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TECHNICAL PAPER
CAA-TP-74-7

# GREATER DISTINCTION BETWEEN COMBAT MODULES IN WAR GAMES

## FINAL REPORT

SEPTEMBER 1974

PREPARED BY
WAR GAMING DIRECTORATE

US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20014

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents. Comments or suggestions should be addressed to:

Commander
USA Concepts Analysis Agency
ATTN: Director, War Gaming
8120 Woodmont Avenue
Bethesda, MD 20014

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| | |
|---|---|
| Theater-level Model | AMMORATES Methodology |
| Model hierarchy | Theater Rates Model |
| Combat modules | Assessment of Theater Warfare (ATWAR) Model |
| Combat samples | CONTACA Model |
| Measures of effectiveness | Tactical decision logic & Tactical air support |

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

This document reports an in-house study effort by USACAA to achieve greater distinction between combat modules in war games by developing a theater-level model of air and ground combat which is not force ratio dependent. Several approaches were explored. The most fruitful proved to be that of a model hierarchy which extrapolates to theater-level the results of manually arrayed combat samples and computerized high resolution, low level models operating on basic weapon performance parameters. The simulation, called the Assessment of Theater Warfare (ATWAR) Model, also integrates a tactical air routine, CONTACA, to portray over

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20. Abstract. (cont'd) air/ground interactions. A tactical decision logic based on user selected criteria determines posture of engaged units and conditions for FEBA movement. ATWAR is closely bound to the manually arrayed combat samples and is highly sensitive to the tactical decision criteria. However, assuming an inventory of combat samples needed for other CAA studies and user familiarity with the tactical decision criteria, ATWAR provides a rapid, realistic simulation of theater air/ground combat that does not depend on aggregated weapons scores or force ratios to assess losses and move the FEBA.

TECHNICAL PAPER
CAA-TP-74-7

# GREATER DISTINCTION BETWEEN COMBAT MODULES IN WAR GAMES

SEPTEMBER 1974

PREPARED BY

WAR GAMING DIRECTORATE

US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20014

FOREWORD

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MOCA-WGP

30 September 1974

MEMORANDUM THRU: CHIEF OF STAFF
TECHNICAL DIRECTOR

FOR: COMMANDER, CAA

SUBJECT: Transmittal of Technical Paper, "Greater Distinction between Combat Modules in War Games"

1. Transmitted herewith is Technical Paper, CAA-TP-74-7, "Greater Distinction between Combat Modules in War Games."

2. The inclosure is the final report on this War Gaming Directorate in-house study project and completes the tasks assigned in the 22 June 1973 tasking directive.

3. The purpose of the study was to develop approaches for the assessment of combat module engagement outcomes which will permit the elimination of the use of a single number, aggregated measure of effectiveness in computerized theater-level models. This goal was achieved by the development of the Assessment of Theater Warfare (ATWAR) Model. The ATWAR Model is the principal product of this study. The hierarchical concept used in the ATWAR Model to simulate theater-level air/ground combat is described in the inclosure.

1 Incl
as

Joseph S. Murphy
JOSEPH B. MURPHY
Colonel, Infantry
Director, War Gaming

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FDCA-ZA 22 June 1973

SUBJECT: Study: Greater Distinction Between Combat Modules in War Games

MEMORANDUM FOR: DIRECTOR, WAR GAMING

1. PURPOSE. To develop approaches for the assessment of combat unit engagement outcomes which will permit the elimination of the use of a single number aggregated MOE in theater level models.

2. REFERENCES.

a. Weapons Systems Evaluation Group Report 165, Methodologies for General Purpose Planning, Volume X, Fire Power Score Review; April 1971, by Jacob A. Stockfish.

b. DA-OUSA letter to OASD(SA), subject: The COMCAP Study and the Problem of Inputs to Theater Level Games, 18 December 1972.

c. DAFD/Scientific Advisor's letter to BG Hallgren, subject: Weapon Effectiveness Indicators (WEI) and Weighted Unit Values (WUV), 23 February 1973.

d. CAA letter of reply to DAFD/Scientific Advisor, same subject, March 1973.

e. USACDC Pamphlet No. 71-1, "Force Developments, The Measurement of Effectiveness," January 1973, UNCLASSIFIED.

3. STUDY SPONSOR. Concepts Analysis Agency.

4. STUDY AGENCY. War Gaming Directorate, US Army Concepts Analysis Agency will perform the study.

5. CAA STUDY MONITOR: CAA Technical Review Board.

6. TERMS OF REFERENCE.

a. Problem. Most of the CAA theater-level war gaming models utilize some form of aggregated measures of force effectiveness (MOE) which are in turn converted to force ratios which determine losses and rates of advance. None of the aggregated MOE are well accepted by gamers and study users. There is a need for further research and analyses to develop more satisfactory methodologies for:

(1) Assessment of unit engagement outcomes based upon objective measures of the capabilities of combat modules (battalion level task forces) to carry [illegible] combat operations under a variety of situations and environmental [illegible]ions.

(2) Generating realistic FEBA movement rates and loss rates.

(3) Quantifying and incorporating into simulations the effects of planned defensive barriers, logistic constraints, and other combat variables.

b. Objective.

(1) Develop new approaches for the assessment of unit engagement outcomes in theater-level models which do not use single valued MOE for each weapon or unit.

(2) Modify a current theater-level model such as ATLAS or CEM to accept the new methodology to yield greater validity and to retain responsiveness and utility.

(3) Determine the sensitivity of the new methodology incorporated into the theater-level models to the assumptions, estimates, and judgments inherent in the methodology.

c. Scope. Review the references in detail and accomplish the following tasks:

(1) Review of current direct approaches to assessment of losses of personnel, weapons, and equipment. This will include the identification of those factors which are most important in driving the models used in CAA studies.

(2) Review field test and experimentation data and other approaches to obtaining realistic estimates of the relative effectiveness of weapons and units.

(3) Develop relationship between battle outcomes and movements considering barriers, force levels, missions, environments, and other variances.

(4) Modify or restructure the current ATLAS or CEM theater-level model to accept the new data.

(5) Investigate the sensitivity of the newly-developed approach to its assumptions, estimates, and judgments by conducting a series of war games with the modified theater-level model.

d. Time frame. The time frame of interest is 1974-1986.

e. Limits. All techniques and data considered in the study will be limited to nonnuclear mid-intensity conflicts oriented toward a war in Europe dominated by armor, and a war in Northeast Asia dominated by personnel. The "NATO First" Scenario will be used.

f. Assumptions.

(1) Sufficient operations research trained personnel will be made available to accomplish the required tasks in the time allotted for the study.

(2) Sufficient programmers will be made available to make the necessary changes to the theater-level model selected for modification.

(3) CAA will monitor those field tests being conducted by CDEC, TECOM, or MASSTER in order to obtain the specific kinds and quantities of data needed to support this project.

g. Essential Elements of Analysis (EEA).

(1) Are there direct approaches to the assessment of losses of personnel, weapons and other equipment which will permit the elimination of the use of a single number aggregated MOE in theater-level models?

(2) Are there field test results available which make comparisons of small units, multiple armored vehicle engagements, combined arms team mixes in a variety of missions, weather, terrain and scenario situations?

(3) Can the relationship between battle outcomes and movements at lowest engagement levels be extrapolated to higher levels, considering barriers, force levels, missions, environments, and other variables?

(4) Can the ATLAS, CEM, or TARTARUS models be modified to accept the new data and approach to yield more credible movement and losses and yet retain the capability to respond rapidly?

(5) Is the new approach, when applied in the modified theater-level models, more valid and objective than current theater-level models?

h. Models.

(1) Consideration will be given to using low level simulation models, such as CARMONETTE, BONDER/IUA, and the AMMORATES models in tasks 1, 2, and 3 listed in the scope.

(2) The ATLAS, TARTARUS, and CEM models will be considered for modification and utilized in tasks 4 and 5 listed in the scope.

7. ENVIRONMENT/THREAT GUIDANCE. The environment is limited to mid-intensity combat in the mid-range time period in Central Europe and Northeast Asia. The "NATO First" Scenario will be used.

8. SUPPORT AND RESOURCE REQUIREMENTS

a. War Gaming Directorate, CAA, will conduct qualitative and quantitative investigation of possible new approaches for the assessment of unit engagement outcomes in theater-level models as described in the terms of reference.

b. Methodology and Resources Directorate will provide analytical and programming assistance.

c. DAFD/OTEA provide guidance, information and design and direct the conduct of additional field tests if directed by DAFD to support the accomplishment of the study. However, such a contingency would require a major reorientation and restructuring of this study.

