above the saturation level are then distributed uniformly over the units of the attacked force/group, and the hit capacity for each unit is reduced accordingly. When hit capacity reaches 0, the ship is adjudicated as sunk. For nuclear weapons, every hit sinks a ship, with the flagship the last to be lost, although this may not be entirely realistic.

The entry price is calculated as follows:

ATTACK SIZE	LONG-RANGE AAW			
	<aaw_min	aaw_min	<aaw_max	>=aaw_max
<=small_attack	0	entry_min	entry_min	entry_min
> small_attack	0	entry_min	interpolated (linear)	entry_max

If the attacking force is made up of aircraft, the model determines the number of aircraft kills made prior to weapons release. This is a function of the surveillance level for both sides, and is determined by a matrix which gives maximum aircraft kills when the defender has the surveillance advantage, and minimum kills when the attacker has the surveillance advantage. The fraction of kills is determined as follows:

Defense Surveillance	Attack Surveillance 0	1	2	3
0	0.3	0.0	0.0	0.0
1	0.5	0.2	0.0	0.0
2	1.0	0.9	0.7	0.2
3	1.0	0.9	0.7	0.5

Surveillance: 0 = none, 1 = onboard only, 2 = offboard only, 3 = both.

Most of the parameters in the naval models can be changed by entering various tables in CAMPER or the file vessel.sec, not a trivial task. Examples include: "vessel" parameter table, "class" parameter table, and the "sea" parameter table. Damage levels on ships that have not been sunk can be changed, the hit capacity of ships can be changed, entry price and saturation level can be changed for force/groups. Naval forces can be displayed in several differing ways from the force window: by nation, force/group, by region, by offensive and defensive assets, and by rules of engagement for each side.

There are, of course, several problems with regard to the sea engagements. (These were discussed in some detail by Dr. Bruce Bennett of RAND in a paper presented earlier this year.) Ship/submarine performance is not degraded until it is sunk -

there currently is no graceful derogation of capability until the unit is lost, and this is not very realistic. There should be as a minimum a linear degradation, and in some cases a geometric or other degradation factor. Also, attacks against one group are not distributed against other groups even though they might be operating together. A simple command and control fix should be feasible here to spread the damage around.

Attacking missiles are spread evenly over all the units in the attacked force/group, rather ignoring targeting information, EW on both sides, cover and deception, etc.. A simple methodology taking into account these factors, and using a matrix and calculation to determine if the attacking weapons would "bunch" on the key targets would seem appropriate. In addition, a factor needs to be entered to take into account the differing capabilities of various weapons - not now considered by the model.

For AAW, short range weapons cover the whole force/group and do not have their own saturation threshold. A change is needed to reflect that short range weapons protect own unit only, and that they have their own saturation level.

6. Naval Command and Control. Naval action can be started currently by including such action as part of an Analytic War Plan (AWP), by issuing Force orders via the Force Window, or, in some cases, by changing the ROE's. (Combat will not occur, e.g., if both forces are in a "defend" status.) Naval war plans need to be developed and either incorporated into an AWP, made part of the default naval models with parameters that can be modified, or made interactive in the case of major naval decisions (initial

engagements, nuclear use, etc.). RAND has proposed five naval postures, an encounter matrix, some search algorithms, and some trail routines. Once the opposing groups have a "find", and the ROE's are appropriate, then an engagement will be likely. Key factors will be which side is the finder, and the maximum weapons range. Previously, orders were required for an attack to be conducted, but it would seem that such an attack should be started, pursued, and broken off based upon some heuristics such as initial salvo size, weapons range, acceptable loss limits, and key weapons load-out.

RAND has also proposed the "naval commander" model which will receive contact reports, review assets, decide when to launch a strike, set a wake-up, and then issue appropriate orders at that time.

RAND has also proposed to use a regional radius concept to determine which units can participate in an attack. This, of course, requires making some aggregation assumptions about regions, steaming times, flight times, etc., but appears useful as a first cut attempt. It is better than the current "everyone is in the regional centroid" concept.

7. <u>Additional Requirements</u>. The Tritten & Channell Technical Report on the RSAS at the Naval Postgraduate School identified the improvements needed to meet NPS and Navy requirements, and this remains the best overall statement of Navy needs. Much has been accomplished in the past year, much remains to be done. The important naval requirements in addition to those in the Tritten & Channell report are:

The major contribution to both sides from locational systems that are not integral to the afloat forces needs to be refined and improved. While there are classification problems in this regard, some means of aggregation should be established.

Convoy operations, including losses from mines, submarines, air attack, and the resulting derogation of throughput need to be addressed for a realistic long term war, and as part of the overall sealift and logistics flow.

Improvements in mine warfare and amphibious warfare are needed, as these are currently played in only a very limited form.

