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Adapting the RAND Strategy Assessment System to Force Assessment Studies in the Joint Staff

Robert D. Howe, David A. Shlapak, Carl M. Jones

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A Report from
The RAND Strategy Assessment Center

RAND | NATIONAL DEFENSE RESEARCH INSTITUTE

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Prepared for the
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RAND

PREFACE

This report documents the results of an effort undertaken on behalf of the Capabilities Assessment Division (CAD) of the Joint Staff. The purpose of the project was twofold: First, to demonstrate that the operations and output of the RAND Strategy Assessment System (RSAS) could be calibrated to that of other models and games currently employed by CAD; second, to allow CAD to evaluate the utility of the RSAS for their purposes.

This report outlines what was done in this effort, how it was done, and the degree to which the results were acceptable to CAD. Because of the sensitivity of the information used by CAD, however, it does not present the data used in the study, the results of system runs, or the specific parameter values that were used for calibration.

The study should be of interest to users or potential users of the RSAS who may find it necessary to retune the various combat models or revise large parts of the system's database. It is assumed that such readers will have at least some familiarity with the structure, operation, and terminology of the RSAS.

The work described in this report was sponsored by the Joint Staff and was conducted by the RAND Strategy Assessment Center (RSAC) under a project entitled "RSAS Applications in the Joint Staff Total Force Capabilities Assessment Process." The research documented was conducted in 1988 and 1989. The RSAC is part of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Staff.

SUMMARY

The Capabilities Assessment Division (CAD) of J-8 (Force Structure Resource and Assessment Directorate) in the Joint Staff has long been a participant in the development of the RAND Strategy Assessment System (RSAS). In December 1987, CAD decided that the RSAS had reached sufficient maturity to justify a formal evaluation of its capability to serve the Division's needs. A team of RAND analysts was asked to emulate the 1988 Total Force Capability Assessment (TFCA) and calibrate the RSAS to the outputs of then-current CAD models. Items of particular interest included the value of the RSAS in developing the TFCA Study Plan, its capability to conduct TFCA excursions, and its potential use to support non-TFCA analyses.

The RSAS was not used directly in the 1988 TFCA evaluation. Instead, the RSAS was run in parallel with the main TFCA game to evaluate its ability to replicate force employment decisions made by the TFCA gamers and the results obtained from CAD's simulation models. The RSAS databases were modified to match those used in the TFCA, applying the force deployments and employments the TFCA gamers had decided on and comparing the RSAS results with those of the extant CAD models. Precise matching was not expected because there are considerable differences in the level of detail and the adjudication techniques used in the various models. It was further expected that there would be some adjustments necessary to the myriad parameters of the RSAS since its outputs had not previously been compared in detail with those of another model.

No attempt was made to develop specific quantitative criteria against which to measure the RSAS "match" with CAD's models (e.g., we did not try to tune the RSAS until its outputs were within some predetermined percentage of their ground-combat model). Likewise, no a priori determinations were made as to what parameters or adjudication routines within the RSAS would be adjusted to accomplish the calibration, since in most cases there were multiple possibilities. The ease with which a part of the RSAS could be calibrated varied considerably with the length of time that the particular component had been in use and the degree to which it had previously been exercised. Hence, ground combat in the main theaters was quite easy to adjust, but it was impossible to compare results for naval surface en-

gagements because that part of the RSAS had not been fully implemented at the time of the study.

The RSAS was also used to support the 1988 planning force evaluation. Rather than attempt to match another model's results, this work involved using the RSAS to generate multi-theater combat outputs according to a written scenario; the RSAS was the principal tool used in conducting this assessment.

Database preparation proved to be straightforward but very time consuming because of format differences between the RSAS and CAD systems and the different structures of their databases. All air and naval forces data were input by hand, since the structure of squadrons and naval task groups is fairly standard, making it easy to develop templates that can be used over and over again. Ground forces input was partially automated.

Inter- and intra-theater movement is modeled in a similar manner by the different models involved, so calibrating the RSAS to cause forces to arrive in theater at approximately the time estimated by the other models was not difficult. Moreover, the RSAS offers an option of bypassing the strategic mobility model entirely and simply having forces arrive at a place and time specified. This option was tested and can readily match another strategic mobility model; indeed, given the specific differences in methodology between CAD's mobility model and that in the RSAS, it was the only way in which matching outputs could be *guaranteed*.

The RSAS uses a model called CAMPAIGN-MT to simulate air and ground combat in Central Europe and Korea. Once the geographic databases were matched, very little parametric adjustment was necessary to calibrate the movement of the forward line of own troops (FLOT) during combat in these theaters. The RSAS calculates this movement by determining a basic movement rate as a function of an effective force ratio, then adjusting that rate by a movement factor for the specific geographic zone in which combat is occurring. These zonal multipliers are pre-defined in the RSAS terrain database. Thus, FLOT movement can be tuned either by modifying the basic movement rate determined by the on-FLOT force ratio or by adjusting the terrain movement factors.

Precise tuning of ground attrition was not attempted because of the differences in the attrition processes between CAMPAIGN-MT and CAD's current model. Actual losses and reductions in unit effectiveness were fairly close between the two systems, however, so long as the RSAS treatment of breakthrough operations was turned off.[1] This modeling of breakthroughs is important in some applications.

Tuning of the air battle proved to be straightforward but time consuming because of the large numbers of parameters that affect losses inflicted on aircraft performing various missions. An excellent match was obtained between the two models with the exception of losses of aircraft on the ground, which in release 3.1 of the RSAS could not be properly adjusted. Analyst intervention was necessary to handle this problem.

Outside of Central Europe and Korea, the RSAS employs CAMPAIGN-ALT, a modeling methodology different from CAMPAIGN-MT although based upon many of the same algorithms. The TFCA emphasized theaters that in the RSAS are modeled using CAMPAIGN-MT; therefore, the CAMPAIGN-ALT models were not heavily exercised. In the planning force exercise, which involved different forces and a different scenario, a CAMPAIGN-ALT model was more extensively used. The results of this exercise indicate that, for CAD purposes, CAMPAIGN-ALT is a suitable platform for assessing theater-level outcomes in peripheral theaters.

The RSAS offers several ways for a user to control the deployment and use of armed forces. First of all, the system includes packages of analytic war plans (AWPs) for each theater. AWPs are the RSAS representation of adaptive theater-level operational war plans; written in RAND-ABEL®, they are both human- and machine-readable. Also, the RSAS offers an interpretive feature that allows the user to change the content of an AWP or other RAND-ABEL program "on the fly." The interpreter should not be employed to alter the basic timing or control flow of a plan; it is most useful when the changes to be made are fairly straightforward and affect the logical or substantive content of a plan.

The RSAS also provides a means of constructing what are, in effect, *ad hoc* AWPs, called *analyst plans*. Unlike an AWP, a typical analyst plan is simple and linear, stepping through a sequence of numbered moves with little adaptive logic. Generally, two analyst plans are required, one each to control Red and Blue forces. There are no analogs to either AWPs or analyst plans in other available models. They represent a major simulation innovation.[2]

We believe that the RSAS has demonstrated its value to CAD for conducting many of the assessments for which that division is

[1] Standard CAD models do not incorporate this phenomenon.

[2] See Davis (1988).

responsible. The combination of AWPs and analyst plans employed in this work proved quite flexible and robust in controlling and modifying scenario details during the course of the assessments. The CAMPAIGN-MT ground and air combat models appear to be suitable for CAD's purposes, as does CAMPAIGN-ALT.

The most pronounced shortcoming of the RSAS from CAD's perspective is the underdeveloped state of the naval models. There has been insufficient testing done to determine whether improvements in the current-generation RSAS naval models have adequately addressed these problems.

Also, this work resulted in several improvements being made to the baseline RSAS system, including changes to graphics software, force data, and air warfare modeling.

ACKNOWLEDGMENTS

The cooperation of the entire Capabilities Assessment Division was essential to the completion of this project; the authors would like to expressly thank Lieutenant Commander E. Payne Kilbourn, USN, for his patience and assistance.

RAND colleagues Bruce Bennett, Mark Hoyer, and Kevin Underriner rendered invaluable assistance in manipulating the databases and installing and maintaining the RSAS and associated hardware, while Dan Fox and Richard Wise provided insightful reviews of an earlier version of this report.

The authors are solely responsible for any errors that remain.

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I. INTRODUCTION

OBJECTIVES

This report describes the results of a project in which the RAND Strategy Assessment System was employed in support of two planning exercises within the Joint Staff. It is concerned primarily with

- Documenting the procedural lessons learned from utilizing the RSAS outside of the laboratory environment in which it was developed and most of its previous applications conducted; and
- Reporting preliminary conclusions about RSAS usefulness for conventional force analyses within J-8 (Force Structure Resource and Assessment Directorate).

The report contains instructions for accomplishing many of the tasks that the authors found difficult or confusing, as many of the same operations may prove important to other users as well.

Because of security considerations, most of the details of the assessments undertaken—including input data, scenario specifics, and model results—are restricted for Joint Staff use only. This report will therefore not describe the substantive content of the work.

PREREQUISITES FOR UNDERSTANDING THIS REPORT

This document is *not* a primer on using or adapting the RSAS, and it assumes that the reader is at least somewhat familiar with the system. Specifically, the reader should have some grasp of:

- RSAS Architecture—the names and basic functions of the major components of the RSAS (the force models CAMPAIGN-MT and CAMPAIGN-ALT, Green Agent, the Red and Blue Agents, and the World Situation Data Set (WSDS)); and
- The RSAS Computing Environment—the basics of the UNIX[1] operating system as implemented by SUN Microsystems for their workstation computer systems.

[1] UNIX is a trademark of Bell Laboratories.

A list of RAND publications describing the RSAS is included in the Bibliography. Additional documentation is available to official RSAS users.

STRUCTURE OF THE REPORT

Section II discusses the TFCA process and the principal models used by CAD in conducting it; it also contains a brief description of the RSAS. Section III discusses the use of the RSAS in reproducing TFCA results and conducting the planning force evaluation; it explains the principal ways in which the system was modified to suit the needs of the project. Section IV then describes how to compare the results of the RSAS CAMPAIGN-MT model with those generated by another theater simulation, and Sec. V comments on the usefulness of the RSAS to the Joint Staff. It also describes some changes that were made in the system to improve that utility.

Appendix A lists and discusses many of the user-changeable parameters in the CAMPAIGN-MT combat models, and Appendix B discusses how to go about creating a new analytic war plan (AWP).

II. CAD, THE TFCA, AND THE RSAS

THE CAPABILITIES ASSESSMENT DIVISION

The Capabilities Assessment Division of J-8 in the Joint Staff is responsible for conducting analyses of the capabilities of U.S. and allied conventional forces on behalf of the Joint Chiefs of Staff. To accomplish this mission, CAD uses a variety of analytic tools including war games and simulations. CAD has long been a participant in the development of the RAND Strategy Assessment System with a view toward eventually adopting the RSAS as a global modeling methodology.[1]

By December 1987, CAD decided that the RSAS was reaching sufficient maturity to justify a first application along with a more formal evaluation of its ability to serve the Division's needs. Accordingly, a RAND project was undertaken under the terms of which a team of RAND analysts would operate the RSAS on a SUN workstation in the CAD offices within the Pentagon; the intent was to emulate the Total Force Capability Assessment (TFCA) to be conducted in 1988. The RSAS would be calibrated to the output of the current CAD models and games, then tested in excursions to determine its utility to CAD. Items of particular interest were the value of the RSAS in developing the TFCA Study Plan, its capabilities to conduct TFCA excursions, and its potential to support CAD's non-TFCA analyses.

This project was also the first application of the RSAS to an analytic effort in an environment different from the RAND system in which it was developed. The project was expected to provide feedback regarding RSAS behavior in a "real-world" setting and to identify RSAS improvements that would enhance its utility to non-RAND users.

THE TFCA PROCESS

The TFCA is an annual effort in which CAD conducts detailed wargaming to evaluate the capabilities of U.S. and allied forces against a specified global threat within a particular scenario. It usually exam-

[1]A first, experimental effort in exploring the applicability of the RSAS to Joint Staff tasks was made in 1986 under William Schwabe's leadership.

ines near-term and future force structures and threats. The TFCA assessment itself takes the form of a computer-assisted war game in which representatives of the services, intelligence agencies, and the Commanders in Chief (CINCs) make force deployment and employment decisions, the results of which CAD evaluates using computer-based simulations. The process is cyclic and iterative, and a full war game takes many weeks to complete.

MODELS EMPLOYED BY CAD FOR THE TFCA

CAD utilizes several different models to support the TFCA games. For the 1988 assessment, a Joint Staff variant of the Tactical Warfare Model (TACWAR) simulated land warfare and air warfare over land, and the Naval Model (NAVMOD) modeled war at sea.

The Institute for Defense Analysis (IDA) developed TACWAR in 1977; various users employ it.[2] It is a fully automated theater-level combat simulation. TACWAR is designed to evaluate the relative effectiveness of opposing combat forces in an environment that may include chemical and nuclear weapons as well as conventional munitions.

The TACWAR user develops the geographic structure for the theater being modeled; this structure can be modified to allow for multiple theaters or multiple simulations in the same theater. The numbers of weapon types, unit types, aircraft types, and units are adjustable as well.

TACWAR operates in 12-hour increments; the user specifies the duration of a run. Commitment and withdrawal of forces to and from contact are handled directly by the user, as TACWAR incorporates no operational-level decision logic to control such actions.

FLOT movement is determined by force ratios and lookup tables, while attrition is derived from a potential/anti-potential process and is a function of the allocation of fire and effectiveness inputs. Attrition to each category of weapon is explicitly calculated. TACWAR's outputs are primarily in the form of summary tables, although graphic output may be generated with a postprocessor.

NAVMOD was also developed by IDA specifically for Joint Staff use.[3] It is an aggregated, deterministic, and fully automated simula-

[2] A more complete description of TACWAR is available in Institute for Defense Analysis, *The Tactical Warfare Model*, IDA Report R-211, Vols. I & II, Arlington, 1975; and Vol. III, Arlington, 1979.