9. ADMINISTRATION

a. The study title is: Greater Distinction Between Combat Modules in War Games. The short title is ORDER-N-74.

b. Study schedule is as follows:

(1) Initiation of study action of CAA special project team - July 1973.

(2) Quarterly IPR by CAA Technical Review Board

(3) Study Report NLT 30 June 1974

c. Control Procedures. Control over the project will be exercised by the CAA Technical Review Board.

d. Study Format. The study will be documented in detail. The format will be at the discretion of the Director, War Gaming.

e. Action Documents. Interim progress can be reported through the quarterly interim progress report briefings to the CAA Technical Review Board. The principal action document will be the final report of the study.

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HAL E. HALLGREN
Brigadier General, USA
Commanding

| RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY | 1. AGENCY ACCESSION* | 2. DATE OF SUMMARY* | REPORT CONTROL SYMBOL DD-DR&E(AR)636 |
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| 10. NO./CODES:* | PROGRAM ELEMENT | PROJECT NUMBER | TASK AREA NUMBER | WORK UNIT NUMBER |
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| a. PRIMARY | | | | |
| b. CONTRIBUTING | | | | |
| c. CONTRIBUTING | | | | |

11. TITLE (Precede with Security Classification Code)*

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17. CONTRACT/GRANT

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b. NUMBER:*

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e. KIND OF AWARD: f. CUM. AMT.

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19. RESPONSIBLE DOD ORGANIZATION

NAME:* US Army Concepts Analysis Agency

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PRINCIPAL INVESTIGATOR (Furnish SSAN if U.S. Academic Institution)

NAME:* LTC Zach Hagedorn

TELEPHONE: 295-1676

SOCIAL SECURITY ACCOUNT NUMBER:

ASSOCIATE INVESTIGATORS

NAME:

NAME:

21. GENERAL USE

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Yes

22. KEYWORDS (Precede EACH with Security Classification Code)

23. TECHNICAL OBJECTIVE,* 24. APPROACH, 25. PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code.)

23. (U) To develop approaches for the assessment of combat unit engagement outcomes which will permit the elimination of single valued aggregated MOE for weapons and units in theater-level war games.

24. (U) The following tasks are to be accomplished.

a. Review current direct approaches to engagement assessments.

b. Review field tests and simulations to obtain realistic estimates of the relative effectiveness of weapons and units.

c. Develop relationship between battle outcomes and movements considering barriers, force levels, and missions.

d. Modify a current theater level model to accept the new data and algorithms.

e. Conduct a sesitivity analysis of the new approach using the modified theater level model.

25. (U) The study is to be initiated in July 1973 and completed by 30 June 1974, unless a requirement for field tests should develop in which case the study will be reoriented and restructured.

*Available to contractors upon originator's approval.

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## SUMMARY


1. Introduction

a. Background. - This technical paper reports the work conducted by War Gaming Directorate, US Army Concepts Analysis Agency (USACAA), on the in-house study "Greater Distinction between Combat Modules in War Games." This study was initiated on 22 June 1973 with the signing of the tasking directive by MG Hal E. Hallgren, Commander, USACAA. At the time of initiation of the study, the computerized theater-level war gaming models in use by USACAA employed various forms of aggregated weapons scores and force ratios to assess the outcomes of simulated combat engagements. This approach, although prevalent in the war gaming community, is not well accepted by gamers or by study users. Therefore, this study was performed to seek a new approach as defined in the purpose and objectives cited below.

b. Purpose. - The purpose of this study is to achieve greater distinction between combat modules in war games by developing approaches for the assessment of combat unit engagement outcomes which will permit the elimination of the use of the single number, aggregated measure of effectiveness/force ratio mechanism that drives current theater-level models.

c. Objectives. - The tasking directive set the following objectives:

(1) Develop a new approach that eliminates the single valued, aggregated measure of effectiveness(MOE).

(2) Modify a current theater-level model to accept the new approach.

(3) Determine the sensitivity of the new methodology to its inherent assumptions, estimates and judgments.

d. Assumption. - It is assumed that there will be a continuing need for the Nonnuclear Ammunition Combat Rates Programing Studies produced for Department of the Army by the USACAA Ammo Rates Group.

e. Essential Elements of Analysis (EEA). - The EEA are normally part of the introductory material, but for conciseness

they are listed with the responses to EEA in paragraph 6 of this Summary.

2. Approaches. - Three approaches toward the problem of eliminating the aggregated MOE/force ratio concept from theater models were explored. They are summarized below.

a. Develop loss assessments and movement rates for the ATLAS*, CEM**, or TARTARUS computerized theater-level air/ground combat models from basic weapons performance parameters.

b. Apply a multi-MOE concept that would employ a set of ratios grouping weapons according to general characteristics--a ratio for area fire weapons, one for small arms, and one for direct fire tank/antitank weapons.

c. Develop a hierarchical approach to extrapolate to theater level the results of low level, high resolution models simulating combat module interactions.

3. Approach Selection

a. The first of the three approaches cited above proved impracticable. When this study began in August 1973, CEM was found not to be sufficiently operational at USACAA to permit this type of investigation, and TARTARUS was in a state of disuse. The ATLAS was found to be deeply enmeshed in the aggregated MOE/force ratio mechanism, and to have it operate on basic weapons performance parameters meant creating an essentially new model. The Weapons Systems Evaluation Group and the Institute for Defense Analyses already had similar efforts well under way.

b. Instead, an approach to modify ATLAS was undertaken using the set of three ratios cited in paragraph 2b above. Each of the three ratios involved the relationship:

$$\frac{\text{Attacker weapons/potential targets}}{\text{Defender weapons/potential targets}}.$$

Historical data from 60 battles of the WW II Italian Campaign were used to attempt to correlate movement rates with these ratios.

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*ATLAS: A Tactical, Logistical, and Air Simulation

**CEM: Concepts Evaluation Model

Little correlation was found, and the approach was discarded.

c. The most fruitful approach, and the one adopted, was that of a model hierarchy. The methodology of the Nonnuclear Ammunition Combat Rates (AMMORATES) Programing uses a set of manually gamed combat samples to establish the level of combat intensity through a day of combat. A group of low level, high resolution submodels using basic weapons performance data assesses casualties and losses and calculates ammunition expenditures. The results are extrapolated to theater level by a Theater Rates Model. This hierarchy does not include FEBA movement, an organic tactical air support routine, terrain, or logistics. The Theater Rates Model was restructured, and the missing features were added. The result was the principal product of this study--the ATWAR (Assessment of Theater Warfare) Model, a comprehensive simulation of theater-level air/ground combat. The ATWAR Model is based upon basic weapons performance data, military judgment, and an automated tactical decision logic, rather than aggregated firepower scores and force ratios.

4. ATWAR Model

a. Structure. - The ATWAR Model has a hierarchical structure. The foundation of the structure is a set of combat samples. The set consists of eight levels of combat activity, or postures, for engaged Blue forces against a Red Combined Arms Army during 12 hours of combat, and the same eight postures for Blue against a Red Tank Army. From these samples, gamers determine the type and frequency of combat at platoon and company level in the engaged forces. The submodels of the Nonnuclear Ammunition Combat Rates Methodology operate on that data and on weapons performance data to assess personnel and equipment losses and ammunition expenditures in a single period of ground combat. These are basic inputs to ATWAR, and it is assumed that they will be available through the AMMORATES Programing.

b. Geometry. - The ATWAR Model divides the theater into 10 parallel sectors or less, Combined Arms Army or Tank Army sectors on the Red side, Corps or smaller sectors on the Blue side. The engaged forces are separated by a FEBA which moves independently in each sector in a direction parallel to that of the sector boundaries. Terrain is defined in four categories which are laid out chessboard fashion across the battlefield. The locations of good defensive terrain are further identified as "defensive positions" for use in the tactical decision logic described below.

c. Tactical Decision Logic - The posture of opposing forces in each sector is determined by a tactical decision logic based upon user selected decision point criteria. The decision point is that fraction of a critical item of equipment or personnel strength below which the sector force cannot continue to maintain its existing posture. When a force falls below this point, it changes to a less aggressive posture, and its opponent changes to a corresponding more aggressive posture. If the change is from defense to delay, the force delays to the next defensive position where it will again attempt to defend. Movement rates in delay and withdrawal postures are stored in a lookup table indexed by terrain type and by posture.

d. Logistics. - A simple logistics routine allows onhand ammunition stocks and transportation assets to affect the attrition process. If consumption of ammunition exceeds throughput capacity, causing unit stockage to fall below input stockage objective levels, the rate of attrition due to the type(s) of ammunition in short supply is reduced in direct proportion to the shortage. Logistics also affects the ground war by means of a repair cycle routine which returns a fraction of equipment losses to action after an appropriate delay.

e. Tactical Air Support

(1) General. - The CONTACA*, a USACAA developed tactical air sortie and mission generator model, was integrated into ATWAR and modified to achieve an organic air/ground interface. The number of effective tactical air sorties on a daily basis is computed in CONTACA for the entire theater. A fraction of this is assigned to the land battle under investigation and transmitted into the ATWAR assessments routine where combat elements killed by effective sorties are computed and subtracted from sector forces.