The area and command names need to be checked and changed to reflect current customary usage on the part of military officers.

A continuing effort will be required to maintain databases, perhaps one of the most difficult problems of all. While updates have been made in certain areas, the current default database is 1985, which is rapidly becoming dated. Without a good, reasonably current database, analysts and other users of the RSAS will loose faith in the system and turn to other programs.

The major naval problem areas are summarized in Part IV below.

Part IV

CONCLUSIONS/RECOMMENDATIONS

1. Improvements. The RSAS is a growing and evolving system that will assist analysts and instructors in conducting strategic assessments and analyses. The models in the system that address the air-land war on the central front, most of the strategic models, and parts of the S-Land models are better developed than those that deal with naval warfare, logistics, command and control, and intelligence. RAND has recognized most of the problem areas, and has plans to improve them.

2. Advantages. The Red side is, or certainly can be, played in accordance with perceived Red strategy. The asymmetries that exist in Red and Blue naval thinking, employment of forces, readiness, and training can be represented readily in the RSAS. Perhaps best of all, a range of options for both sides can be developed and studied in the RSAS in reasonable amounts of time, and at reasonable costs.

3. ASW Detection. The ASW model does not treat adequately the detection capabilities (or lack thereof) for the various ocean areas. This can probably best be done by assigning a detection factor for each area based upon experienced judgment regarding fixed and/or other non-integral system capabilities for the area. It should be recalled that individual units have little likelihood of detection success if not assisted by some of the more broad area search assets.

4. ASW Ocean Areas. The ASW model needs to take into account the sea basin problem for selected sea regions, where search and detection capabilities differ according to season, weather, shipping traffic, etc.. The Mediterranean and the North Atlantic/ Norwegian Sea areas could be used as pilot models for development. Other areas outside the primary operating/engagement areas could probably be aggregated at this stage in RSAS development.

5. Battle Group Operations. Individual ships, as such, are not as important following their assignment to battle groups. It might be easier and require less system resource time if the emphasis were on aggregate battle groups rather than on individual ships. Submarines, due to the nature of their operations, probably should still be modeled as individual units. Something is lacking also in equating MPA to SSN's.

6. Air Wing Strikes. The generation of carrier air wing strikes is too complex. There should be a default mode which considers the nature of the attacked force/group, and which simulates standard air wing tactics to conduct the strike. This type of simulation should be adequate for the level of the RSAS.

7. Ship Locations. Something needs to be done about the locational data on naval units. The system does not actually know where ships are located beyond the centroid of the sea region, unless the unit is in a well defined chokepoint. This may be adequate for small ocean areas, but larger ones such as the eastern Atlantic need refinement. Perhaps a compromise solution such as using lat/long for high intensity areas such as the

western Pacific, the north Atlantic, and the Mediterranean would be appropriate.

8. Intelligence. With regard to detection and location problems, the RSAS models make some allowances; however, the factors are rough, and do not permit playing effectively an important aspect of naval warfare. Ground truth, or perfect intelligence, is basically given to both sides. Work is in progress, at least with the naval models, regarding the availability of information on the opposing forces. This is a complex problem that needs more work - some means must be developed to filter the information.

9. Convoy Operations. Convoy operations need to be modeled in some detail, to include losses from mines, air and submarine attacks. The resulting derogation in the throughput of personnel and material should be considered as part of the resupply of the air-land battle ashore.

10. Amphibious Warfare. Amphibious warfare needs to be played from a true amphibious point of view, rather than as a simple reinforcement unit to the land battle. Amphibious ships are not in the current naval model and need to be added, in aggregate as a minimum, in terms of an amphibious force/group. A grouping of amphibious shipping and embarked Marine forces with mobility, defense, and damage factors should be sufficient.

11. Mine Warfare. The mining capability needs to be improved. The current model of mining and clearing without regard to assets should be addressed.

12. Analyst Use. The RSAS is far too complex for most users, who will probably be interested in the details of only certain portions of the entire system, and would prefer that the other parts run in an acceptable default mode. Efforts should be made to apply reasonable defaults to all variables, to expand the explanations for key algorithms, and to develop additional default scenarios.

13. Database Upkeep. Database upkeep is an important issue. Information must be kept up-to-date or users will loose confidence in the output, and will discard the RSAS as a valuable tool. In addition the database entries, for the naval portion at least, must be derived from the best all-source information available on the Red side, and the most reliable data available on the Blue and Green sides. Data base responsibilities must be clearly delineated.

14. RSAS Strengths. On balance, however, the RSAS does very well at moving large numbers of units around and conducting engagement assessments for multiple battles. Many of the deficiencies in the naval models have been overcome, and most of those remaining are being addressed. Even now we have a system that can model Red and Blue land, sea, and air forces on a global scale, using a relatively inexpensive workstation, and software that executes rapidly.

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