[3] More complete descriptions of NAVMOD are available in Institute for Defense Analyses, *NAVMOD: A Naval Warfare Model*, IDA R-278, Arlington, 1985.

tion of naval combat capable of depicting the mutual interactions of land-based air and naval forces as well as ship-to-ship combat.

To use NAVMOD, an ocean or sea region is first divided into six separate subregions. All ships of a given side in a given area are represented as a single task force, which can move from area to area. Red forces can be in any of five areas, with the sixth set aside as a Blue "sanctuary," and Red submarines can form barriers between regions. User input controls Blue's movements between areas, while Red is governed by a set of automated tactical decision rules. Effectiveness parameters for various weapons are set by area and hence may change as forces move from subregion to subregion.

Combat in NAVMOD consists of a "D-day shootout" followed by repeated cycles through other combat interactions. The full spectrum of possible interactions among air, surface, and submarine forces is simulated. After each cycle of combat activities, movement occurs, with the possibility of further combat between the Blue task force and Red barrier submarines. This process continues until either the user-specified duration of the simulation elapses or one side has no effective forces left in the region.

RSAS

The RSAS is a game-structured analytic system for conducting multi-scenario analysis of single and multi-theater conflict. The principal components of the system include rule-based decision models and combat simulation models. The RSAS depicts conventional and nuclear combat, including central nuclear war.

There are two theater-warfare methodologies employed within the RSAS. For NATO's Center Region and Korea, the model CAMPAIGN-MT is used.[4] CAMPAIGN-MT uses a grid system of geography encompassing a fixed number of parallel axes. CAMPAIGN-ALT is used for all other land theaters and is based upon a system of links and nodes that combine to form a network-like theater representation.[5]

Forces are represented at the same levels of aggregation in both CAMPAIGN-MT and CAMPAIGN-ALT. Ground forces are carried at the division and brigade levels, with weapons holdings for each di-

[4]CAMPAIGN-MT is documented Bennett et al. (1988).

[5]CAMPAIGN-ALT is described in Allen and Wilson (1987).

vided into eight classes.[6] The effectiveness of a ground force unit depends upon its surviving weapons and a series of other factors reflecting, for example, training time, unit cohesion, and national fighting effectiveness. All of these factors can be readily adjusted by the analyst.

Air forces are aggregated as squadrons (or regiments for Red), with aircraft distinguished by type. Naval forces are carried as individual, named ships but fight as task forces.

Combat adjudication in both CAMPAIGN-MT and CAMPAIGN-ALT includes air-to-ground, air-to-air, ground-to-air, and ground-to-ground actions. Ground combat attrition is calculated using lookup tables as a function of force ratios, as is FLOT movement; both are adjusted to reflect geography, air power, defender density, battle type, mission orders, and other variables.

The RSAS does not currently use anything like a potential/anti-potential method, but combat adjudication is more sophisticated than a simple force-ratio calculation using WEI/WUVS.[7] For example, helicopters are treated as aircraft, scores are adjusted dynamically, and there are special rules to mitigate the most important defects of simpler aggregated techniques.

The RSAS routinely produces both tabular and graphic output. Both kinds of displays are available interactively and for post-run analysis.

THE RSAS IN THE TFCA PROCESS

The RSAS was not used directly in the 1988 TFCA evaluation. Instead, it was run in parallel with the main TFCA game to evaluate its ability to replicate the results obtained from CAD's other models. This was done by modifying the RSAS's databases to match those used in the TFCA, applying the force deployments and employments decided upon by the TFCA gamers, and comparing the RSAS results with those of the extant CAD models. Precise matching was not expected since there are considerable differences in the level of detail and the adjudication techniques used in the various models. It was further expected that adjustments would be necessary to the myriad

[6]Tanks, infantry fighting vehicles (IFVs), armored personnel carriers (APCs), mortars, artillery, small arms, attack helicopters, and air defense systems.

[7]Weapons Effectiveness Indices/Weighted Unit Values are a method of measuring ground combat potential. For a complete description, see U.S. Army Concepts Analysis Agency, *Weapon Effectiveness Indices/Weighted Unit Values (WEI/WUV)*, Vol. I, Bethesda, Maryland, 1974.

parameters of the RSAS since its outputs had not previously been compared in detail with those of another model.

For some uses, the greater degree of resolution offered by the models currently employed by CAD is important; however, we believe the RSAS models represent substantial improvements over them.

For example, both CAMPAIGN-MT and CAMPAIGN-ALT incorporate representations of *attacker breakthroughs*. A breakthrough occurs when a defender, having been ordered to hold ground, reaches a density insufficient to allow him to cover a sector adequately. At this point, the defense fails catastrophically and very rapid attacker movement ensues. This feature can readily be turned off if the purpose is to match the RSAS results to those of another model; we did in fact switch it off for the CAD exercise documented here. In other work, however, RAND has noted the importance of representing this breakthrough phenomenon.

No attempt was made to develop specific quantitative criteria against which to measure the RSAS's "match" with CAD's models (e.g., we did not try to tune the RSAS until its outputs were within some predetermined percentage of TACWAR). Likewise, no a priori determinations were made as to what parameters or adjudication routines within the RSAS would be adjusted to accomplish the calibration, since in most cases there were multiple possibilities. Not surprisingly, the ease with which a part of the RSAS could be calibrated varied greatly with the length of time the particular component had been in use and the degree to which it had previously been exercised. Hence, ground combat in the main theaters was quite easy to adjust, but it proved impossible to compare results for naval surface engagements because that part of the RSAS had not yet been fully implemented at the time of the study.

TACWAR's behavior is broadly similar to that of the RSAS in many respects. The differences between the two arise primarily from variation in data (representation of forces and terrain, etc.) and parametric values.

The RSAS combat models are distinctly different in two areas however. First, both CAMPAIGN-MT and CAMPAIGN-ALT contain some treatment of certain maneuver phenomena, such as breakthroughs and, to some extent, encirclement. Also, using baseline parameter settings, the RSAS ground combat models permit substantial slowing of FLOT movement to be achieved through the defender's use of heavy concentrations of close air support (CAS) and battlefield air interdiction (BAI). For purposes of this study, these unique structural features were suppressed, since it was clear a priori that their use would prevent calibration.

III. USING THE RSAS TO SUPPORT THE TFCA

METHODOLOGY

The purpose of this project was not to provide a comparison of the models involved for purposes of choosing between them but rather to establish how well the RSAS could replicate the existing models. Hence, there was no consideration of modifying either TACWAR or NAVMOD. All modifications for comparability were made in the RSAS.

Initial comparison of the models established that other features of the RSAS besides its breakthrough representation would have to be turned off to allow for the desired calibration. Chief among these were the decision models for commitment and withdrawal of ground forces and for the allocation of ground support air sorties; these decisions are made by human game inputs in TFCA.

Although terrain representation in the two models is similar, TACWAR allows for a variable number of sectors, whereas the RSAS terrain data in the Central Region model are fixed at a maximum of 10 axes. Terrain data could thus not be precisely matched between the two models. Approximations were developed initially, but the adjustment of the terrain effect on combat outcomes and FLOT movement was of necessity a trial and error process during the calibration.

The attrition processes of the models differ substantially in that TACWAR calculates losses of specific weapons, whereas the RSAS calculates losses in equivalent divisions and then disaggregates this attrition across individual items of equipment. It was quickly evident that comparison of attrition at the equipment level was not practical. However, both models employ a concept of unit capability called *effectiveness* in TACWAR and *cohesion* in the RSAS. Although calculated in somewhat different ways, these measures are used to determine when a unit can be committed to battle and when it must be withdrawn. Attrition matching was therefore oriented toward keeping these two terms comparable. Given the different time steps of the models,[1] we believed that if a unit reached the withdrawal level on the same day in both, attrition had been adequately matched.

[1] Twelve hours in TACWAR, four hours in CAMPAIGN-MT.

Both CAD models deal with aircraft by specific type, such as the F-16C, whereas the RSAS apportions and allocates sorties by type, such as "multi," and per sortie attrition is then allocated across all aircraft performing that mission during that time. Therefore, aircraft attrition comparison and adjustment was made at the more generic RSAS level without attempting to match the results by specific aircraft type. As mentioned below, matching even in this way required some direct analyst intervention at a few points, as some parametric limitations in RSAS 3.1 precluded adequate tuning.

Strategic mobility data used in the TFCA are provided from models with far greater resolution than that of their RSAS counterpart. RSAS tuning parameters make it fairly easy to bring force arrivals in theater in line with the data provided, but as there were no data regarding arrivals under alternative assumptions there could be no determination as to whether the RSAS could replicate the more detailed model. We frequently chose to script arrivals in the RSAS rather than adjust the strategic mobility parameters.

DATABASES

Database preparation proved to be straightforward but very time consuming because of format differences between the RSAS and CAD systems and the different structures of their databases. All air and naval forces data were input by hand since the structure of squadrons and naval task groups is fairly standard, making it easy to develop templates that could be used over and over again.

Although both the RSAS and TACWAR use air force data aggregated at the squadron level, TACWAR squadrons can be composed of multiple aircraft types, while the RSAS allows only one type per squadron. Hence, in a few cases it was necessary to create dummy squadrons in the RSAS to represent units that in TACWAR were composed of multiple aircraft types.

The RSAS and NAVMOD both represent naval forces at the same level. The major problem encountered in matching the two naval databases, then, was ensuring that the mix of ship classes within battle groups was the same in the two databases. There were some difficulties in adding new task groups to the database; their correction is documented in Sec. IV.

Land force units vary widely in both the quality and quantity of equipment held; also, the large number of small units depicted in the source data necessitated considerable aggregation to make them compatible with the RSAS. Automated tools were developed for the more onerous tasks of aggregating forces and calculating the value of weapons holdings. These routines were provided to J-8/CAD but would have limited utility for other RSAS users, since they function only to convert data from one specific format to another.

The RSAS land force database carries eight classes of weapons for ground forces; raw data used to create this file can use any number of classes, with the RSAS database input processor aggregating them as needed. The differences in represented weapon types between TACWAR and the RSAS were not a large problem. However, the RSAS refers to ground force units by name, and TACWAR identifies them numerically; ensuring comparability between the two presented greater difficulty.[2]

STRATEGIC MOBILITY

Inter- and intra-theater movement is modeled in a similar manner by the different models involved, so calibrating the RSAS to cause forces to arrive in theater at approximately the time estimated by the other models was not difficult. Moreover, the RSAS offers an option of bypassing the strategic mobility model entirely and simply having forces arrive at a place and time specified. This option was tested and can readily match another strategic mobility model; indeed it is the only way to guarantee such a match. However, this method is entirely dependent on the analyst to adjust for assumed changes in lift assets and availability, and to account for enroute attrition.

For example, in the RSAS the order

```
script force deploy 1-MECH/3-BDE CEur-8 33.5
```

would cause the 3d brigade of the U.S. First Infantry Division (Mechanized) to appear on axis CEur-8 (U.S. VII Corps in the model) at noon on day 33 of the simulation. This deployment would occur without reference to the availability or absence of adequate lift assets.

MAIN THEATER MODEL

As noted earlier, the RSAS uses two different modeling approaches for theater warfare. CAMPAIGN-MT is a fairly high resolution model

[2]For further information on the structure and composition of the RSAS forces data base, see CACI Products Company, *RSAS Data Base Preparation Manual Version 3.5*, Arlington, August 1989.

written in the C programming language and is currently applied only to the Center Region of NATO and Korea. Other theaters are represented using the CAMPAIGN-ALT methodology, which is somewhat less complex and, because it is written in the RAND-ABEL® language, more transparent than CAMPAIGN-MT. The following discussion applies to CAMPAIGN-MT.

Once the geographic databases were matched, very little parametric adjustment was necessary to calibrate the movement of the FLOT during combat in these theaters.[3] The RSAS calculates this movement independently for each axis by determining a basic movement rate as a function of an effective frontal force ratio, then adjusting that rate by a movement factor for the specific geographic zone in which combat is occurring, as well as for factors related to defender density and the slowing effects of heavy defender air support.[4] The zonal multipliers are pre-defined in the RSAS terrain database. Thus, FLOT movement can be tuned by either modifying the basic movement rate determined by the on-FLOT force ratio or adjusting the terrain movement factors. The latter method proved to be far simpler and was the technique used.

Table 1 shows an example of terrain data for an RSAS zone in the Central European theater. Zone 10.06 is in Austria and begins 100 km west of the Austro-Czechoslovak border; it ends (and the next zone begins) at kilometer 150. Zone 10.06 is defined as being 100 km wide, of which 50 km is militarily usable. There is no delay imposed

Table 1

SAMPLE RSAS ZONE TERRAIN DATA

Zone	Region	Red er.d	Width geo	mil	D e l	Terrain Ratio	Vel	Adja cent	Mil flank (%)
10.06	Austria	100	100	50	0	1.25	0.75	9.06	50
10.07	Austria	150	100	50	0	1.25	0.75	9.07	50

[3]This was true at least in part because many of the RSAS's special features, such as the breakthrough methodology, can be turned off when needed to match up with another model's outputs.

[4]Including CAS, BAI, and attack helicopter operations.

on units entering the zone; such a delay could represent, for example, the need to cross a major river at the start of the zone. The terrain in this zone has a ratio value of 1.25, meaning that defending forces within this zone are 25 percent more effective than would be the case in default terrain, while the velocity multiplier of 0.75 indicates that after all other FLOT movement calculations are made, the result will be reduced by one-quarter to represent inherent terrain difficulties. Hence, if the calculated FLOT advance were 20 km per day, the actual movement would only be 15 km. Thus, to calibrate movement, one can simply change the velocity multiplier for a given zone to an appropriate value. [5]

Precise tuning of ground attrition was not attempted because of the differences in the attrition processes between CAMPAIGN-MT and TACWAR. The TACWAR model uses a force-on-force process in which weapons are killed directly by other weapons; these losses are then summed to determine their effect on a given unit. In the RSAS, attrition is calculated as a loss rate per time period, with the losses then distributed across the various weapon system types in the unit. Thus, although physical losses and reductions in unit effectiveness were fairly [illegible] between the two systems, comparisons of the losses of individual systems such as tanks would be specious.