(2) Mission Allocation. - The CONTACA Model simulates six aircraft types performing eight types of missions: (1) interceptor or escort, (2) counterair, (3) airbase attack, (4) interdiction, (5) close air support, (6) armed reconnaissance, (7) unarmed reconnaissance and (8) transport. Gamer inputs provide the allocation of available sorties to missions for the duration of the campaign. This may be modified by a user option which permits the mission allocation to change if FEBA displacement exceeds preset intervals.

(3) Sector Allocation. - The allocation of close air support and armed reconnaissance sorties to the various sectors

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*CONTACA: Conventional Tactical Air Model is a user option. Sorties may be allocated evenly to all sectors; a specified fraction may be allocated to one sector on the basis of FEBA displacement and the remainder, evenly to all sectors; or a specified fraction may be allocated to one sector on the basis of strength in a user specified equipment item, including personnel, and the balance, evenly to all sectors.

(4) Interdiction. - The application of interdiction missions may also influence the ground campaign by causing a degradation of the amount of ammunition flowing through the logistics networks.

(5) Ground/Air Interactions. - By the exercise of the various options described above, the user has a unique opportunity to examine the synergistic relationship between air and ground combat.

f. Replacements. - The ATWAR Model simulates a policy of individual replacement of men and equipment for the Blue side and a combination of individual and unit replacement for Red. Red and Blue assets available for individual replacement are specified in the input data in terms of numbers per day. The ATWAR Model then replaces losses of personnel and equipment up to that specified number. If replacements are not sufficient to replace all losses, the replacements are distributed in proportion to shortfall by sector. If there are replacement divisions available in theater reserve, Red divisions are replaced when their user specified assets fall below a user specified breakpoint criterion.

g. Model Outputs. - The following data is output by ATWAR by combat cycle (12-hour period), by day, at campaign conclusion, or at other gamer specified intervals:

(1) FEBA location by sector.

(2) Total casualties and ground weapons systems losses by cause, including those to tactical air.

(3) Status of ground weapons systems by type, including personnel, and by sector.

(4) Tactical air availability, aborts, actual launches and losses by aircraft type, by wave, and by day.

(5) Tactical air effective sorties by mission allocation, type aircraft, wave, day, and sector.

(6) Status of aircraft following each wave commitment.

(7) Data that would permit calculation of ammunition expenditures if needed.

h. Sequence of Operations. - The sequence in which ATWAR employs its component routines to simulate theater warfare is shown in the flow chart, Figure 1.

5. ATWAR Sensitivities. - A set of test runs of the ATWAR Model was conducted to investigate its sensitivity to the assumptions, judgments and estimates inherent in its design. The basic attrition data used in the tests was derived from the latest published Non-nuclear Ammunition Combat Rates Programing adjusted to the ATWAR matrix of postures and 12-hour combat periods. Tests were conducted varying the following inputs:

a. Equipment and personnel replacement rates.

b. Level of close air support.

c. Tactical air deployment options.

d. Location and number of defensive positions on the terrain.

e. Maintenance cycle data.

f. Tactical decision criteria.

Results of these variations are displayed in Chapter IV. The ATWAR Model was found to be highly sensitive to the tactical decision criteria.

6. Responses to Essential Elements of Analysis. - The EEA and responses thereto are summarized below:

a. EEA 1: Are there direct approaches to the assessment of losses of personnel, weapons, and other equipment which will permit the elimination of the single number, aggregated measure of effectiveness in theater-level models?

Yes. ATWAR, the COMCAP Studies, VECTOR 1 and LULEJIAN I achieve this goal by different approaches.

b. EEA 2: Are there field test results available which make comparisons of small units, multiple armored vehicle engagements, and combined arms team mixes in a variety of missions, weather, terrain, and scenario situations?

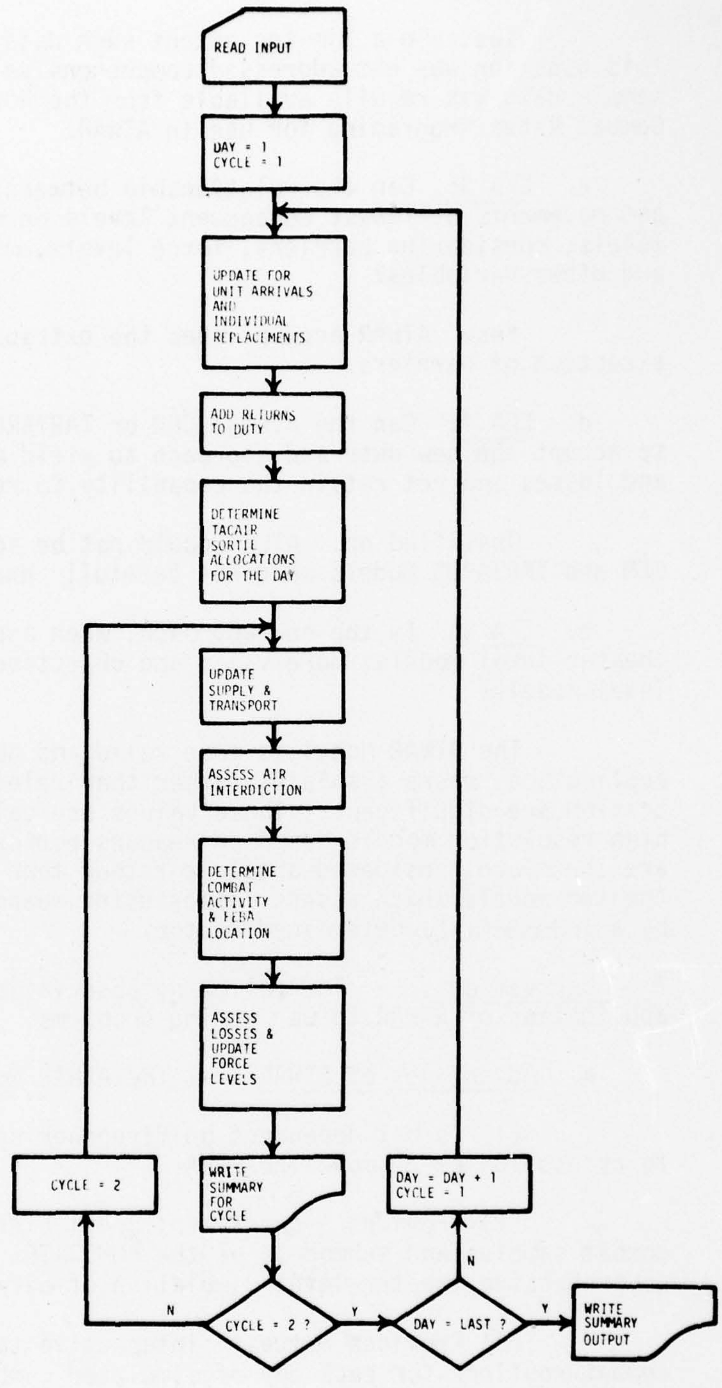


**FIGURE 1, ATWAR Model Flow Chart**

Yes. To a limited extent such data is available, but this question was not addressed comprehensively bacause the combat sample data was readily available from the Nonnuclear Ammunition Combat Rates Programing for use in ATWAR.

c. EEA 3: Can the relationship between battle outcomes and movements at lowest engagement levels be extrapolated to higher levels, considering barriers, force levels, missions, environments, and other variables?

Yes. ATWAR accomplishes the extrapolation with the exception of barriers.

d. EEA 4: Can the ATLAS, CEM or TARTARUS Models be modified to accept the new data and approach to yield more credible movement and losses and yet retain the capability to respond rapidly?

Qualified no. ATLAS could not be so modified. The CEM and TARTARUS Models were not carefully examined in this study.

e. EEA 5: Is the new approach, when applied in the modified theater-level models, more valid and objective than current theater-level models?

The ATWAR Model is more valid and objective in those applications where absolute, rather than relative, values of attrition are significant. These values are calculated in low level, high resolution models based on weapons performance data. They are therefore considered absolute rather than relative as in those theater models which assess losses using weapons scores adjusted by a judgmentally determined factor.

7. Observations. - The following observations pertain to the application of ATWAR to war gaming problems:

a. Advantages of ATWAR. - The ATWAR Model--

(1) Is not dependent on firepower scores or force ratio to assess losses or move the FEBA.

(2) Provides a consistent model hierarchy linking the combat samples and submodels of the AMMORATES Methodology to a comprehensive theater-level simulation of air/ground combat.

(3) Provides mutually interactive tactical air and ground combat routines for each day of simulated combat.

(4) Provides very rapid simulation of theater combat--about 1 second of CPU time per day of combat and 1 or 2 technical man-days of setup time--assuming the availability of combat samples and AMMORATES submodel outputs.

b. Limitations of ATWAR. - The ATWAR Model--

(1) Is closely bound to the matrix of manually gamed combat samples, inferring setup times for new situations not previously gamed.

(2) Has no logic for automatically committing the reserve.

(3) Has no logic for creating new sectors during a campaign.

(4) Does not simulate envelopments or other flank engagements.

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# GREATER DISTINCTION BETWEEN COMBAT MODULES IN WAR GAMES

## CHAPTER I
## INTRODUCTION

1. Purpose. - The purpose of this study is to achieve greater distinction between combat modules* in war games by developing approaches for the assessment of combat unit engagement outcomes which will permit the elimination of the use of a single number, aggregated measure of effectiveness (MOE) in theater-level models. All of the computerized theater-level war gaming models used by the US Army Concepts Analysis Agency (USACAA) at the time of initiation of this study, as well as those known to be used elsewhere in the war gaming community, employed some form of aggregated measure of effectiveness to assess combat engagement outcomes.[1, 2, 3] Gamers ascribe relative scores to the various weapons types to be simulated; the scores are summed over the engaged forces of each of the two opposing sides; the ratio of the sums of the opposing forces' scores is computed; and that force ratio is used to assess casualties and equipment losses and determine rates of advance. This methodology is not well accepted by gamers or by study users because it tends to obscure the distinction between combat modules. From this shortcoming evolved the name and purpose of this study.

2. Objectives. - The tasking directive signed by MG Hal E. Hallgren, Commander USACAA, on 22 June 1973 established this project as an in-house USACAA study with the following objectives:

a. New Approaches. - Develop new approaches for the assessment of unit engagement outcomes in theater-level models which do not use single valued MOE for each weapon or unit.

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*Combat modules are defined as those sets of units which interact by design with the enemy in direct contact, by application of firepower while not in direct contact, or by tactical movement of other combat modules. Examples of combat modules are mechanized infantry battalions, 155mm field artillery battalions, and assault helicopter companies.

b. Apply to Current Model. - Modify a current theater-level model such as ATLAS* or CEM** to accept the new methodology, to yield greater validity, and to retain responsiveness and utility.

c. Determine Sensitivity. - Determine the sensitivity of the new methodology incorporated into the theater-level models to the assumptions, estimates, and judgments inherent in the methodology.

3. Limitations

a. Scope. - This investigation was initially limited to those theater-level models already operational at USACAA when the study began. Later it was expanded to include monitoring efforts by other agencies and by contractors oriented on a similar purpose--the development of a theater-level model that is not driven by the aggregated weapons score/force ratio mechanism. All techniques and data considered in the study are limited to nonnuclear, mid-intensity conflicts such as a war in Europe dominated by armor, or a war in Northeast Asia dominated by personnel. The "NATO First" Scenario is specified.4/

b. Time Frame. - The time frame of interest is 1974-1986.

c. Assumptions. - It is assumed that there will be a continuing requirement for the Nonnuclear Ammunition Combat Rates Programing Studies produced annually for Department of the Army by the USACAA Ammo Rates Group.5/ The low level simulations prepared for these AMMORATES studies provide the basis for the ATWAR Model developed as a result of the subject study.

d. Essential Elements of Analysis. - The essential elements of analysis (EEA) are reproduced below as stated in the Tasking Directive:

(1) Are there direct approaches to the assessment of losses of personnel, weapons, and other equipment which will permit the elimination of the use of a single number, aggregated MOE in theater-level models?

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*ATLAS: A Tactical, Logistical, and Air Simulation.

**CEM: Concepts Evaluation Model.

(2) Are there field test results available which make comparisons of small units, multiple armored vehicle engagements, and combined arms team mixes in a variety of missions, weather, terrain, and scenario situations?

(3) Can the relationship between battle outcomes and movements at lowest engagement levels be extrapolated to higher levels, considering barriers, force levels, missions, environments and other variables?

(4) Can the ATLAS, CEM, or TARTARUS Models be modified to accept the new data and approach to yield more credible movement and losses and yet retain the capability to respond rapidly?

(5) Is the new approach, when applied in the modified theater-level models, more valid and objective than current theater-level models?

Responses to these EEA are provided in Chapter V.

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GREATER DISTINCTION BETWEEN
COMBAT MODULES IN WAR GAMES

# CHAPTER II
# APPROACHES

1. Background. - The exploratory research conducted early in this study revealed three possible approaches toward solving the problem of eliminating the aggregated MOE/force ratio mechanism from theater-level models:

a. Develop assessments and movement rates for ATLAS, CEM or TARTARUS from basic weapons performance parameters as derived from laboratory and field testing.

b. Apply a multi-MOE concept that would utilize a set of ratios grouping weapons according to their general characteristics.

c. Develop a hierarchical concept to extrapolate to theater-level the results of low level, high resolution models simulating combat module interactions.

Paragraph 6h of the tasking directive specified that consideration be given to using low level simulation models, such as the CARMONETTE, BONDER/IUA, or AMMORATES Models, to achieve the study objectives. Ultimately, the third approach, the hierarchical concept using modified AMMORATES Methodology,[6] was selected as that most likely to achieve the study objectives within time and resource constraints (11 calendar months, two professional staffers). The USACAA Technical Review Board approved this approach at the 1 Feb 1974 In Progress Review of this study. The rationale for selecting this route is outlined in succeeding paragraphs.

2. Available Theater-Level Models. - At the time of issuance of tasking for this study, it appeared that at least three theater-level models--ATLAS, CEM, and TARTARUS--would be available for study at USACAA. Unfortunately, when the study began, CEM was not yet operational on the USACAA UNIVAC 1108 computer, and the production version did not become fully operational until March 1974. This reason, plus the fact that CEM and its associated programers were dedicated to a high priority study, CONAF III, effectively eliminated the CEM from further consideration in this study. The TARTARUS Model, a computer assisted theater-level game developed by the US Army Strategy and Tactics Analysis Group in 1964, was in a state of disuse at the time this study began and contained many undocumented programing changes. The extensive effort needed to use TARTARUS, plus the long gaming time require-

ments (weeks), mitigated against its candidacy for this project. This left ATLAS, which was operational and was being used in several active USACAA studies. The ATLAS was carefully analyzed in terms of its structure and the results that it was yielding in the ongoing studies. The ATLAS was found to be so heavily dependent upon weapons scores and force ratios that its conversion to a simulation employing basic weapons performance characteristics would result in creation of essentially a new model. Such work was already underway at the Weapons Systems Evaluation Group, the Institute for Defense Analyses, Vector Research, Inc., and Lulejian & Associates, Inc. [7, 8, 9] with much more sizeable research efforts. Instead, consideration was given to modifying ATLAS using a multiple ratio approach. The results of this investigation are described next.