Tuning of the air battle proved to be straightforward but time consuming because of the large numbers of parameters that affect losses inflicted on aircraft performing various missions.[6] Although we were able to adjust the RSAS air-to-air and surface-to-air losses to parallel those predicted by TACWAR, it was impossible to match the figures for aircraft lost on the ground. In the RSAS version used for the CAD evaluation, the vulnerability of aircraft in shelters and in the open was a global parameter; this meant that any change affected both sides to the same extent.[7] For study purposes, it was necessary to adjust the losses on the ground to match those of the TACWAR side with the fewest losses, then use the RSAS "kill" command to impose additional losses on the other side. It was possible to match TACWAR outputs perfectly with the RSAS by this means.

[5] Of course, this would not be a valid calibration method if the underlying model logics were greatly different; in this case, however, they were not.

[6] See in particular the description of the parameters beginning with "para_" found in Table B.12.

[7] This has been changed in version 3.5 of the RSAS.

CAMPAIGN-ALT

The TFCA emphasized theaters that in the RSAS are modeled with the CAMPAIGN-MT methodology; therefore, the CAMPAIGN-ALT models were not heavily exercised. Activity in the theaters represented using CAMPAIGN-ALT consisted largely of unopposed movement of U.S./NATO and Soviet/Pact forces with very limited combat, and the model was able to reproduce the results to an acceptable degree of accuracy. Thus, the RSAS CAMPAIGN-ALT models were not extensively modified.

CAMPAIGN-ALT embodies techniques for adjudicating combat that are fundamentally different from those used in either TACWAR or CAMPAIGN-MT. In light of this, we did not attempt to calibrate either side's losses in any of the campaigns played out in any of the peripheral theaters. However, we were able to match FLOT positions and movements fairly successfully. Also, the military geography represented in CAMPAIGN-ALT appears quite compatible to that used for the parallel theaters in TACWAR.

In the second CAD analysis involving the planning force and a different scenario, CAMPAIGN-ALT was more extensively employed. As was the case in the work using CAMPAIGN-MT, both U.S. and enemy forces deployed according to a prespecified timeline, both sides used airpower in support of their theater plans, and combat results were adjudicated for the course of a full campaign.

The CAMPAIGN-MT strategic mobility model is used to deploy forces to all theaters, including those modeled using CAMPAIGN-ALT. To sequence unit arrivals in synch with those specified in the scenario timeline, the same "script force deploy" technique was used here as in the TFCA runs.

The results of this exercise, as well as the flexibility demonstrated, indicated that for CAD purposes CAMPAIGN-ALT is a suitable platform for assessing theater-level outcomes in peripheral theaters. The land combat models in CAMPAIGN-ALT are not derived from a "piston" metaphor.[8] Rather, combat takes place on a complex of nodes (point axes) and paths (LOC axes). Together, these form a kind of network, as shown in Fig. 1. Special rules are required to govern the movement of forces around the network under a variety of special

[8]CAMPAIGN-MT, while having many features going beyond the characteristic of true piston models, is nonetheless a derivative of that approach, sharing all of its advantages and some of its drawbacks.

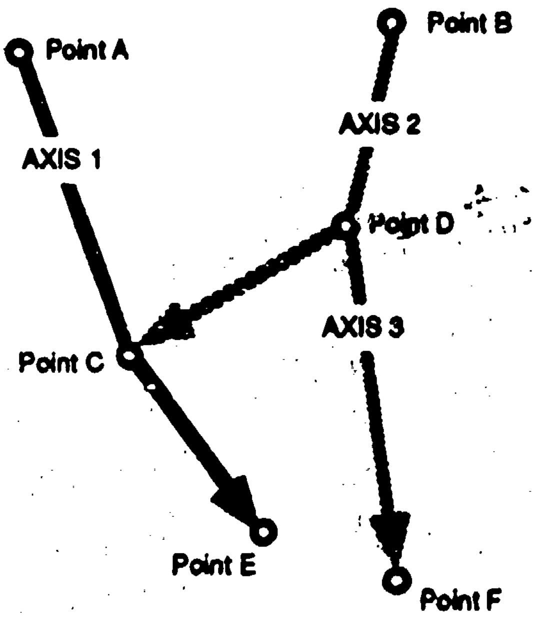

Fig. 1—Sample CAMPAIGN-ALT axis layout

cases, such as multiple lines of advance (LOC axes) converging on a single node (point axis). Understanding these rules is necessary to avoid misinterpreting the outputs from CAMPAIGN-ALT.

For example, in Fig. 1, LOC axes 1 and 2 converge on point axis C. If an attacker is fighting his way down both axes 1 and 2 and the FLOT on one reaches point C before the other, the second LOC axis is judged to be cut off. All defending forces on the cutoff axis retreat to a point on LOC axis 1 just below point C, while all the attacking forces on the cut off LOC advance immediately to point C. When this happens, the user will see a sudden "jump" in the FLOT position on the cutoff axis that appears to be unrelated to anything happening on that particular LOC. In fact, such a jump was observed in several runs conducted in support of the planning force exercise. Unless the whole of a CAMPAIGN-ALT theater representation is understood as an interrelated system, such events will be both disquieting and inexplicable when they occur.

CAMPAIGN-ALT offers some substantial advantages: Its network-like structure allows for representation of some operational-level maneuver phenomena, and it includes explicit representation of such key locations and facilities as crossroads, seaports, airfields, and national capitals. Finally, it is written in RAND-ABEL; most of its logic is contained in decision tables that are easy for a nonprogrammer to understand and can be modified to suit various study-specific requirements or objectives.

CONTROLLING FORCE OPERATIONS

Analytic War Plans

The RSAS offers several ways for a user to control the deployment and use of armed forces. First of all, for each theater the system includes packages of analytic war plans, which are the RSAS representation of theater-level operational war plans; written in RAND-ABEL, they are both human- and machine-readable. AWPs are *adaptive*, meaning that force employment decisions made at a given point may depend upon the specifics of the situation encountered at that juncture, rather than simply being read out from a predefined script.[9]

A sample order table from an AWP is shown in Fig. 2.

Within the RSAS, AWPs are organized both geographically and functionally. For example, AFCENT plans control operations in NATO's Central Region, while JCS plans handle global mobilization and deployment tasks. For the CAD exercise, we used the AWPs included in the RSAS release installed at J-8 as starting points and modified them to suit our specific needs. Our original intent was to use the adaptive qualities of these AWPs to generate excursion cases

```
Table Deploy-by-name-order
   unit-name              owner   to-region   to-overlay
   ====================   =====   =========   ==========.
   " 82-Airborne"         US      Egypt       --
   "101-AirAsslt/1-Bde"   US      Oman        --
   " 24-Mech/1-Bde"       US      --          AG-Iran-24
   "  9-Mtzd/3-Bde"       US      --          AG-Iran-2
[End Table].
```

Fig. 2— Sample RAND-ABEL order table

[9]The early concept of AWPs is discussed in Davis and Winnefeld (1983) and Davis (1984). The design, structure, and methodology of current AWPs will be documented in forthcoming RAND research.

from the TFCA baseline; unfortunately, time constraints prevented that.

A user can modify an AWP in various ways. Changes meant to be permanent can be made directly to the source code for the plan and compiled into the RSAS. Temporary alterations can be made by interpreting modified versions of functions found in AWPs or creating control plans.

The RAND-ABEL Interpreter

Any function[10] in an AWP can be changed before or during a run using the RAND-ABEL interpreter. A function set aside for interpretation is executed at run time according to the instructions stored in a copy of the function located in a special UNIX directory. The code contained in this file overrides that in the compiled version of the function.

The interpreter is most useful when the changes to be made are fairly straightforward and affect the substantive content of a plan rather than its timing or control logic. For example, according to the orders in Fig. 2, the U.S. 82d Airborne Division is ordered to deploy to Egypt.[11] A typical use of the interpreter would be to change the 82d's ordered destination to, say, Greece by making a copy of the entire function containing the order table and putting it into an interpreter file. The change to the 82d's destination would be made in this file, which would be executed when the RSAS is run in lieu of the version compiled into the system. Even analysts who are not programmers can readily make such changes.

As is the case with any interpreted language, code handled by the RAND-ABEL interpreter actually executes much more slowly than would a compiled version of the same function. Thus, care should be taken in designating functions for interpretation. For example, functions containing long loops, or loops that iterate many times, will exact considerable time penalties if interpreted.[12]

[10]A function in an AWP or any RAND-ABEL program is a contiguous, coherent block of instructions that generally carries out one task or a small number of closely related tasks. It is analogous to a subroutine in FORTRAN.

[11]All RAND-ABEL examples are illustrative and do not necessarily reflect code used in the work done for CAD.

[12]If this is a problem, the baseline AWP can sometimes be rewritten to avoid, shorten, or separate out the offending loop(s).

Control Plans

Major changes to the timing of the control flow of an AWP cannot easily be accommodated through simple modification of specific functions. Instead, the RSAS provides a special facility for creating what are, in effect, *ad hoc* AWPs. Variously referred to in RSAS documentation as *analyst plans* or *control plans*, these are special interpreted files that can be used to override all or parts of one or more AWPs.[13] Part of a sample analyst plan is shown in Fig. 3.

Unlike an AWP, which is built around a small number of control loops,[14] a typical analyst plan is linear. It simply steps through a sequence of numbered moves, executing the appropriate orders at designated times or when a specified event or set of events occurs. Compiled-in or interpreted AWP order functions can be called from within an analyst plan, or the user can specify in full detail the actions he wants taken at each step. As in an AWP, both RAND-ABEL variables and CAMPAIGN parameters and displays are accessible to an analyst plan, the former directly and the latter through the standard, predefined interface functions used by all RSAS RAND-ABEL models. Analyst plans are especially useful for testing out concepts or precisely reproducing a specified scheme of force employment.

Generally, two analyst plans are required, one each for Red and Blue. It is also possible to use a third plan to substitute for all or part of Green Agent. In the work at CAD, all three kinds of plans were used, in varying degrees of complexity.

To successfully employ analyst plans, a user must first be familiar with both the scenario he wishes to generate and the AWPs he is using as starting points. It is important to keep the actions performed by the analyst plan(s) in phase with those of the residual AWPs in the system so that, for example, a division deployed to Korea by the analyst on day ten is not redeployed to Iran on day 15 by some unnoticed order within an AWP. Typically, the process of synchronizing analyst plans with the rest of the RSAS is a matter of some trial and error, the duration of which is inversely proportional to the time invested in understanding the original AWPs and anticipating the effects of changes to them.

---

[13]For example, a user could employ an analyst plan in one theater while using standard AWPs in others; alternatively, an analyst plan could substitute for one part of a given AWP.

[14]Shlapak, Allen, and Schwabe (1986) describe the basic design of AWP control flows.

There are no analogs to either AWPs or analyst plans in other available models. They represent a major simulation innovation.[15]

```
Owner: Blue.

Define Control-plan:

   [At time zero, before other agents have run]

   If Move-number is 0
   Then
   {
      Table Deploy-by-name-order
         unit-name   owner   to-region  to-overlay
         =========   =====   ========== ==========.
         " 3-ARMD"   US      --         CEur-7 [V Corps]
         " 8-MECH"   US      --         CEur-7
         "11-ACR "   US      --         CEur-7
      [End Table].

      [Next move is day 2]

      Let Next-move-time-limit be 2 * 24.
      Let Next-move-planned-wakeup be the address of
       Never-wake.
      Increase Move-number by 1.
      Exit.
   }

   If Move-number is 1
   Then
   [And so on for the desired number of moves]


End.
```

Fig. 3—Extract from sample analyst plan

[15]See Davis (1984).

IV. COMPARING CAMPAIGN-MT WITH ANOTHER THEATER MODEL

Comparison of the outputs of CAMPAIGN-MT runs with the results of other theater-level combat models was a large part of the effort documented in this report. To be useful, any such comparison must take full account of the likely differences between the RSAS and the other model. This section discusses how to conduct such a comparison.

To some extent, comparing model outputs is more an art than a science; therefore, these suggestions may be less specific or detailed than might otherwise be expected. The intent is to provide some insights into what kinds of things to look for and what knobs to twiddle to adjust certain results. Unfortunately, however, we cannot tell you what settings are "right"; trial and error are necessary for that.

This discussion assumes that the RSAS is the "dependent" model. That is, the database and inputs to the RSAS will be adjusted so that the output matches the other model. The procedure would vary in detail but not in principle should the comparison be reversed. We also assume that the base model simulation with which the RSAS is being compared is completed before the start of the comparison activity. This implies that all needed output of the base model can be obtained at one time. In practice, of course, the RSAS comparison will frequently, if not always, be conducted in parallel with the use of the base model in a war game or other analytic activity. The mechanics of the process are unchanged in this mode; however, since changes will be made to the base model in the course of the analysis, each of the activities described below would be repeated iteratively rather than as a single activity.

The usual "final examination" in a calibration such as this is to change the inputs of both the base model and the RSAS and see if the change has a comparable effect on the results. This is a valid test and should certainly be applied. However, we recommend that such a test be run with great care, because it is not always easy to ensure that one is actually changing the exact same things in two models possibly having substantial differences in data structures, data resolution, and algorithmic processes.

For example, if the analyst is using the aggregated air base option in the RSAS, it would be difficult if not impossible to change inputs to target offensive counter air (OCA) sorties exclusively on enemy fighter bases. To make such a test valid would require that the RSAS be run (and recalibrated) using the available explicit air base logic.

DATA REQUIREMENTS

Database

All forces to be considered in the simulation must be identified and converted to RSAS format. The quantity and quality of weapons in each land, air, and naval force are needed. If the two models differ regarding aggregation of forces, rules for aggregating or disaggregating the RSAS forces must be established. Since RSAS ground forces can be scored in various ways, a scoring system (e.g., WEI/WUV, TASCFORM,[1] etc.) must be selected. The resulting force data must then be entered into the RSAS database source files.[2] Particular attention must be paid at this point as to how fire support assets, such as artillery and helicopters, are handled in the base simulation; any such unit that is to be committed or withdrawn separately from its parent army, corps, or division must be entered into the database as a separate unit to allow such manipulation.