3. Multiple Ratios. - Besides obscuring the distinction between combat modules, the summing of weapons scores into a single MOE collides with the basic physical difference in effects between area fire weapons and direct fire weapons. The Firepower Potential (FPP) Methodology [10] attempts to equate different types of weapons by means of a correlation factor (f), the value of which is highly dependent on analysts' judgment. If one defines the weapons of a combat module in three categories--small arms (up to 30mm), antiarmor (30mm and above), and area fire--the current approach toward arriving at a unit score would sum the three, adjusting by the appropriate correlation factors:

$$\text{FPP} = f_1\,(\text{small arms}) + f_2\,(\text{antiarmor}) + \text{Area Fire}$$

Then the FPP are summed for all units on each side and the force ratio expressed as FPP (attacker)/FPP (defender). But this conceals the relative strengths and weaknesses of the combat modules; in other words, it fails to distinguish between them. An approach undertaken by this study to achieve greater distinction was to consider three ratios:

$$\frac{\text{Small arms (attacker)}}{\text{Small arms (defender)}},$$

$$\frac{\text{Antiarmor (attacker)}}{\text{Antiarmor (defender)}}, \text{ and}$$

$$\frac{\text{Area fire (attacker)}}{\text{Area fire (defender)}}.$$

It was considered more meaningful to express these in terms of weapons per potential target. Hence, the ratios were further modified to become:

$$\frac{\text{Small arms (attacker)/Defender personnel}}{\text{Small arms (defender)/Attacker personnel}},$$

$$\frac{\text{Antiarmor (attacker)/Defender armor}}{\text{Antiarmor (defender)/Attacker armor}}, \text{ and}$$

$$\frac{\text{Area fire (attacker)/Defender personnel}}{\text{Area fire (defender)/Attacker personnel}}.$$

In this form, tank weapons could be introduced separately and not summed with antitank weapons. It was assumed that families of curves could be developed from historical combat or field test data for movement rates varying with these ratios. An analysis of 60 battles from the Italian Campaign of World War II failed to reveal significant correlation between movement rate and these ratios. The approach was discarded but is documented in detail in Appendix C.

4. Hierarchical Concept. - The most fruitful approach resulted from the consideration of a model hierarchy. When this study began, General Research Corporation (GRC) was already under Department of Army contract to attempt to extend its model hierarchy--CARMONETTE, COMANEX and Division Battle Model[11]--to theater-level in the COMCAP III Study.[12] The GRC is accomplishing this by developing a methodology that permits extrapolation from the present hierarchy to CEM. The Greater Distinction project team turned to another model hierarchy, the AMMORATES group of models,[13] which is used to generate the Nonnuclear Ammunition Combat Rates Programing Studies. This model hierarchy is not a complete theater-level simulation, for it lacks FEBA movement, an organic close air support model, terrain, and logistics. It offers the advantage that its ground combat submodels operate on basic weapons performance parameters rather than weapons scores. If the missing features could be added without resorting to weapons scores and force ratios, the modified model would fulfill the study objectives. These modifications were undertaken, and the result was the ATWAR (Assessment of Theater Warfare) Model. The ATWAR Model is the principal product of this study, and the remainder of this paper is devoted to its description.

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GREATER DISTINCTION BETWEEN
COMBAT MODULES IN WAR GAMES

# CHAPTER III
# ATWAR MODEL

1. AMMORATES Methodology. - The ATWAR Model is rooted in the methodology linking the set of submodels of the AMMORATES Methodology. To provide the setting for ATWAR, the AMMORATES Methodology is summarized here, based on reference 6 and briefing material presented to the Department of Army Staff by the USACAA AMMORATES Group.

a. Combat Samples. - The AMMORATES Methodology[14] simulates theater-level conflict through the use of a hierarchy of high and low resolution models. The basis for the methodology lies in a set of combat samples* representing opposing forces engaged in four different levels of combat activity in a given theater of operations:

(1) Friendly force delaying against an attacking threat force.

(2) Friendly force defending against an attacking threat force.

(3) Friendly and threat force both defending.

(4) Friendly force attacking a defending threat force.

Each combat sample is gamed and analyzed manually, supported by the set of high resolution submodels. The combat sample begins with a force target array appropriate for the given theater of operations. The size of the sample varies, but in general it covers 30 to 50 kilometers of the forward edge of the battle area (FEBA) and 50 kilometers in depth on each side of the FEBA. The arrays are resolved to platoon/company/battery level on terrain considered by the gamers to be typical for the theater under study. Military gamers then analyze the situation, forces, posture, and terrain to determine the types and frequencies of engagements expected to occur between the engaged units during the course

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*A combat sample is defined as an example engagement over a variable period of time by two opposing forces arrayed in a specified condition.

of a 24-hour period. The result of this analysis is a series of small battles which are then simulated in the set of submodels as diagrammed in Figure III-1.

b. AMMORATES Submodels

(1) The Tank/Antitank Simulation Model and the Infantry Combat Model are exercised first, generating personnel losses, weapons systems losses, and ammunition expenditures. These models also establish close support requirements for the maneuver units. Certain requirements may be satisfied by helicopters, and the sorties are simulated by two helicopter models (one against armor, one against personnel) which yield helicopter effects imposed on threat forces, helicopter losses, and helicopter ammunition expenditures. The other close support requirements generate demands for priority artillery support in the form of preparation, preplanned, and final protective fires. Close air support by fixed-wing aircraft is not included at this point.

(2) To account for those combat activities not directly attributable to combat module engagements on or near the FEBA, the target arrays are processed through the Target Acquisition Model. This model produces a sequence of acquisitions which occur over the combat period. A portion of these become targets for available helicopter and close air support sorties (received as direct Air Force input). The remainder are processed along with the priority artillery requirements in the fire support planning models, one each for Red and Blue forces. These models service target requirements to the extent permitted by available assets. The outputs are ammunition, fuze and propellant expenditures, and personnel and tank losses attributed to those expenditures. The calculation of number of rounds required to neutralize a target is accomplished by the Artillery Assessment Model. When the calculations for all battles that are estimated to occur throughout the 24-hour period have been completed, the results (losses and expenditures) are stored for future extrapolation by the Theater Rates Model.

c. Theater Rates Model. - The high resolution models described above provide inputs into the Theater Rates Model (TRM). The TRM extrapolates from the combat sample results to theater level based on an initial theater-wide deployment of forces in terms of Warsaw Pact Combined Arms Armies, appropriate opposing Blue forces, and scenario dependent deployment schedules. The TRM logic is portrayed in Figure III-2. The level of combat activity may be determined over the theater on a force ratio basis or may be input based on scenario. The extrapolation of losses and ammunition consumption is made linearly from the

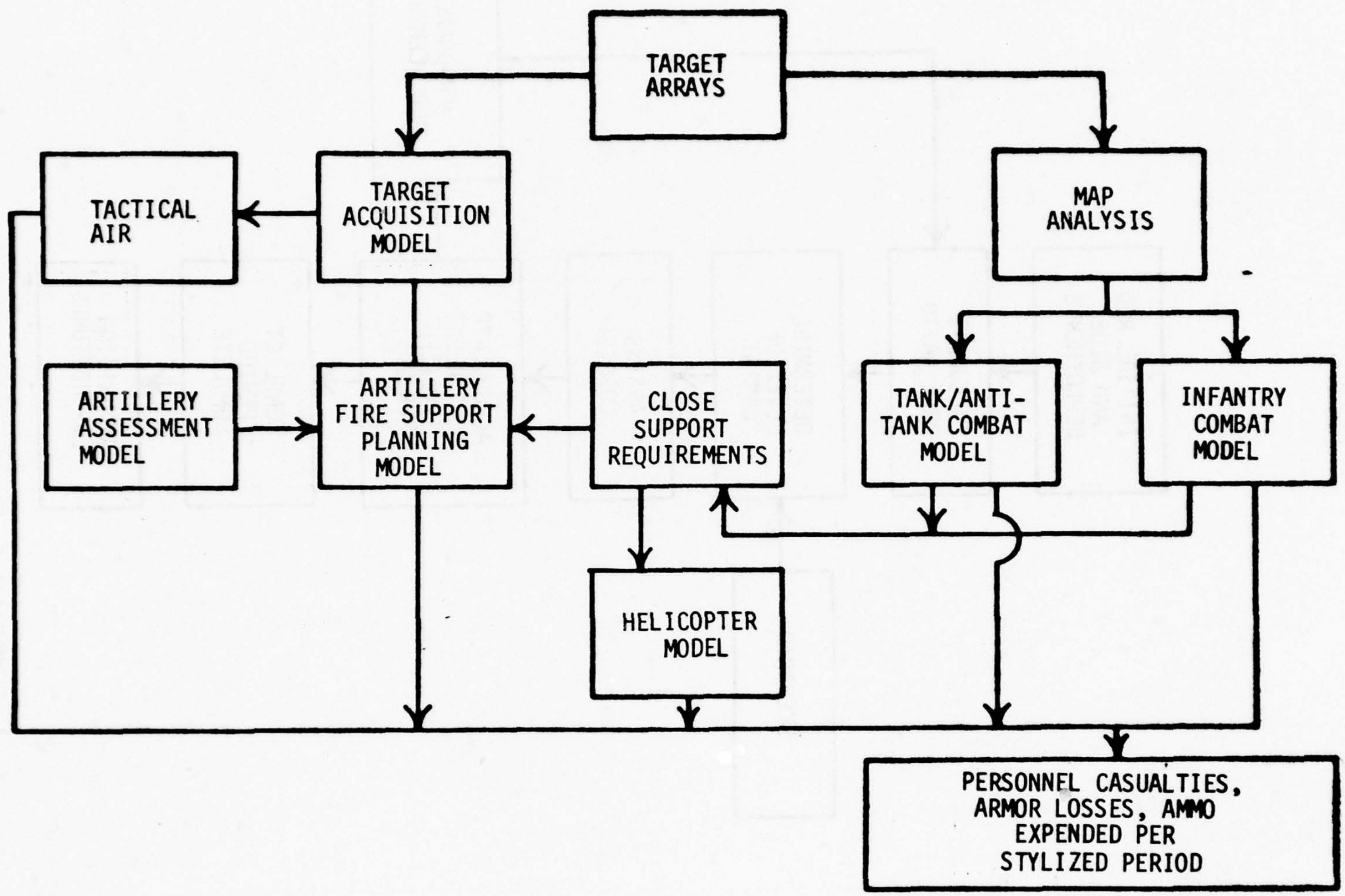


FIGURE III-1, AMMORATES Submodels

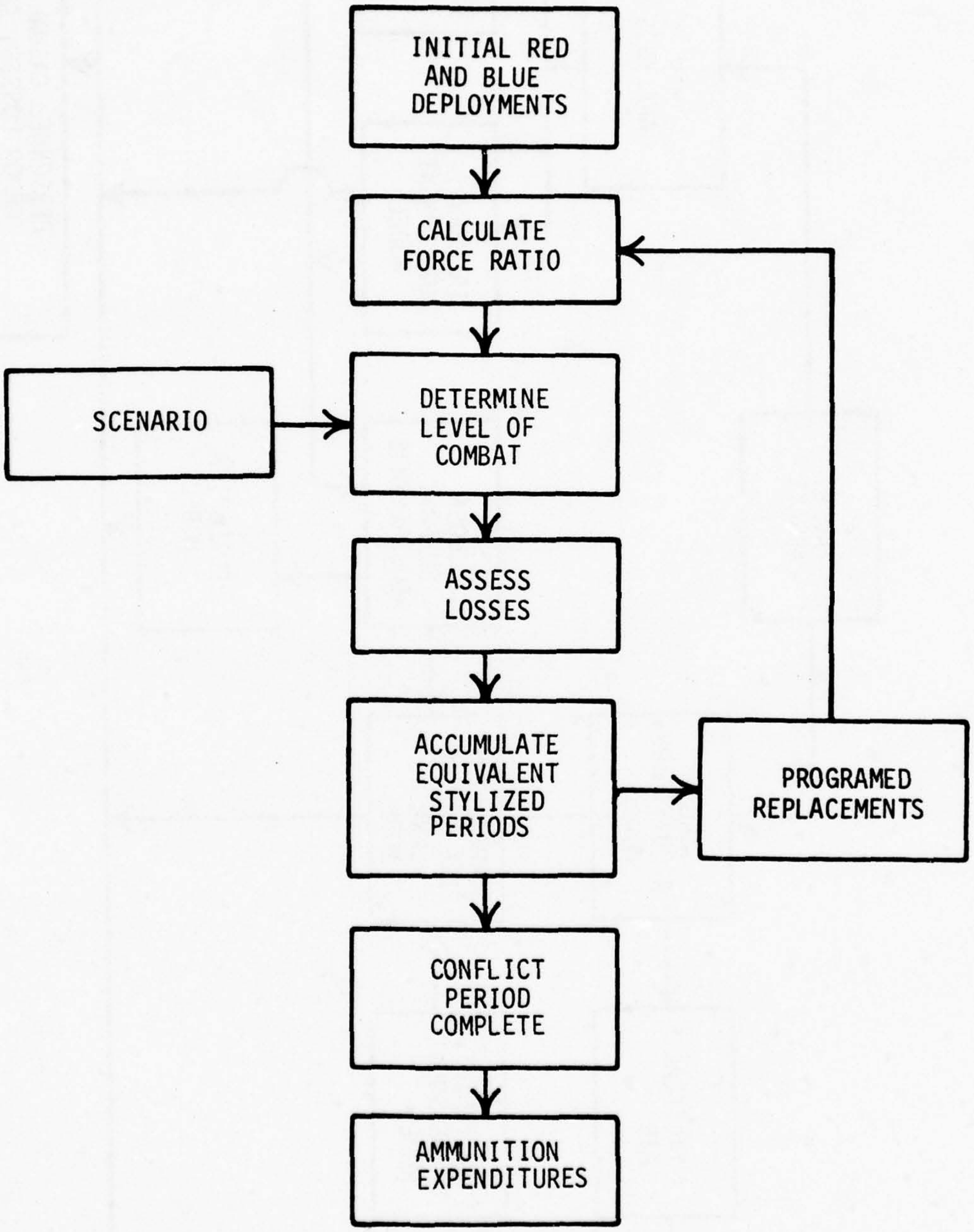


FIGURE III-2, Theater Rates Model Flow Chart appropriate combat sample to the number of forces engaged in the theater for each period of combat. The loss assessments and ammunition consumption are then modified linearly in accordance with the degree of attrition already sustained by the engaged forces. The model next operates on personnel and equipment replacements. These replacements include individuals returning to a replacement pool either as battle or nonbattle casualties, equipment passing through a maintenance or repair cycle, replacement personnel and equipment newly entering the theater, and new divisions entering the theater as specified in the deployment schedule. If this is not the final combat period, the model recycles through the logic, recomputing a force ratio or selecting an activity level from the scenario and computing new assessments. After the final period of combat, accumulated losses and parameters for the calculation of ammunition are computed and output.

2. ATWAR Model Structure

a. Hierarchical Concept. - The ATWAR Model begins with the basic hierarchical structure of the Theater Rates Model. The ATWAR Model uses the manually gamed combat samples and the high resolution submodels to generate casualty and equipment losses and ammunition expenditures. These results are then extrapolated to theater level. The following changes were made in the TRM to convert it into a more nearly complete simulation of theater air/ground conflict:

(1) Segment the Model. - The TRM was completely restructured on a functional basis to facilitate the addition of new functions.

(2) Blue Deployment and Assessment by Sector. - The capability to deploy Blue replacement units or individual personnel into specific sectors was added. Loss assessments for both sides by sector rather than theater-wide were also added.

(3) Red Replacements. - The capability to replace Red divisions instead of armies, or to use individual replacements for Red forces was added.

(4) Terrain. - Macroterrain on a theater-wide basis was added.

(5) FEBA Movement. - The FEBA location on the macroterrain was inserted, and the capability to follow its location on a cycle-by-cycle basis was added.

(6) Tactical Decision Logic. - A tactical decision logic was developed to move the FEBA and determine posture, rather than use force ratios. The scenario option was retained.

(7) Logistics Routine. - A routine was added to permit the available level of ammunition and transportation to affect the combat assessments.

(8) Tactical Air Activity. - Explicit treatment of tactical aircraft operations was achieved by adaptation of USACAA's CONTACA Model.