Terrain Representation

Terrain in the RSAS CAMPAIGN-MT is represented by ten axes in the NATO Center Region and six in Korea, which cover the entire width of each theater. If the base model uses a different representation, the analyst must determine the best approximation of the terrain data to match the two models. The character of the axes in the CAMPAIGN-MT can be changed as a data input, but the number of axes cannot be increased without extensive modification to the underlying CAMPAIGN-MT models; such changes are probably beyond the capabilities of any RSAS user.[3]

---

[1]The Analytic Sciences Corporation Formula is another method of deriving firepower scores and combat potentials.

[2] See CACI Products Company (1989).

[3]For details on terrain definition see the Axis Table part of Section 18 of CACI Products Company (1989). Also, the map definition of the theater for the RSAS graphics requires a separate input file showing the latitude and longitude of the corners of each zone. The file *Run/G/D/theaters* is read by the graphics program at run time; if that file were replaced by a usable new version, the new geography could be represented without recompilation.

The CAMPAIGN-ALT model uses network theater representations; these are defined in RAND-ABEL code, which is available to users. Axes and point locations may be added or subtracted more or less at will; it is thus possible to simply modify the RSAS terrain representation to match the base model.[4] However, this modification should be attempted only with the assistance of a qualified RSAS system programmer.

Base Model Results

Results of the base model simulation are needed in three areas: force deployment and employment, attrition, and FLOT movement.

For each time period it is necessary to identify the location and activity of all forces being considered in the simulation. Critical data for ground forces include not only the location but the identification of forces engaged in the close battle, those close enough to be a target for BAI, and those sufficiently far in the rear to be subject only to deep interdiction. For air forces, missions being flown by time period are critical. If naval forces are involved, there must be identification of time periods in which they are engaged and the type of engagement.

The RSAS automatically adjusts its internal clock to the pace of events in a simulation, with the result that the models may advance time in chunks as large as 24 hours or as small as a few seconds. During force deployment and conventional war, the system operates in four-hour time increments and assesses attrition in any or all of the following categories for each period. Base model results must be extracted to support comparison at the appropriate level.

- Engaged ground force losses due to:
  - CAS
  - attack helicopters
  - opposing ground forces
- Reserve ground force losses
- Attack helicopter losses
- CAS aircraft losses due to FLOT air defenses[5]
- FLOT air defense losses due to helicopters and CAS

[4]Such changes require remaking the RSAS data dictionary, which is a time-consuming chore. There is also an upper limit to the number of point and LOC axes that may be defined within a theater because of the complexity of CAMPAIGN-ALT's routing logic, which increases geometrically as more axes are added. For most purposes, 50 axes should suffice to provide a reasonable theater representation.

[5]Surface-to-air defense organic to ground forces deployed at the line of contact.

- Penetrating aircraft losses due to:
  - FLOT force surface-to-air missiles (SAMs)
  - SAM belts
  - air defense interceptors
  - terminal SAMs
- Aircraft losses in friendly territory due to:
  - penetrating escorts
  - air base attack
- Submarine losses due to antisubmarine warfare (ASW)
- Surface force losses due to:
  - submarines
  - surface forces
  - aircraft
- Naval aircraft losses due to enemy fighters and SAMs.

Comparison of FLOT movement necessitates extracting the base model's movement results by axis and tim period for each theater being addressed in the comparison.

INITIAL RSAS SETUP

Preparation of Control Structure

The RSAS offers two options for overall control of a simulation, such as determining scenario time lines and participation by various countries. The RSAS Data Editor can be used to create a file called a *delta-WSDS*, which incorporates changes to the baseline startup WSDS. There is also an option to use the RAND-ABEL interpreter to create and run one or more analyst plans, as described in Sec. III.

A delta-WSDS is somewhat time consuming to create but is very useful for applying changes that are expected to be constant throughout the analysis. For example, it could be used to set up a group of CAMPAIGN displays to be written to the log file at regular intervals. An analyst plan, however, is quite easy to change and should be used for all decisions that are likely to be modified during the analysis.

An RSAS AWP is a flexible instrument intended to reflect decisionmaking at various levels in the military command hierarchy. Using the loop structure of the plan and decision logic, an analyst can set up conditional decisions based on alternative situations that might arise. The RSAS is delivered with one or more AWPs for each theater as well as the global level, but the existing sets are unlikely to be adequate to meet the specific needs of any new analysis. However, it is highly desirable that the results of each analysis be captured to expand the available RSAS decision set and to allow for later excursions from the base case. Therefore, we recommend that a set of AWPs be created before the analysis starts. These AWPs would be rather sparse initially, but by incorporating decisions and their underlying logic during the course of the analysis, the AWPs can become capable of reproducing the simulation on their own and of conducting excursions under changed conditions. Eventually, most of the content of the various analyst plans used to conduct a specific analysis should be recorded in one or more AWPs at the appropriate command levels.

To facilitate the creation of AWPs, the analyst should be alert during the course of the calibration to extract the reasons for decisions made in the base model runs. Knowing that the model withdrew Blue forces 50 km along one axis to straighten the front is more useful than knowing only that the FLOT made a sudden jump in a given time step if that behavior is to be represented in an AWP.

A discussion of some aspects of creating an AWP can be found in App. B.

Inter-Theater Movement

The RSAS incorporates a model of strategic mobility that will move military forces to designated theaters. The available lift is apportioned to theaters, and inter-theater deliveries are made in accordance with the lift available, the lift requirements of the forces to be moved (a database input), and the movement priorities established by the analyst. By adjusting these factors the analyst can calibrate the model to approximate the force arrivals used in the base model. If later work will involve the strategic mobility model, and especially if it is planned to turn the results into an AWP set, the analyst should perform this tuning. Initially, however, the TPFDL option described next will be preferable.

With this method, the arrival of ground and air forces in any theater can be controlled precisely. The force arrival list from the base model is replicated using the CAMPAIGN-MT Force table parameters *deploy* for ground forces moving to the Center Region and Korea, *gnd_move* for ground forces going anywhere else in the world, and *air_move* for air forces deploying to any location. Each force so ordered will arrive at the prescribed destination at the game day and time specified without imposing any demand on strategic mobility assets. Thus, if this option is elected for any unit, it should be used for all, or else other forces may be delivered unreasonably quickly because of the reduced demand on lift assets.

Forces deployed using the TPFDL process are not subject to enroute attrition. If enroute attrition was a factor in the base model, the analyst can use the RSAS *kill* option to duplicate that attrition.

Ground Force Employment

Ground forces are deployed to and removed from the corps sectors using the "deploy" order. A complete set of orders matching the base simulation should be prepared in advance. This can be done in an analyst plan by scheduling a move each day that orders must be issued or by using a phase of the AWP and the "If Today is D+" option. Movement within any theater takes time based on the distance to be traveled and the movement rate of the unit, so orders must be given in advance of the unit's arrival at the destination.

As with inter-theater movement, the deploy option can be used here to control the precise arrival of unit at a desired location should that prove necessary.

The RSAS optional Ground Commander Model (GCM) should be turned off during a calibration such as this. It is extremely unlikely that a set of control parameters for the GCM can be developed that will cause it to produce adequately precise commitment decisions for comparison with the base model.

The RSAS employs an Axis Commander submodel that moves forces from axis reserve to contact and from contact to axis reserve. The parameters for this model are listed in appendix Table A.21, and their values must be set to replicate the base simulation.

For example, if the base simulation assumed that attacking forces could absorb 50 percent attrition before breaking off the attack, the parameters *attk_repl*, *attk_pull*, and *attk_brk* must be adjusted to match. Given the differences among models in the ways in which such factors are calculated, there will be some iteration during the course of the analysis to find the values for these parameters that allow for matching the models' outputs.

Air Force Employment

The apportionment of air forces to missions is an input to the RSAS as is any change thereto. This apportionment is done by sortie rather than by aircraft. Hence, if the base simulation apportioned specific aircraft (e.g., F-16) to specific missions, a considerable amount of translation may be necessary to arrive at the RSAS apportionments in which sorties by aircraft class (e.g., multis) are apportioned. The analyst should expect this to be an iterative process requiring adjustment of sortie rates by type of aircraft and nationality to achieve the correct number of sorties throughout the simulation.

In addition to the daily apportionment, the RSAS distributes the available sorties among the six time periods each day (see *cas_timing*, *bai_timing*, and *air_timing* in appendix Table A.8). Even if the base simulation did not make this distribution it must be developed for the RSAS because improper timing can result in some sorties not being flown or in some being less effective than expected; for example, sorties meant to fly during daylight might be skipped or flown ineffectively because the model executed them at night.

Superpower and allied air forces can be apportioned separately. Also, air army assets and naval aircraft flying in support of a ground theater must be delegated to that theater and are apportioned separately from the other theater assets.

Allocation of Ground Support Missions

There are options in RSAS for automatic allocation of ground support missions to axes based on decision rules. These are useful options but are unlikely to adequately replicate the distribution of support in the base simulation, and it will probably be necessary to prepare a daily allocation vector to match the base case (see the "Allocate" order in appendix Table A.7). Like apportionment, this vector operates as a percentage of available assets by time period rather than in absolute numbers of aircraft or sorties.

Aircraft apportioned to fly either interdiction missions or offensive counter air missions distribute their effort in accordance with the "Laydown" and "Plan" orders cited in appendix Table A.7. Once a plan with its incorporated laydown is specified, aircraft apportioned to that mission will be distributed as specified until a new plan is implemented. The system does not incorporate any automatic adjustments to the plan; rather, the logic for such changes should be specified in the analyst's plan(s).

Aside from missions flown as part of the daily apportionment cycle, an analyst may also wish to perform one-time only air raids on specified targets. In the RSAS, such a raid is accomplished using the "Strike" order. In ordering a strike, the analyst identifies the target(s) to be struck and the units participating. The strike order is independent of and preempts the normal daily apportionment. If such raids occurred in the base simulation, the analyst should prepare the necessary strike orders in advance and incorporate them in the analyst plans.

In many theaters, it is planned that some aircraft will be withheld from conventional missions to be available for nuclear attack missions should they become necessary. The RSAS provides an option for this withhold by keeping back a percentage of the sorties of a given class of aircraft; it can be difficult to ensure that the correct number of aircraft by type are being withheld. Frequent adjustment of the apportionments may be necessary, particularly if the number and type withheld vary during the course of the base simulation. If the number withheld is fixed, consideration should be given to simply removing the appropriate number and types of aircraft from the RSAS database.

Testing the RSAS

When the packages of orders have been completed, the analyst should conduct a run of the RSAS without combat to verify the validity of all orders. An electronic search of the output "log" file can then quickly detect typographical or other syntax errors in the inputs. The most helpful entries in the "log" file for these purposes are labelled ERROR, WARNING, and (n forces affected). Although this discussion refers to testing the initial setup, it is good practice at the completion of any run to search the "log" file for these indicators of problems.

- The ERROR message–An ERROR usually results from a mistake in the syntax of an order. An example might be:

  ```
  ERROR: CEur is not a valid region.
  ```

  This would result from an order to an air force unit to deploy to the theater CEur instead of one of the countries within the theater. If the problem that causes the error is not obvious, the best way to check the syntax is to issue the order interactively in CAMPAIGN-MT and compare the output in the "com" file with the order as given.
  Another common ERROR type is:

  ```
  ERROR: 1st-ARMD is not a valid force.
  ```

The cause of this message is issuing an order to a unit that does not exist in the database. It most frequently results from simple typographical errors such as calling the unit "1st Armored" in the database and "1st ARMD" in an order. A check of the appropriate input data file will usually clarify the problem.

- The WARNING message–A WARNING might read:

> WARNING: No action is possible regarding the 1st Armd Division.

The warning is usually accompanied by an explanatory note. This type of a problem generally happens when an order is issued to a unit currently precluded from receiving orders. For example, when a unit has been ordered to deploy using the TPFDL option described above, its mission cannot be changed nor can its movement be modified until it arrives at its destination.

- The "(n forces affected)" message–When any order is issued to CAMPAIGN-MT, the number of discrete units, regardless of size, recognized by CAMPAIGN-MT and affected by the order is printed in the log file immediately following the record for the order. An order to the US 1st Armored Division should result in the message "(3 forces affected)" whereas one to the 3d Brigade of the 1st Armored Division should result in "(1 forces affected)". If a Soviet Army consisted of four divisions, two helicopter regiments, and an artillery brigade, an order to the entire army should result in "(7 forces affected)". If, for example, an order intended to mobilize the entire West German army resulted in the message "(0 forces affected)", it would be evident that there is a problem with the order.

ANALYSIS OF RESULTS

General

The first step in the calibration process is, of course, determining what is happening in the RSAS run and comparing its results with those from the base simulation. Only highlights of the displays are noted here. Complete documentation for each display is available through the RSAS online documentation.[6]

Displays

A quick overview of the ground battle is best obtained using the "X-land" display. This compact display shows the location and current movement rates of the FLOT by sector, the number and capability of units engaged on each axis as well as the total reserves available, the daily attrition rate by cause, and the type of battle occurring on each axis. This overview can show at a glance where results may be diverging. A great deal of the data in this display show current results expressed in rates per 24 hours. Thus, if the FLOT rate is shown as 12 km per day, it will actually move 2 km during the current four hour time period; the movement rate may change during the next time step. Hence, the display shows a prediction, not necessarily what will occur.

The major value of the "Zone" display is in determining the location of forces in the theater. Calling for the zone display for, say, CEur-4 will show enemy and friendly forces committed to the FLOT battle and whether those forces are engaged or in axis reserve. It will also show from the rear of axis CEur-4 the identification, location, and activity of all units located on that axis. The same display for WTVD-4 will reverse the FLOT forces and then show the WTVD forces to the rear of the axis.

The "Axis" display provides detail as to the activity on the axis specified for the current time period including such data as the defensive value of the terrain in the sector. It is also the source of information on the number of fixed wing and helicopter sorties actually flown in support of this axis and whether those sorties resulted in a slowing of the FLOT rate. To get a complete picture of a day it would be necessary to print this display for each time period for each axis.