The flow chart, Figure III-3, gives the overall ATWAR Model structure, and the remainder of this chapter describes the model's operation.

b. Ground Combat Submodels. - Although ATWAR was designed to operate on the outputs of the five ground combat submodels of the AMMORATES methodology, other high resolution models could be used as the source of the high resolution data.

c. Combat Samples. - The ATWAR is designed to operate on a matrix of 16 combat samples. The matrix consists of eight levels of combat activity, or postures, for engaged Blue forces against a Red Combined Arms Army during 12 hours of combat, and the same eight postures against a Red Tank Army. The eight postures are listed in Table III-1 below:

TABLE III-1, List of ATWAR Postures

| Blue Postures | Corresponding Red Posture |
|---|---|
| Withdrawal | Unopposed Pursuit |
| Delay | Pursuit |
| Defend (1st day) | Attack (1st day) |
| Defend (Succeeding days) | Attack (Succeeding days) |
| Hold | Hold |
| Attack (1st day) | Defend (1st day) |
| Attack (Succeeding days) | Defend (Succeeding days) |
| Pursuit | Delay |

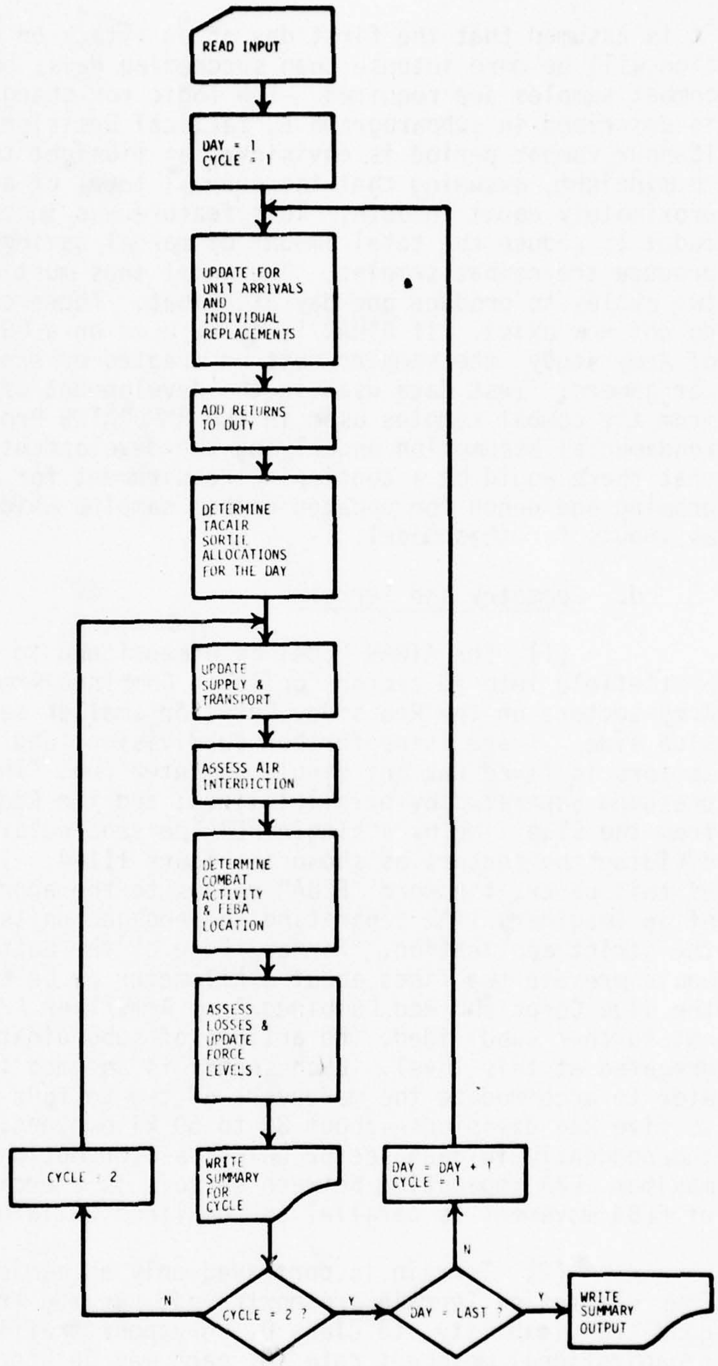


FIGURE III-3, ATWAR Model Flow Chart

It is assumed that the first day of an attack on a defensive position will be more intense than succeeding days; hence, separate combat samples are required. The logic for changing postures is described in subparagraph e, Tactical Decision Logic. The 12-hour combat period is envisioned as midnight to noon or noon to midnight, assuming that the overall level of activity is approximately equal in both. This feature was incorporated in the model to reduce the total amount of manual gaming required to produce the combat samples. The model thus must operate through two cycles to produce one day of combat. These combat samples do not now exist. If ATWAR is to be used on a USACAA or Department of Army study, the samples must be created by experienced military war gamers. Test data used in the development of ATWAR was derived from the combat samples used in the AMMORATES Programing.15/ The fundamental assumption underlying the development of ATWAR was that there would be a continuing requirement for AMMORATES Programing and hence for updated combat samples which can be used as inputs for this model.

d. Geometry and Terrain

(1) The ATWAR Model is dimensioned to divide the theater battlefield into 10 sectors or less, Combined Arms Army or Tank Army sectors on the Red side, Corps or smaller sectors, on the Blue side. There is no further subdivision, and the number of sectors is fixed for any single computer run. The sectors are presumed separated by parallel lines, and the Red side is separated from the Blue side by a single FEBA perpendicular to the lines dividing the sectors as shown in Figure III-4. In the context of this paper, the word "FEBA" refers to the approximate location of an imaginary line separating the engaged units, rather than the strict application, "Forward Edge of the Battle Area," which would presume two lines about a kilometer or so apart. Since the Blue Corps and Red Combined Arms Army/Tank Army sectors are not further subdivided, the actions of subordinate units are aggregated at this level. Each sector is assumed to be sufficiently wide to accommodate the maneuvers of two to four Blue and three to five Red divisions--about 30 to 50 kilometers. The FEBA moves independently in each sector unless a user option to limit the maximum FEBA separation between sectors is exercised. The direction of FEBA movement is parallel to the lines dividing the sectors.

(2) Terrain is portrayed only on a macro-basis in ATWAR. Four classes of Terrain are portrayed, varying from Class A, very good trafficability, to Class D, very poor trafficability. The organizational movement rate for each may be specified by the user. Movement rates are stored in a lookup table indexed by terrain type and posture. Movement occurs between defensive positions

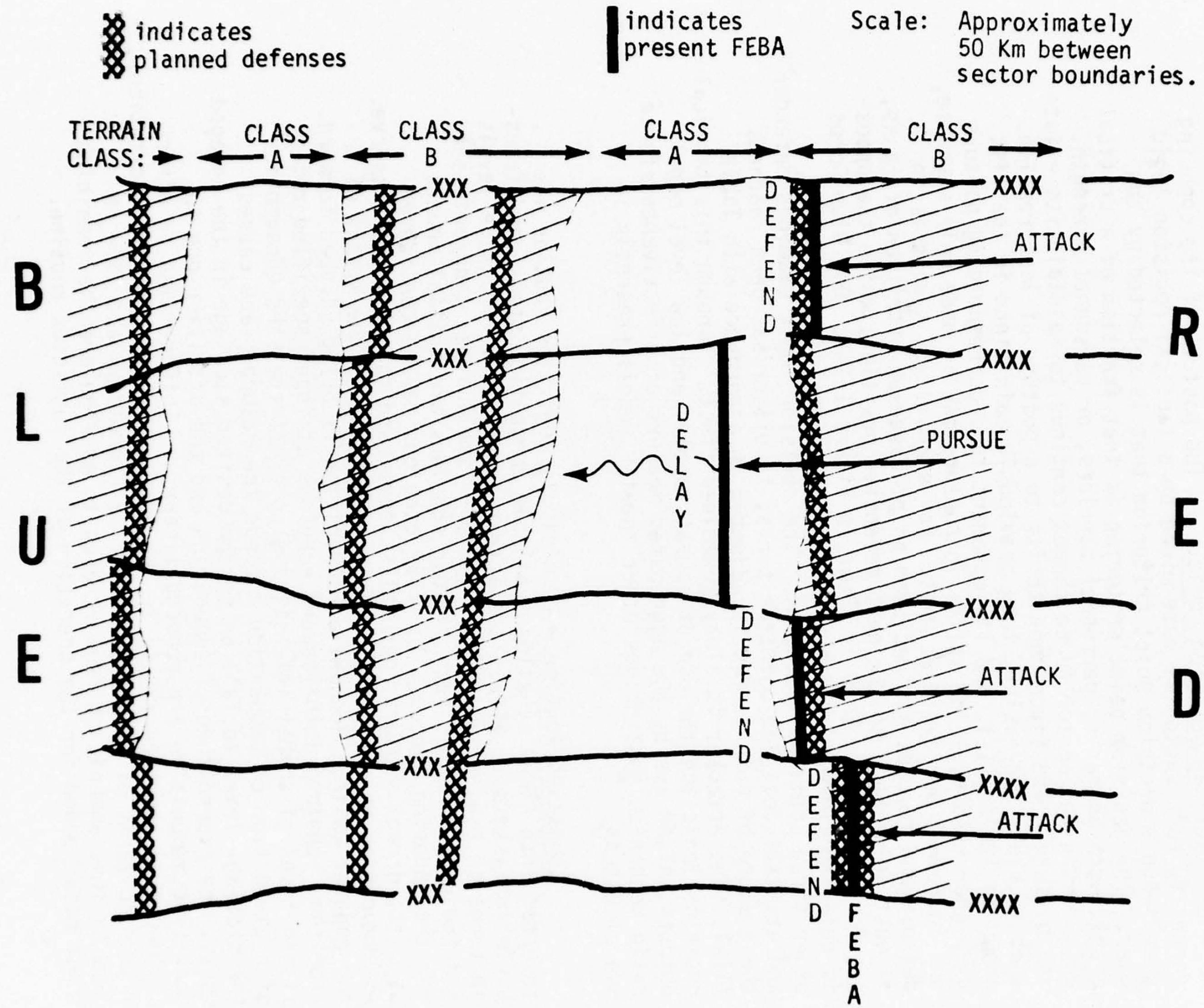


FIGURE III-4, ATWAR Terrain and Posture Schematic in delay or withdrawal postures only. The locations of defensive positions (Figure III-4) are inputs derived from map analysis by gamers or from the scenario.