For each unit on an axis for which the display is requested, the "G+" display lists the on-hand equipment inventory by RSAS equipment class as well as the authorized quantity. The authorized amount is simply the starting inventory in the database; regardless of the quantity of replacement equipment available the on-hand amount will not exceed the starting inventory. This display will allow for calculation of the damage to each unit. However, *it should not be*

[6]Help can be obtained when the CAMPAIGN-MT window is active by typing "display help".

used to compare equipment items lost with such losses in the base model since the RSAS calculates attrition to equivalent divisions and then distributes that attrition to items of equipment rather than calculating it directly in equipment lost.

The "Tacair" display summarizes the air battle for the previous day. It includes the number of sorties flown by class of aircraft and by type. Losses to aircraft in the air are also shown.

The "Theater-air" display shows the total number of aircraft deployed to the theater and the cumulative losses by type. It further shows the capability to produce sorties for the next day based on remaining aircraft and current sortie rate.

Since the display is cumulative throughout a run, the losses for a given time period are calculated from the difference between those at the beginning and at the end. It shows superpower and allied data separately. This is the only display that shows aircraft lost on the ground.[7]

The "Units" display is used to obtain specific data for air or ground force units. If it called for USAF units in the FRG, it would list all such units by name and show the authorized and on-hand aircraft for each.

The RSAS GraphTool provides pictorial presentation of data that in some cases is more detailed than that obtainable through the tabular displays; it can also present some data over time. This is particularly useful if it is necessary to examine, for example, the distribution of losses by cause over the course of a run. The default setting for the history file writes data for each 24 hour time period. If the base model uses a time step of, for example, 12 hours, the RSAS history frequency can be adjusted with the force parameter *his_step*.

Adjustment of the Model

The rate of FLOT movement is the easiest comparison factor to adjust in the RSAS. The basic value is calculated from a table based on the type of battle being waged on a given axis and the force ratio; these tables can be found in the theater.sec data file. If RSAS movement differs from the base model, first verify that the correct battle table is being used. If a defender is supposed to be in prepared positions but the X-land display indicates that the type of battle is "Hasty," the preparation of defenses must be scripted. If the type of

[7]More recent versions of the RSAS offer a new "Mission-to-task" display, which includes this information as well.

battle is correct and movement differs by a more or less common multiple for all types of battles, the general purpose parameter *adv_mult* can be used to adjust the RSAS advance rate to match or the movement lookup tables adjusted as necessary. If the differences vary for different battle types, adjust the tables found in the theater.sec input file. If the movement is generally correct but is off in only a zone or two, the zone specific parameter *velocity* should be modified to make the adjustment.

The RSAS uses concepts of hold density and breakthrough, either of which may not be present in the base model. If defending forces on an axis reach a density defined by *hld_density*, FLOT movement on that axis is reduced according to the value of the parameter *hold_mult*. If the base model does not use this approach, *hold_mult* should be set to 1.0. When the defender density falls to that specified by *brk_density*, the attacker is adjudicated as having attained a breakthrough on the axis, and both attrition and movement are plotted on a different curve. If the base model does not allow for breakthroughs, they can be avoided in the RSAS simply by setting *brk_density* (the frontage that can be defended without breakthrough) to a large number such as 999.[8]

In the RSAS, both fixed wing and rotary wing aircraft can reduce FLOT movement directly. If this effect is not desired, the parameters *hel_hr_delay*, *cas_hr_delay*, and *bai_hr_delay* should be set to 0.

The defender attrition in equivalent divisions (EDs) per day is calculated based on the force ratio on the axis and the type of battle. The attacker attrition is calculated by determining an exchange rate based on the force ratio and type of battle and multiplying the defender attrition by that exchange rate. These rates are established in theater.sec, and the attrition rates for the current time period can be found in the X-land display. If the RSAS rates are consistently higher or lower than the base model, the general purpose multiplier *att_mult* can be used to adjust them. However, using this parameter will also affect attrition due to air attacks, and it should be used with care. If desired, setting the landwar parameter *loss_meth* to equations will convert the attrition process to calculation from equations so that the analyst can experiment with attrition interactively.[9]

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[8]These model features were developed because there is reason to believe that they are needed to reflect basic movement effects of the sort emphasized in Soviet operational art and achieved in many campaigns in World War II.

[9]The constants of the equations are accessible as parameters.

Attrition to ground forces from fixed wing aircraft and that from helicopters are combined and shown in the "air" column of the X-land display. The separate values can be obtained using the graphic displays. The axis display will indicate how many sorties of each were flown and provide a guide for adjustment. If the overall number of sorties flown in the theater is correct but the number of fixed wing aircraft supporting the axis in question is incorrect, the allocation vector must be adjusted. If the number of helicopter sorties is not correct, the number of helicopters assigned to the axis must be changed or their sortie rate must be adjusted. Once the number of sorties is correct the attrition is adjusted using the appropriate parameters listed in appendix Table A.29.

Helicopters are lost to ground defenses and fixed-wing attacks on forward arming and refueling points (FARPs). The nominal loss rate due to ground defenses is controlled by the parameters *hvuln_atk*, *hvuln_def*, and *hvuln_oth*, depending on the posture of the supported force. These nominal rates are based on an assumed enemy air defense density, and the actual losses will vary as the air defense density varies. Losses in the FARPs are controlled by the enemy parameters *cas_farp* and *bai_farp*.

Fixed wing losses occur in many ways and there are numerous ways of adjusting them.

- Losses on the ground
  - Aircraft on an airbase can be lost to enemy attacks on that base. The losses are a function of the number and quality of attacking aircraft and the number of aircraft exposed. If an attack occurs when most of the aircraft are in the air, losses are correspondingly reduced. The easiest way to adjust on-the-ground losses is with the parameters *ac_shel_psi* and *ac_unshl_psi*, which determine the vulnerability of sheltered and unsheltered aircraft respectively. The parameters are set by country and are in the region table.
- CAS losses
  - Aircraft on CAS missions are assumed not to cross the FLOT and are subject only to attrition from enemy ground-based air defenses in the FLOT forces. The nominal per sortie loss rate is set by the parameter *flot_pen* and assumes a certain density of air defense weapons. Actual losses are adjusted to reflect the actual air defense environment.

- Air defense losses
  - Aircraft with an air defense mission are lost only to escorts accompanying enemy penetrating aircraft. The loss rate is determined by the number and quality of aircraft involved. The number of air defense aircraft that scramble to meet a penetration is, of course, limited by the number apportioned to air defense and is further specified by the airwar parameter *para_scram*. Losses on each side can be adjusted using the parameter *para_air*, which changes the engagement rate.[10]
- Penetrating aircraft
  - Aircraft ordered to fly missions into enemy territory, whether through a specific strike tasking or just flying their apportioned missions, are subject to attrition from a variety of sources.
  - FLOT air defenses: As the aircraft cross the FLOT, they are subject to losses from enemy ground forces as discussed for CAS aircraft above.
  - SAM belt: If the opposing side has a SAM belt, attrition is imposed as penetrators cross it. The remaining value of the SAM belt is determined by the ratio of remaining *belt_kms* to the starting value. The analyst can adjust this value up or down. The parameter *belt_pen* determines the losses inflicted by the SAM belt if it is unsuppressed. If aircraft were assigned to defense suppression, penetrator losses are reduced to *belt_cor* if the belt is fully suppressed or to a value between *belt_pen* and *belt_cor* if only partially suppressed. Defense suppression reduces the value of the SAM belt (*belt_kms*) by the parameter *belt_kill*.
  - Enemy air defense aircraft: If the penetrators are escorted or have a self-escort capability, the first encounter is between the escorts and enemy air defense aircraft, and losses are adjudicated as described for air defense aircraft. Once the escort/air defense engagement is adjudicated the strike aircraft also suffer attrition, which is adjusted using the parameter *para_bbr*.[11] The

[10]It may be necessary to adjust aircraft effectiveness values in air.sec if the base model calculates attrition by a process different from that in the RSAS.

[11]Assuming, of course, there are surviving interceptors to engage them.

total losses are calculated and then distributed between ingress and egress according to the parameter *para_ing*.

— Terminal SAMS: If the target is protected by ground-to-air missiles, losses to penetrators that reach the target are adjudicated based on the parameter *term_sam*.

SUGGESTED EXCURSIONS

Ground Commander Model

Once the RSAS has been acceptably calibrated to the base model, the GCM should be tested. The GCM makes employment decisions based on the guidance defined by the parameters in appendix Table A.18. Adjustment of these guidance parameters can allow the GCM to approximate the decisions made in the calibration, thereby replicating the outcome. It should not be expected that the GCM can be calibrated to precisely match the employments in the calibrated run; this is an excellent example of where close is probably the best possible. The analyst should also expect to have to adjust guidance during the course of the simulation. It is part of basic RSAS design philosophy to do so in RAND-ABEL functions rather than to bury subtle adjustment logic in the C code of the GCM. See the function AFCENT-adjust-axis-priority in the file Src/AWP/Blue/Afcent /library.A for an example of dynamic GCM guidance.

Analytic War Plans

One of the most useful features of the RSAS is the ability to use a well developed set of AWPs to rapidly test the effect of changed decisions. If, during the course of the analysis, alternative decisions and the reasons for them were recorded, the analyst plan guidance can be changed to exercise those alternatives. Ideally, the decisions and the results thereof would then be tested against the base model to complete the process of determining acceptability.

V. CONCLUSIONS

USING THE RSAS IN J-8/CAD

The RSAS has demonstrated its value to CAD for the conduct of many of the assessments for which that division is responsible. It cannot serve as a replacement for the more detailed models used in such exercises as the TFCA since higher resolution is desirable for some aspects of that work. However, it can supplement those models in the TFCA process, particularly in pregame explcrations and excursions. The RSAS may also be a useful substitute for more manpower-intensive models in the conduct of other, smaller-scale CAD analyses.

The combination of AWPs and analyst plans employed in this work proved quite flexible and robust in controlling and modifying scenario details during the course of the assessments. In particular, we encountered little difficulty in implementing the TFCA gamers' decisions within the RSAS, at least in those areas where the system's force models are reasonably complete.

The CAMPAIGN-MT ground combat model appears to be suitable for CAD's purposes and proved capable of replicating the outputs of TACWAR along most meaningful dimensions. Further improvement in current and future RSAS releases should increase the system's utility to CAD and other users with similar requirements. The modeling of air-to-air and air-to-ground combat was deficient in some respects, but identification of these shortcomings has led to corrections in current RSAS versions.

Although subjected to only a limited test, the CAMPAIGN-ALT model used for theaters other than Central Europe and Korea was adequate to the extent that it was used. Again, current versions of these models represent improvements over those in use at CAD during the conduct of this study, and further enhancements are planned.

The generally satisfactory performance of the RSAS did not extend to naval combat, nor has sufficient testing been done to determine whether improvements in the current-generation RSAS naval models have sufficiently addressed these problems.

IMPROVING THE UTILITY OF THE RSAS

In addition to being the first detailed comparison between the RSAS and another model, this project was the first serious application of the RSAS outside the RAND computing environment. Thus it was no surprise that several problems arose and improvements were identified. Listed here are some changes to the RSAS at least partly due to this project.

Navy Task Group Names

RSAS graphics applications were designed to allow the depiction of navy battle groups on map displays. However, their implementation required that all task group names defined in the CAMPAIGN-MT naval database also be defined as enumerated values for the appropriate RAND-ABEL variables. This process required the recompilation of the entire system for each addition of a task group. Moreover, any errors in this enumeration tended to cause core dumps at run time. We recommended that this process be simplified and preferably automated.

The RSAS graphics software has since been modified to eliminate the enumeration requirement.

Airbase Resolution

The RSAS 3.1 used for this study represented airbases in a highly aggregated way. It was not possible to apportion air base attack selectively to simulate, for example, initial attacks on fighter bases followed by more widespread strikes. This limitation presented some problems in matching the details of the TACWAR air war.

As a result of this project, as well as suggestions by other RSAS users, the system now supports both the assignment of air units to specific bases and selective targeting of those bases. Moreover, bases can now be overrun by ground forces that penetrate sufficiently deeply into friendly territory; this had not previously been possible in CAMPAIGN-MT.

These changes are not unmitigated blessings because they introduce additional complexities to the management of the simulation. For example, either the user or his automated surrogate (an AWP or analyst plan) must now monitor the position of the FLOT relative to the location of airbases so that units based at threatened installations may be evacuated before being overrun.

Aircraft Vulnerability on the Ground

The RSAS uses the parameters *ac_shel_psi* and *ac_unshl_psi* to control the vulnerability to enemy ground attack aircraft of sheltered and unsheltered aircraft respectively. In RSAS 3.1, these parameters were implemented in a way that caused a single value to be applied to *all* airbases of *all* participants, making it difficult to adjust losses of aircraft on the ground. Any parametric change made to reduce Red losses, say, also cut down Blue's attrition.

To correct this problem, these two parameters were put into the region table to allow different values to be set for each recognized RSAS region.

Database Improvement

The actual databases used in this project could not be physically removed from the CAD facility. However, in several cases where we encountered disagreement between their data and that in the RSAS databases, we were able to obtain corrected values from other sources. This improved the overall validity of the RSAS database.

Creating a New AWP

As can be seen from the description in App. C, the process of creating an entirely new AWP requires the manual modification of several RAND-ABEL data dictionary files. Within RAND, this process had always been handled by people expert in those parts of the system; the potential for obscure errors had therefore not been previously recognized.

Ideally this process would be completely automated, but this has not yet been done. However, as a result of our experience we were able to improve the documentation of the process, which reduces the likelihood of a user encountering an utterly bewildering error.

Appendix A
UNDERSTANDING CAMPAIGN-MT

The following is a cross reference to the basic data, types of orders, and parameters that affect adjudications in CAMPAIGN-MT. This is intended to be a reference guide, *not* a textbook. Description of an item is usually restricted to a "one-liner," which is by no means definitive or of sufficient detail to include all information a user may need in deciding how to cause a particular change in the simulation scenario or adjudication. If more information is needed or desired, consult the referenced data file or the on-line help available within CAMPAIGN-MT.

Figure A.1 indicates the grouping of the parameters and how the various packages feed into successive activities.

Once a user has identified data, orders, or parameters that appear to offer the capability he seeks, he can obtain additional information about the item as follows:

- Data Files: Edit the referenced data file in the /Force-C/D directory and find additional documentation therein.
- Orders: Run the RSAS and, from the Force window, use the documentation "help" option available in the orders syntax sequence.
- Parameters: Run the "helper" program in the /Force-C/A directory to find more extensive documentation about the parameter keywords available in the various parameter tables.

This appendix applies specifically to release 3.5 of the RSAS; most or all of its contents will be applicable to later versions of the system as well. However, some options available in later releases, such as explicit basing of aircraft, are not described here.

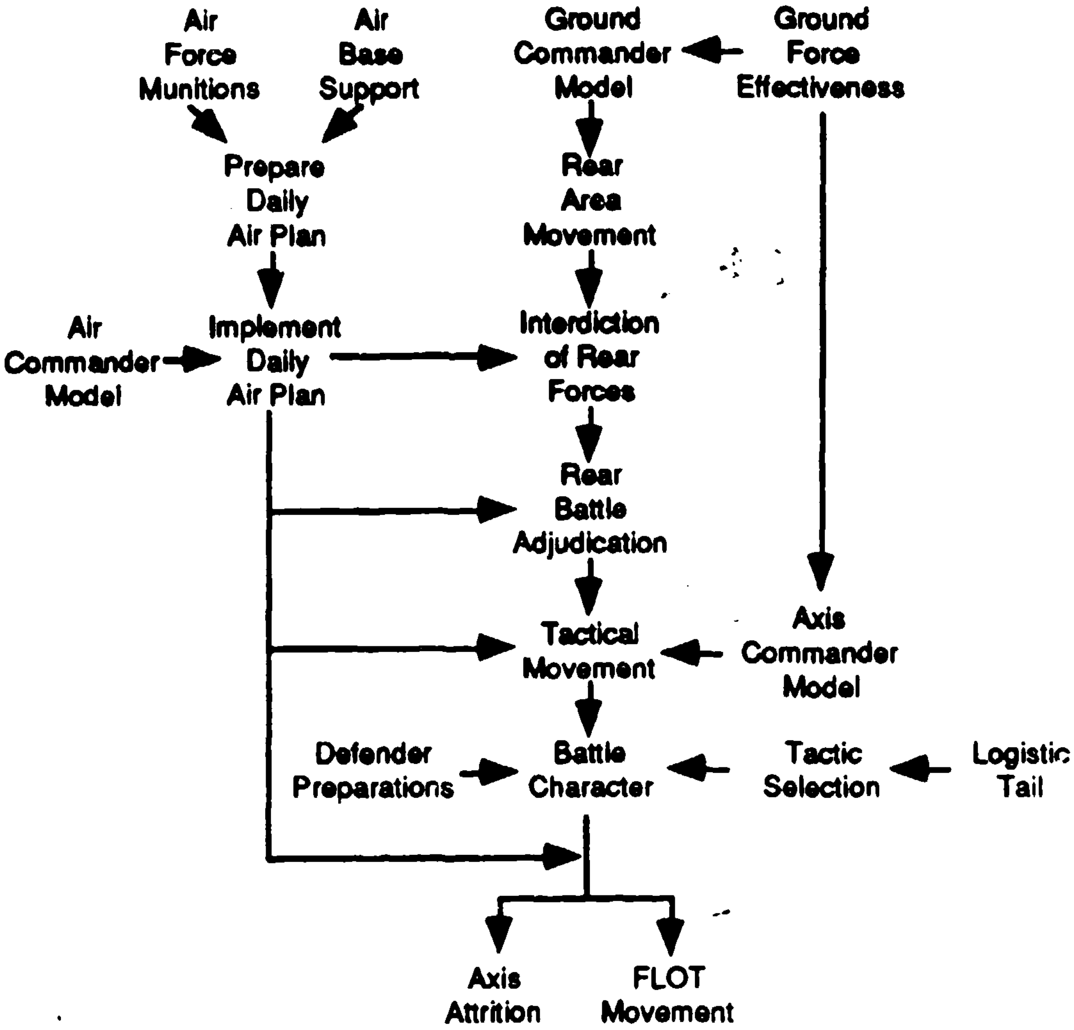

Fig. A.1— Generalized CAMPAIGN-MT flowchart

AIR COMBAT

Air Force Munitions

The availability of high-tech versus other types of air munitions[1] affects the capability of tactical air sorties. Resolution is by type of munition and owner (e.g., the inventory of Belgian *Mavericks* is known, expendable by Belgian aircraft capable of using *Maverick*, and may be attacked in storage sites by enemy aircraft).

Tables A.1, A.2, and A.3 show the data files, orders, and parameters associated with CAMPAIGN-MT's representation of air munitions.

Airbase Support

Resolution is quantity of bases by base class and by geographical RSAS region (e.g., MAIR_major[2] airbases in the FRG might support 250 sorties per day when undamaged and can be attacked by enemy and repaired by friendlies).[3] Tables A.4 and A.5 list the data files and orders that touch on airbase support.

Theater Daily Air Plan

Each side in each theater prepares a plan at midnight each day specifying sorties to be flown by source of aircraft (US/USSR, allies, and delegates), type of aircraft (multi, CAS, interdictor, bombers, fighters) and mission (see Apportion order for mission types). The plan is based on assets and capabilities as of the time the plan is made and is not modified upward because of arrivals or repairs occurring during a day, nor is it remade during a day if new orders are given (i.e., orders take effect the next plan cycle, not the current one). Tables A.6, A.7, and A.8 list relevant files, orders, and parameters.

[1]High-tech munitions are latest-generation weapons, such as all-aspect air-to-air missiles, "smart" bombs, guided air-to-surface missiles, and so forth.

[2]Air bases in CAMPAIGN-MT are categorized as being either military (MAIR_) or civil (CAIR_) in nature, and of being either large (MAIR/CAIR_major) or small (MAIR/CAIR_minor).

[3]Versions of the RSAS numbered higher than 3.5 allow for explicit airbases and for those bases to be overrun by ground attacks.

Air Commander Model

The Air Commander Model (ACM) is a parameter driven routine that determines the allocation of available CAS and BAI sorties to the axes.

Tables A.9 and A.10 describe data files and parameters relevant to the ACM.

Implement Daily Air Plans

Daily plans are implemented according to the air timing vectors. Sufficient losses to air assets can cause the plan to be underflown. New squadrons arriving during a day can assist in meeting planned sorties but do not cause any increase in the number of planned sorties.

Tables A.11 and A.12 list data files and parameters that govern the action in CAMPAIGN-MT's air war representation.

GROUND COMBAT

Ground forces are resolved as brigade and division units (e.g., 1st-Armd/2d Bde US or 8th-Shock/112th-TKD USSR are identifiable entities). Each ground force has specific weapon quantities and qualities that permit calculation of a current value score expressed in EDs. The forces also have other characteristics that allow the adjustment of this score to what is currently projectable against the enemy (usually less than or equal to the unit's ED score) referred to as effective EDs (EEDs). In general, the gross capability of a side on an axis is the sum of the EEDs of forces in the axis.

Numerous situational calculations, although not altering the EEDs of individual forces *per se*, affect force ratios and other calculations that use the sums of EEDs of forces in the axis and, specifically, of forces at the axis FLOT. The factors that affect the conversion of a specific unit's ED score into EEDs are:

- mobilization level
- training level
- munition levels
- homeland defense
- language considerations
- cohesion

- owner multipliers
- region multipliers

All other factors may affect total or force ratio calculations, but not the individual unit ED to EED calculations.

Tables A.13, A.14, and A.15 list data files, orders, and parameters that affect the results of the ground war in a CAMPAIGN-MT theater.

THE GROUND COMMANDER MODEL

The ground commander model (GCM) is a rule-based, parameter-driven package designed to help RSAS users control ground forces. Two levels of GCM are provided:

- The Theater Commander, which may be switched on or off at the user's discretion; and
- The Axis Commander, which is always on since it manages tactical-level activities for which no direct user control is provided.

The Theater Commander Model

The Theater Commander translates parametric user inputs into force assignments and logistics handling. Units may be committed to specific axes from theater reserve or vice versa. Also, corps boundaries may be shifted by moving units from one axis to a neighboring one. Logistics support is allocated on demand; when insufficient stocks remain to meet all requirements, resupply is based on individual axis priority.

Tables A.16, A.17, and A.18 list data files, orders, and parameters that affect and control the Theater Commander.

Axis Commander Employment Decisions

Tables A.19, A.20, and A.21 list data files, orders, and parameters relevant to the Axis Commander Model's conduct of corps-level operations.

Tables A.22 and A.23 summarize the orders and parameters that affect axis tactic selection.

Current forces of each axis are managed by one of the following models, depending on the current tactic:

- peace_commander: Decisions before combat is initiated
- attack_commander: Main attack, support attack, and pin attack
- defend_commander: Defense (hasty, deliberate, prepared, and fortified)
- delay_commander: Recover, withdraw, and delay

Axis Tactic Selection

Current activity, which to some extent is properly described as the "mindset" of the Axis Commander Models, is based on:

- Past and current events that proscribe the ability of an axis to follow orders (e.g., an axis trying to recover from a major breakthrough cannot decide to attack).
- Explicit orders given by the user (e.g., delay through position x) if not proscribed by past or current events.
- In the absence of either of the above, default rules take over (e.g., attack if short of ordered position and able, withdraw if beyond ordered position, otherwise defend).

Defender Preparations

Deliberate, prepared, and fortified barriers can be scripted or ordered constructed anywhere in the theater overlay. Deliberate defenses are considered to be those prepared by a defending unit with its own assets and are constructed by any axis that is stationary or being pushed back slowly. Units that are not moving, or are on an axis where the FLOT is moving more slowly than the rate specified in the Force Table parameter *dlib_build*, will always construct deliberate defenses. Prepared and fortified defenses are considered to require nondivisional assets and must be explicitly ordered.

Tables A.24, A.25, and A.26 list the data files, orders, and parameters that affect defender preparations.

Logistics Tail

A simple arithmetic model allows an advancing axis to outrun its logistical support and automatically stops an advance when the support tail exceeds some specified length. Tables A.44 and A.45 list data files and parameters that play in moving the axis logistics tail.

Battle Characterization

Once each side on an axis has selected its tactic for the current time-step, the type of battle to be adjudicated is automatically determined from a simple look-up matrix and defensive preparations, if any. No external data, orders, or scripts directly affect this determination.

Attrition to Axis Forces

Ground forces on an axis may suffer attrition because of the actions of opposing ground and tacair forces and enemy attack helicopters.[4] Losses to FLOT forces are "cascaded" among sister units such that losses attributed to individual forces are higher for forces that have suffered more attrition than to forces that have suffered less. Total losses of weapons among all forces are the same as if there had been no cascading.

Tables A.27, A.28, and A.29 break out the data files, orders, and parameters affecting ground force attrition.

FLOT Movement

Opposed FLOT movement rates depend on EED ratio, terrain characteristics, and battle characterization. Tables A.30, A.31, and A.32 list the data files, orders, and parameters that affect FLOT movement rates.

REAR AREA MOVEMENT AND LOGISTICS

Rear Area Force Movements

The Zone Table data describes land LOC connectivity and capacity to support movement. Tables A.33, A.34, and A.35 show the data files, orders, and parameters that determine the nature of rear area movement.

[4]Enemy nuclear attacks can also kill ground forces; we do not discuss that mechanism in this appendix, however.

Interdiction of Rear Forces

Air attacks against forces moving in the rear areas and in axis rear causes attrition and movement delay. Tables A.36 and A.37 show data files and parameters affecting the interdiction of rear area forces.

Adjudication of Rear Area Battles

CAMPAIGN-MT has simple models to consider the insertion of, attrition to, and effects of operational maneuver group (OMG), airborne, and airmobile operations in a theater. Tables A.38, A.39, and A.40 summarize the data files, orders, and parameters that determine the shape of rear area battles.

Tactical Movement

A simple within-axis tactical movement model allows interdiction of forces from the time they are committed from axis reserves to the time they arrive at FLOT positions. Tables A.41, A.42, and A.43 list data files, orders, and parameters that affect within-axis tactical movement.

Table A.1

AIR MUNITIONS DATA FILES

Data Files	Relevant Contents
weapon.sec	Definition of munition types and characteristics
air.sec	Specification of load by mission and aircraft type
weapon2.sec	Inventories by munition type, owner, and location

Table A.2

ORDERS AFFECTING AIR MUNITIONS

Order Types	Relevant Effects
Assign	Only assigned aircraft consume theater air munitions
Deploy	Aircraft assigned and deployed consume theater air munitions
Alert/hold	Alert rate affects sortie generation
Strike	Aircraft on strikes consume air munitions; enemy strikes on STOR_nucwpn or STOR_ammo destroy munitions

Table A.3

PARAMETERS AFFECTING AIR MUNITIONS

Table	Keyword	Relevant Effects
govt	sort_mult	Multiplier of sortie rates for aircraft owned by a government
aftype	sort_rate	Maximum sorties per aircraft per day given adequate base support
	avail_rate	Fraction of total aircraft available to sortie
airwar	surge_rate	Multiplier of sort_rate during theater surge period
	surge_days	Duration of theater surge period
logdata	air_air_use	Fraction of load actually expended per air-to-air sortie
	air_gnd_use	Fraction of load actually expended per air-to-ground sortie
supply	weapon_type	Create or destroy high-tech munitions by type/owner/location
	air_air_oth	Create or destroy low-tech air-to-air munitions
	air_gnd_oth	Create or destroy low-tech air-to-ground munitions

Table A.4

DATA FILES AFFECTING AIRBASE SUPPORT

Data Files	Relevant Contents
facility.sec	Number of airbases by location/owner/type; full-strength capacity to support combat sorties; number of shelters by base class and beddown capacity
air.sec	Basing priorities by type of aircraft

Table A.5

ORDERS AFFECTING AIRBASE SUPPORT

Order Types	Relevant Effects
Deploy	Excess aircraft deployed to a region reduce aircraft sortie capability so as not to exceed base capacity
Strike	Strikes targeted at CAIR and MAIR target categories damage sortie support capability, which may reduce sortie generation

Table A.6

DATA FILES AFFECTING THEATER AIR PLAN

Data Files	Relevant Contents
theater.sec	Default Apportion orders; Default Plan orders; Default Allocation orders; list of theater support regions
air.sec	Sortie rates by aircraft type

Table A.7

ORDERS AFFECTING THEATER AIR PLAN

Order Types	Relevant Effects
Assign	Only assigned or delegated aircraft can participate in the daily plan operations
Delegate	Naval or army air units can be delegated to support theater operations
Deploy	Only aircraft deployed to theater support regions may participate
Apportion	Specifies percentage of aircraft by source (Red/Blue, Allies, Delegates) and type to perform each mission
Allocate	Partitions planned CAS and BAI sorties across axes. Will be ignored if ACM is On.
Alert/hold	Aircraft alert rates affect sorties flown
Laydown	Defines target sets for use in bombing plans
Plan	Divides penetration missions (e.g., not CAS or BAI) to specific laydown or regional bombing missions
Strike	Conventional or nuclear strike missions preempt specific squadrons or regiments from participating in the daily theater plan

Table A.8

PARAMETERS AFFECTING THEATER AIR PLAN

Table	Keyword	Relevant Effects
govt	sort_mult	Multiplier of sortie rates for aircraft owned by a government
airwar	avail_rate	Fraction of total aircraft available to sortie
	surge_rate	Multiplier of sort_rate during theater surge period
	surge_days	Duration of theater surge period
	cas_timing	Specifies percentage of total CAS flown each time period
	bai_timing	Specifies percentage of total BAI flown each time period
	air_timing	Specifies percentage of total OCA/AI flown each time period

Table A.9

DATA FILES AFFECTING THE AIR COMMANDER MODEL

Data Files	Relevant Contents
theater.sec	Default values for parameters

Table A.10

PARAMETERS AFFECTING THE AIR COMMANDER MODEL

Table	Keyword	Relevant Effects
ocl	air_on	Turns the ACM on for a theater
	air_off	Turns the ACM off for a theater
	cas_weights	Weighting factors used in CAS allocation
	bai_weights	Weighting factors used in BAI allocation

Table A.11

DATA FILES AFFECTING THE AIR WAR

Data Files	Relevant Contents
air.sec	Air-to-air effectiveness scores by type of aircraft and load; air-to-ground effectiveness scores by type of aircraft and load
theater.sec	Air-to-air adjudication factors; ground-to-air adjudication factors; defense suppression effects data

Table A.12

PARAMETERS AFFECTING THE AIR WAR

Table	Keyword	Relevant Effects
airwar	escort_max	Fraction of penetrators with self-escort capability
	escort_ratio	Explicit escort needed to preclude use of self-escort
	belt_cor	Base penetrator loss rate when defense suppression is adequate
	belt_pen	Base penetrator loss rate if no defense suppression
	belt_kms	Current "density" of SAM defenses in a theater
	belt_kill	Quantity of SAM "density" killed per suppression sortie
	flot_pen	Loss rate of penetrators to divisional air defenses
	frac_sup	Proportion of penetrators dedicated to suppression
	sam_kill	Analyst multiplier for SAMs killed by suppression
	sam_mult	Analyst multiplier of SAM effectiveness
	night_kill	Multiplier of mission effectiveness for night sorties
	night_loss	Multiplier of losses for night penetrations
	abort_rate	Rate at which penetrators abort when losses are excessive
	abort_thresh	Loss rate considered "excessive"
	para_air	Interceptor-escort loss adjudication tuning parameter
	para_bbr	Interceptor-penetrator tuning parameter
	para_ing	Fraction of losses incurred on ingress
	para_sam	Fraction of escorts subject to SAM losses
	para_scram	Maximum desired interceptor to penetrator ratio

Table A.13

DATA FILES AFFECTING THE OVERALL GROUND WAR

Data Files	Relevant Contents
ground.sec	Ground type data common to all units of the same type; Ground unit data including weapon holdings and values; Individual POMCUS unit breakout times

Table A.14

ORDERS AFFECTING THE OVERALL GROUND WAR

Order Types	Relevant Effects
Assign	Assignment of specific forces to theaters
Mobilize	Ordered increased training and readiness
Deploy	Movement of forces to and within theaters
Mission	Assignment of specific missions to selected ground units
Disperse	Order axes to a tactical nuclear dispersal posture

Table A.15

PARAMETERS AFFECTING THE OVERALL GROUND WAR

Table	Keyword	Relevant Effects
govt	gnd_mult	EED multiplier for all ground forces owned by a government
	tng_rate	Rate at which ground forces approach full readiness
	lang_mult	Multiplier of ground effectiveness when part of a multi-national force
	interopr_mult	Degree to which ground weapons are interoperable
region	gnd_mult	Analyst EED multiplier for all ground forces on an axis
	mob_mult	Analyst multiplier for mobilization rate in a region
axis	surp_mult	Force ratio multiplier while surprise lasts in a theater
	surp_time	Duration of analyst-scripted axis surprise
	ammo_max	Qty of munitions that can be delivered to an axis daily
	ammo_mult	Analyst multiplier for ammo_max
force	pomcus_delay	Set additional hours of delay for all POMCUS units beyond that specified in ground.sec.
	no_tng	Eliminate training from explicit cohesion calculations
ground	kill	Scripted attrition to ground forces
	mobilize	Scripted increase in ground force mobilization levels
	train	Scripted increase in ground forces training levels
	supply	Scripted increase in ground force on-hand munitions
landwar	home_mult	Multiplier of EDs when defending home country
	surp_mult	Force ratio multiplier while surprise lasts in a theater
	surp_time	Duration of analyst-scripted theater surprise
	tng_min	Minimum training level for deployment to a theater
	omg_disrupt	Effect of operational maneuver group (OMG) in disrupting FLOT forces
	abn_disrupt	Effect of airborne in disrupting FLOT forces
	oth_disrupt	Effect of airmobile in disrupting FLOT forces
logdata	atk_rate	Daily munition expenditure per ED when attacking
	def_rate	Daily munition expenditure per ED when defending or delaying
	pos_rate	Daily munition expenditure per ED when stalemated
	oth_rate	Daily munition expenditure per ED when not in contact
	agg_rate	Multiplier of expenditure rate when combat is intense
	roo_main	Days of supply authorized in main thrust axes
	roo_high	Days of supply authorized in high thrust axes
	roo_low	Days of supply authorized in low thrust axes
	rcn_rate	Maximum rate for replacing unit equipment losses
	iss_rate	Constraint on daily issue from war reserve material (WRM) stocks

Table A.15—continued

Table	Keyword	Relevant Effects
ppwrm	weapon	Script additional WRM into a theater
supply	gnd_owner	Script delivery of ground ammo for owner use only
	gnd_interop	Script delivery of ground ammo for owner or ally use
airwar	cas_disrupt	Disruption caused by CAS sorties
	bai_disrupt	Disruption caused by BAI sorties
unit	training	Change the training level of a specific unit
	convert	Order an airborne/airmobile unit to function as infantry
	delay	Cause a unit to be nondeployable for a specified time
	kill	Destroy a specified fraction of weapons in a unit
	pomcus_delay	Set delay for a specific POMCUS unit to break out
zone	barrier	Create barriers that affect defender's EEDs
	prepared	Build prepared defenses that affect defender's EEDs
	fortified	Build fortified defenses that affect defender's EEDs
	ratio	Defender effectiveness multiplier in force ratios

Table A.16

DATA FILES AFFECTING THE GROUND COMMANDER MODEL

Data Files	Relevant Contents
theater.sec	Default values for parameters

Table A.17

ORDERS AFFECTING THE GROUND COMMANDER MODEL

Order Types	Relevant Effects
Permit/Deny	Establish rules for national employment of forces
Position	Set objective position for an axis
Mission	Missions to ground forces proscribe GCM employment of them

Table A.18

PARAMETERS AFFECTING THE GROUND COMMANDER MODEL

Table	Keyword	Relevant Effects
ocl	on	Turn the GCM on for a theater
	off	Turn the GCM off for a theater
	enhance	Use special RSAS 3.0 enhanced GCM methodology
	adjust_efft	Specify delay before defense identifies main thrusts
	alt_plan	Name of a use file to submit if a wake-up should occur
	prefix	Specify a root name of an automatic use file sequence
	stop_day	Specify a day on which a wake-up is desired
	wake_off	Ignore all GCM-specified wake-ups
	wake_on	Wake up whenever GCM specifies
	atk_crit_loc	Attacker's axis objective position
	atk_wake_day	Attacker's axis time for reaching objective
	def_crit_loc	Defender's axis critical defense position
	def_wake_loc	Defender's axis wake-up position
	thrust	Specify an axis as main, high, or low thrust
	priority	Specify axis priority within a thrust class
	main_def_spd	Acceptable FLOT loss speed in main thrust axes
	main_div_day	Maximum divisions committable per day to main thrust axes
	main_rate_atk	Force ratio required for attack on main thrust axes
	high_def_spd	Acceptable FLOT loss speed in high thrust axes
	high_div_day	Maximum divisions committable per day to high thrust axes
	high_rate_atk	Force ratio required for attack on high thrust axes
	low_def_spd	Acceptable FLOT loss speed in low thrust axes
	low_div_day	Maximum divisions committable per day to low thrust axes
	low_rate_atk	Force ratio required for attack on low thrust axes
	min_main_atk	Lowest of two ratios used to determine if attack permitted
	min_atk_day	Number of days lowest ratio attacks are permitted
	min_rest_day	Number of days before lowest ratio is again usable
	max_main_atk	Highest of two ratios used to determine if attack is permitted
	max_int_days	Maximum days intense combat can last
	min_rsv_divs	Number of US/Soviet divisions withheld by GCM

Table A.19

DATA FILES AFFECTING THE AXIS COMMANDER MODEL

Data Files	Relevant Contents
theater.sec	Zone data defining military FLOT widths and military flanks; zone data defining terrain difficulty; standard division data

Table A.20

ORDERS AFFECTING THE AXIS COMMANDER MODEL

Order Types	Relevant Effects
Deploy	Only forces deployed to an axis are available to the axis commander model.

Table A.21

PARAMETERS AFFECTING THE AXIS COMMANDER MODEL

Table	Keyword	Relevant Effects
landwar	atk_density	Maximum FLOT density for attacking forces
	def_density	Maximum FLOT density for defending forces
	hld_density	Hold density for defending axes
	min_density	Minimum defender density with adequate reserves
	brk_density	Density at which defender suffers a breakthrough
	flank_dense	Relative density required on the exposed flanks of an axis
	axis_res	Fraction of axis maneuver forces normally in reserve
	arrive_delay	Delay after axis arrival before forces are available
	attk_pref	Desired cohesion level to commit a force to attack
	attk_min	Minimum cohesion level to commit a force to attack
	attk_repl	Level of cohesion at which it is desirable to replace an attacking unit
	attk_pull	Cohesion level at which an attacking unit is withdrawn
	def_pref	Desired cohesion level to commit a force to defense
	def_min	Minimum cohesion level to commit a force to defense
	def_repl	Level of cohesion at which it is desirable to replace a defending unit
	def_pull	Cohesion level at which a defending unit is withdrawn

Table A.22

ORDERS AFFECTING AXIS TACTIC SELECTION

Order Types	Relevant Effects
Attack	No combat in theater until at least one side attacks
Position	Establishes objective positions for ground forces
Mission	Explicitly orders tactics at various overlay positions
Terminate	No combat in theater after termination

Table A.23

PARAMETERS AFFECTING AXIS TACTIC SELECTION

Table	Keyword	Relevant Effects
landwar	atk_main	Minimum force ratio to attack on main thrust axes
	atk_rglr	Minimum force ratio to attack on other axes
	dfdr_flank	Maximum defender exposed flank before automatic withdrawal
	flank_lim	Maximum attacker exposed flank before automatic switch to defense
	can_atk	Minimum ratio of attack-capable forces to defender forces
	intns_ratio	Minimum force ratio to adjudicate an attack as intense combat
force	cover_break	Density required to resume defense after suffering a breakthrough

Table A.24

DATA FILES AFFECTING DEFENDER PREPARATIONS

Data Files	Relevant Contents
theater.sec	Peacetime barrier data from zone tables

Table A.25

ORDERS AFFECTING DEFENDER PREPARATIONS

Order Types	Relevant Effects
Mission	A mission of "dig-in" causes a unit to prepare defenses and await the arrival of the FLOT

Table A.26

PARAMETERS AFFECTING DEFENDER PREPARATIONS

Table	Keyword	Relevant Effects
zone	prepared	Orders construction of prepared defenses
	fortified	Orders construction of fortified defenses
	barrier	Instantaneous analyst scripting of barriers
logdata	prep_rate	Rate of construction of prepared defenses
	prep_left	Stock of material for construction of prepared defenses
	fort_rate	Rate of construction of fortified defenses
	fort_left	Stock of material for construction of fortified defenses
	dlib_deep	Doctrinal depth of deliberate defenses
	dlib_rate	Rate of construction of deliberate defenses
force	dlib_build	Sets the maximum FLOT speed for unit defense construction

Table A.27

DATA FILF ... CTING GROUND ATTRITION

Data Files	Relevant Contents
theater.sec	Defender loss rate curves or equation parameters; attacker exchange ratio curves or equation parameters; flank loss parameters; CAS, BAI, and attack helicopter equivalent sortie effectiveness data; target and lethal area data for tactical-nuclear adjudication

NOTE: Loss rates, exchange ratio data, and opposed FLOT movement rates are specified by posture: breakthrough, withdraw, delay, hasty, deliberate, prepared, fortified, meeting, pinning, or stalemate, plus two sets of curves used during the mop-up phase of an envelopment.

Target A.28

ORDERS AFFECTING GROUND ATTRITION

Order Types	Relevant Effects
Allocate	Distribute CAS support across axes; will be ignored if the ACM is on
Strike	Order conventional or nuclear air or missile strikes, or nuclear artillery strikes, against opposing axis forces

Table A.29

PARAMETERS AFFECTING GROUND ATTRITION

Table	Keyword	Relevant Effects
helos	hkill_atk	Vehicles killed per sortie in support of an attacker
	hkill_def	Vehicles killed per sortie in support of a defender
	hkill_oth	Vehicles killed per sortie in other postures
	hkill_inf	Nonvehicle weapons lost if target is infantry
	hvuln_atk	Losses per sortie supporting an attacker
	hvuln_def	Losses per sortie supporting a defender
	hvuln_oth	Losses per sortie in other postures
	hsort_atk	Sortie rate supporting an attack
	hsort_def	Sortie rate supporting defense
	hsort_oth	Sortie rate in other postures
	hmult_eff	General multiplier of effectiveness in all postures
	hmult_vul	General multiplier of losses per sortie in all postures
landwar	atr_int_mult	Multiplier of attrition when combat is adjudicated as intense
	cbt_timing	Vector distributing combat activity across six daily time steps
	flank_attrit	Attrition rate to forces on axis flanks
logdata	k_kill	Fraction of adjudicated kills that are nonreparable
	dep_repair	Fraction of adjudicated kills that must be evacuated for depot repair
	dep_days	Time required to repair equipment at depot
ppwrm	weapon	Scripted delivery of WRM stocks to a side in a theater
airwar	cas_attack	Vehicles killed per CAS sortie against an attacker
	cas_defend	Vehicles killed per CAS sortie against a defender
	cas_delay	Vehicles killed per CAS sortie versus forces in Delay or Withdraw posture
	cas_stale	Vehicles killed per CAS sortie when no attacker
	cas_no_cont	Vehicles killed per CAS sortie when no contact
	cas_inf	Ratio of infantry to vehicle weapon kills
	cas_tgting	Vector specifying CAS explicitly targeted against artillery and FARPs
	cas_arty	Vehicles killed per CAS sortie against artillery
	cas_farp	Attack helicopters killed per CAS sortie against FARPs
	bai_attack	Vehicles killed per BAI sortie against an attacker
	bai_defend	Vehicles killed per BAI sortie against a defender
	bai_delay	Vehicles killed per BAI sortie versus forces in Delay or Withdraw posture
	bai_stale	Vehicles killed per BAI sortie when no attacker
	bai_no_cont	Vehicles killed per BAI sortie when no contact
	bai_inf	Ratio of infantry to vehicle weapon kills
	bai_tgting	Vector specifying BAI explicitly targeted against artillery and FARPs
	bai_arty	Vehicles killed per BAI sortie against artillery
	bai_farp	Attack helicopters killed per BAI sortie against FARPs

Table A.30

DATA FILES AFFECTING FLOT MOVEMENT

Data Files	Relevant Contents
theater.sec	Opposed FLOT movement rate curves; zone difficulty-of-movement data; theater maximum movement rate

Table A.31

ORDERS AFFECTING FLOT MOVEMENT

Order Types	Relevant Effects
Disperse	Nuclear dispersal densities may affect movement

Table A.32

PARAMETERS AFFECTING FLOT MOVEMENT

Table	Keyword	Relevant Effects
helos	hel_hr_delay	Hours of delay one attack helicopter sortie causes a moving one-ED force
airwar	cas_hr_delay	Hours of delay one CAS sortie causes a moving one-ED force
	bai_hr_delay	Hours of delay one BAI sortie causes a moving one-ED force
	low_flot	Minimum FLOT speed below which air cannot slow it further
landwar	vel_int_mult	Multiplier of FLOT movement during intense combat
	cbt_timing	Vector dividing combat activity among six four-hour time-steps per day
	hld_density	FLOT density above which hold density multiplier obtains
	min_density	FLOT density below which movement rate increases above curves
	brk_density	FLOT density at and below which a breakthrough is adjudicated
	adv_mult	Scripted analyst multiplier of FLOT movement rate
zone	velocity	Zonal FLOT movement rate multiplier
axis	advance	Analyst-scripted FLOT movement

Table A.33

DATA FILES AFFECTING REAR AREA FORCE MOVEMENT

Data Files	Relevant Contents
theater.sec	Rear area basic movement rate; zone overlay structure (connectivity/network/capacities)

Table A.34

ORDERS AFFECTING REAR AREA FORCE MOVEMENT

Order Types	Relevant Effects
Deploy	Causes force to move across the LOC network
Mission	May result in implied Deploy orders
Plan/Strike	Interdiction delays movement of struck forces; attacks on THTR_loc damage LOCs and restrict capacity

Table A.35

PARAMETERS AFFECTING REAR AREA FORCE MOVEMENT

Table	Keyword	Relevant Effects
landwar	rear_speed	Basic movement rate on the rear network
zone	thruput	Number of longitudinal "divisional" roads in a zone
	crossput	Number of latitudinal "divisional" roads in a zone
	locdelay	Script a delay in a zone before any force therein can move
	locvuln	Vulnerability of a zone's LOCs to damage
	locrepair	Speed with which a zone's LOCs recover from damage
	locquality	Multiplier of standard speed in a specified zone

Table A.36

DATA FILES AFFECTING REAR AREA FORCE INTERDICTION

Data Files	Relevant Contents
theater.sec	Standard aircraft air-to-ground effects data
air.sec	Air-to-ground mission effectiveness scores by aircraft type and load
weapon.sec	Effects of standard killer and air-to-ground munitions

Table A.37

PARAMETERS AFFECTING REAR AREA FORCE INTERDICTION

Table	Keyword	Relevant Effects
airwar	bai_tgting	Vector of BAI targeting allocations
	bai_attack	Vehicles killed per BAI sortie against moving targets
	bai_no_cont	Vehicles killed per BAI sortie against forces in assembly areas
	bai_disrupt	Nonlethal disruption effects on FLOT forces of a BAI sortie
	bai_inf	Multiplier of systems killed per sortie when target is an infantry unit
	bai_hr_delay	Hours delay one BAI sortie causes a moving force of one ED

Table A.38

DATA FILES AFFECTING REAR AREA BATTLE ADJUDICATION

Data Files	Relevant Contents
theater.sec	Rear battle adjudication factors; envelopment adjudication curves

Table A.39

ORDERS AFFECTING REAR AREA BATTLE ADJUDICATION

Order Types	Relevant Effects
Mission	Causes envelopments and OMG/airborne/air-assault insertions

Table A.40

PARAMETERS AFFECTING REAR AREA FORCE BATTLE ADJUDICATION

Table	Keyword	Relevant Effects
landwar	omg_tactics	Perceived force ratio needed to attempt insertion
	omg_ratio	Force ratio needed for insertion to succeed
	omg_cas	CAS needed to defeat insertion
	omg_rsrv	Reserves needed to defeat insertion
	omg_kill	Loss to defenders when OMG successfully inserts
	omg_loss	Loss to OMG in successful insertion
	omg_fail	Loss to OMG in failed insertion
	omg_adv	Distance behind FLOT to which OMG deploys
	omg_air_wgt	Weighting factor for diverting CAS against OMG
	omg_defeat	Cumulative losses that defeat an OMG
	omg_disrupt	Effect of an OMG in disrupting FLOT forces
	omg_duration	Time an OMG can survive without relief
	omg_ed_kill	FLOT EDs killed per ED of OMG
	omg_ex_ratio	Exchange ratio of OMG forces to defending forces
	omg_log_kill	Kills of defender logistics by OMG
	abn_air_wgt	Weighting factor for diverting CAS against airborne
	abn_defeat	Cumulative losses that defeat airborne operation
	abn_disrupt	Effect of airborne forces in disrupting FLOT forces
	abn_duration	Time an airborne force can survive without relief
	abn_ed_kill	FLOT EDs killed per ED of airborne forces
	abn_ex_ratio	Exchange ratio of airborne forces to enemy forces
	abn_log_kill	Kills of defender logistics by airborne forces
	abn_ldg_kill	Landing zone (LZ) losses of airborne forces
	oth_air_wgt	Weighting factor for diverting CAS against airmobile forces
	oth_defeat	Cumulative losses that defeat airmobile operation
	oth_disrupt	Effect of airmobile forces in disrupting FLOT forces
	oth_duration	Time an airmobile force can survive without relief
	oth_ed_kill	FLOT EDs killed per ED of airmobile forces
	oth_ex_ratio	Exchange ratio of airmobile forces to enemy forces
	oth_log_kill	Kills of defender logistics by airmobile forces
	oth_ldg_kill	LZ losses of airmobile forces

Table A.41

DATA FILES AFFECTING TACTICAL MOVEMENT

Data Files	Relevant Contents
theater.sec	Locations of first- and second-echelon lines

Table A.42

ORDERS AFFECTING TACTICAL MOVEMENT

Order Types	Relevant Effects
Mission	Can be used to order forces to prepare rear positions or to order delay missions that change movement technique
Plan/Strike	BAI/Interdiction sorties delay movement of attacked forces

Table A.43

PARAMETERS AFFECTING TACTICAL MOVEMENT

Table	Keyword	Relevant Effects
landwar	arrive_delay	Delay after unit arrival at axis before axis commander can employ it
	night_only	Only night movement allowed if this parameter is set

Table A.44

DATA FILES AFFECTING AXIS LOGISTICS

Data Files	Relevant Contents
theater.sec	Basic log tail support and movement data

Table A.45

PARAMETERS AFFECTING AXIS LOGISTICS

Table	Keyword	Relevant Effects
logdata	tail_atk	Maximum length tail can be to start an attack
	tail_spd	Maximum rate at which the tail can move as the FLOT does
	tail_max	Maximum tail length to support an ongoing attack
	tail_min	Minimum tail length

Appendix B
CREATING AN ANALYTIC WAR PLAN

WHY WRITE AN AWP?

Every RSAS release includes a set of AWPs that provides at least minimal coverage for all modeled theaters. For many users and purposes, however, these will not be adequate; analyst plans and interpreted functions are meant to help bridge this gap. It may, however, be desirable to "concretize" the decisions and decision criteria of human players in an RSAS-supported game by recording them in an AWP, thus allowing for replay of or excursions from the game itself. At some point, then, it is useful to codify the contents of analyst plans and interpreted files into one or more AWPs, thereby making them a permanent part of the RSAS itself.

Whether or not it is worthwhile to create a new AWP will depend primarily upon the nature of the changes contained in the analyst plans and interpreted files. If, for example, the modifications consist largely of changes to force names (perhaps because of use of an out-year database), it may be sufficient to incorporate the new data items into an existing plan that is based upon the same strategy as that employed in the analysis.

However, an AWP is meant to represent a particular operational strategy; this means that different strategies should be put in different AWPs. For example, the standard RSAS AWP package includes separate plans for mobilized and unmobilized–Warsaw Pact attacks into Western Europe; likewise, there could be two plans for USCENTCOM reflecting different levels of U.S. commitment to the defense of the Persian Gulf. If the strategy employed by either side in any theater is sufficiently at variance with those encompassed by existing AWPs, it should be written up as a separate plan.[1]

[1]Obviously, one could build an AWP incorporating many concepts of operations, using case statements and parameter settings to select among them; this approach was considered early in the RSAS development. It was decided, however, that the plan constructed in such a manner would be much less transparent to those trying to concentrate on operational-level issues; it would also be difficult to modify and maintain. Hence, the one-strategy, one-AWP approach.

BUILDING AN AWP

We cannot describe here how to correctly write, debug, and use a new AWP; the ones found in the RSAS should be used as templates and order functions cannibalized wherever possible.[2] We would like to suggest several points of caution, however.

First, adding an AWP means making substantial changes to the RAND-ABEL data dictionary. Even if no global variables are added to those already defined,[3] declarations must be included for all the functions defined in the new plan. *It is important not to duplicate the name of any existing function or global variable.* Such a slipup will cause any attempt to compile or run the RSAS to fail. Also bear in mind that remaking the RSAS data dictionary takes four to six hours depending upon machine configuration.

A declaration of the new plan's name must also be added to the appropriate file. If the plan is for the USSR, add its name to the enumeration "type-AWP" in the file Src/AWP/Red/Dict/type.D;[4] if it's a Blue plan, add the name to the list in Src/AWP/Blue/Dict/type.D. Again, *be sure that the plan name chosen is unique.*

The system now needs be told where to find the source file for the new plan when it compiles the AWPs. In the directory Src/AWP/Make are a group of files with names like "include1.A."[5] Search these files to find where the other plans for the theater being worked with have been listed; for example, if a plan for AFCENT is being added, find something like the following in one or another of the include files:

```
Include "../../Blue/afcent0.A"
Include "../../Blue/afcent1.A"
Include "../../Blue/afcent2.A"
Include "../../Blue/afcent3.A"
Include "../../Blue/afcent4.A"
```

Simply add the name of the file containing the new AWP to this list.

Finally, the new AWP must be plugged into the functions that actually start the plans at the beginning of an RSAS run. *The in-*

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[2]Forthcoming RAND research will address this problem.

[3]There should be little need to do so.

[4]By convention, all RAND-ABEL data dictionary file names end in the suffix ".D".

[5]By convention, all RAND-ABEL source file names end in the suffix ".A".

structions given here are appropriate only if the RSAS is being run in user-generated mode. Other changes must also be made if you intend to use either of the automated national command level models.

To ensure that the plan will run, a line for it must be added to the decision table found in the function "Start-new-plan". There are actually two functions by that name, one each for Red and Blue. The former is found in the file Src/Interface/to-AWP/red.A, the latter in the file blue.A in the same directory.

Figure B.1 shows a sample entry in the Start-new-plan table. There are five entries required for each plan in the table:

- *name:* This is the name given to the new plan (e.g., AFCENT9, HCFSW4).
- *plan-beginning:* The name of the first function to run when the plan is started, such as (function Plan-AFCENT9); make sure to use the word "function" before the name and enclose the entire entry in parentheses.
- *plan-string:* Usually the same as the *name*, only enclosed in quotation marks ("AFCENT9").
- *cmd-id:* The command with which the plan is associated, such as AFCENT, JCS, or NWCOM.
- Finally, the *lookahead function:* Since the automated NCL models are not run in user-generated mode, simply put two dashes (--) in this column.

```
Decision Table
                                         plan-       cmd-    lookahead-
name    /  plan-beginning                string      id      function
------- /  ----------------------        ---------   ------  ----------
AFCENT9    (function Plan-AFCENT9)       "AFCENT9"   AFCENT  --
```

Fig. B.1—Plan entry in Start-new-plan

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