e. Tactical Decision Logic. - The posture of the opposing forces in each sector is determined by a tactical decision logic based upon a decision point criterion that is selected by the user. The decision point criterion is that fraction of a critical asset, such as tanks, personnel carriers, or personnel strength, below which the sector force cannot continue to maintain its existing posture. The force then shifts to a posture of less resolve, that is, less aggressive, than previously maintained in the list shown in Table III-1, and its opponent to a corresponding posture of higher resolve. The shifts in posture may be made only stepwise, one increment per cycle at most. For example, if a unit is in defense and reaches its decision point based on attrition of tanks, it must delay back to the next defensive position, while the opposing force pursues. This is shown in Figure III-4. One Blue Corps is delaying rearward to the next defensive position while the other three continue to defend. The decision logic examines defender and attacker decision point criteria; if either has been reached, the posture of both forces is adjusted in accordance with Table III-1. The attacker is always examined first. Through this tactical decision logic and the use of combat samples and low level model outputs, ATWAR avoids the aggregated measure of effectiveness/force ratio mechanism that drives other theater models presently in use at USACAA.

f. Logistics Routine. - A simple logistics routine was inserted into ATWAR to allow available ammunition stocks and transportation assets to affect the attrition process. Stockage levels in terms of tons of ammunition by type (small arms, tank/antitank, and indirect fire) at each of four echelons are initial inputs for the opposing forces. The four echelons may be considered as unit, direct support, general support, and theater/depot reserve. As ammunition is consumed, it is subtracted from the stocks of the engaged units. Meanwhile, ammunition is being shipped forward from rear echelons into forward echelons at input specified rates. If the level of combat intensity is so great that the consumption of a given type of ammunition exceeds the resupply and causes the stockage level to fall below the desired stockage in the engaged units, the expenditure of ammunition and the attrition due to that type ammunition are reduced linearly. This remains in effect as long as a shortage exists in the engaged units. The transportation assets in terms of throughput capacity (tons/day) and time in days to move ammunition from echelon to echelon are the remaining input data needed for the operation of the logistics routine.

g. Tactical Air Support. - An explicit Tactical Air routine was needed in ATWAR to achieve a more nearly complete theater model with realistic interface between air and ground combat activities. A model developed recently at USACAA and already in operation on the UNIVAC 1108 was integrated into ATWAR for this purpose. The model is CONTACA (Conventional Tactical Air Model),[16] which was selected because of its basic simplicity, realism, and ready availability.

(1) CONTACA as Submodel. - The detailed description of CONTACA is contained in reference 16. Only its function in ATWAR is presented here. The CONTACA Model simulates air activity for each day of the ATWAR campaign with output on a wave-by-wave basis. (Each wave is composed of an initial Red attack which is flown and assessed in terms of effective sorties and aircraft losses, followed by a Blue attack assessed in turn.) The number of effective tactical air sorties is computed and transmitted into the ATWAR assessments routine where total target kills by effective tactical air sorties are computed and subtracted from sector forces.

(2) Mission Allocation. - The CONTACA Model is designed to simulate up to six aircraft types performing eight possible mission types: (1) inteceptor or escort, (2) counterair, (3) airbase attack, (4) interdiction, (5) close air support (CAS), (6) armed reconnaissance, (7) unarmed reconnaissance, and (8) transport. The last two do not affect ATWAR results except to detract from overall available aircraft and shelter resources. Gamer defined inputs provide the initial plan for allocation of available aircraft sorties among possible missions for the duration of the campaign, including the number of waves that will be flown daily.

(a) Influence of Tactical Air on Ground Combat. - In allocating the available sorties within each mission type to the various sectors, a logic was prepared which gives the user five options:

I. Allocate all air assets evenly across all sectors.

II. Allocate N percent (N specified by user) of assets across all sectors and the balance to the sector having the least strength in a user specified equipment item or personnel.

III. Allocate N percent evenly across all sectors and the balance to the greatest strength in the specified item.

IV. Allocate N percent evenly across all sectors and the balance to the sector having the maximum FEBA displacement.

V. Allocate N percent evenly across all sectors and the balance to the sector having the minimum FEBA displacement.

The user may specify different options for Red or Blue for different mission types. Thus, the application of tactical air resources may influence ground combat activity directly by the exercise of these options. The application of interdiction missions may also influence the ground campaign by causing a degradation of the amount of ammunition flowing through the logistics system.

(b) Influence of Ground Combat on Tactical Air. - Another routine added to ATWAR as a user option allows the ground war to influence the tactical air activity. If the FEBA has displaced M distance in any sector (M, specified by user), the mission allocation of aircraft within mission types is changed in accordance with another allocation plan. For example, if the ground war is going very well or very badly, the logic permits a change in the relative number of CAS versus other missions. This option may be exercised presently at two separate preplanned FEBA displacements. Others could be added if the user desires.

3. Model Inputs. - The inputs required for ATWAR operation are the following data:

a. Forces. - Initially deployed Blue and Red forces organized into Corps, Combined Arms Armies or Tank Armies, respectively, with personnel strengths and inventories of principal weapons or equipment which cause attrition or are attrited in the AMMORATES submodels, are basic inputs. Initial population of replacement pools is also input.

b. Combat Samples and Submodels of AMMORATES. - The attrition outputs and ammunition consumption as calculated in the AMMORATES Programing are needed for extrapolating this data to theater level.

c. Deployment Schedule and Personnel Replacements. - Arrival time of new divisions and the arrival rate of individual replacements into the theater are needed as the war progresses.

d. Macroterrain. - The four general classes of terrain and logical defensive positions must be laid out by sector.

e. Initial FEBA Location and FEBA Movement Rates. - The initial location of the FEBA and the matrix of movement rates by terrain and posture must be entered. The maximum separation allowed between FEBAs in adjacent sectors must also be entered. If this feature is not desired, a very large number should be entered.

f. Tactical Decision Criteria. - The level of strength (in personnel or specified major equipment items) at which a commander would be unwilling to continue a defense or an attack must be identified for use in the tactical decision logic.

g. Repair Cycle. - A fraction of equipment losses is considered repairable at either of two echelons of maintenance, and an appropriate delay is inserted at each level (direct support and general support) before the equipment is returned to action. Personnel losses are treated similarly, and a fraction is returned to duty through the replacement pool after an appropriate delay time. The fraction of repairable items and delay times at each echelon of maintenance are user inputs. Any nonbattle loss data, deadline rates, and maintenance float fractions are also required inputs.

h. Initial Tactical Air Forces, Augmentation, and Distribution into Shelters. - The initial inventory of Tactical Air forces, their deployment priority for available shelters, and the number of shelters available, must be input. The total number of aircraft available outside the theater for augmenting theater forces and the rate at which theater forces are augmented are also inputs.

i. Initial Tactical Air Mission Allocation Plan. - The plan for day-by-day mission allocation of tactical aircraft and number of waves per day for the entire campaign must be input. The initial allocation option of aircraft to each sector and subsequent options changing mission allocations with corresponding FEBA locations must be input.

j. Tactical Air Effectiveness. - The effectiveness per sortie of tactical aircraft performing CAS, armed reconnaissance, or interdiction missions is an input. This is required in the form of expected value target kills per effective aircraft sortie with a given type of ordnance loading. Aircraft effectiveness against shelters is also an entry.

k. Tactical Air Operational Factors. - The probabilities of various types of aircraft being in commission, not having an abort, having no gross navigational errors, and not jettisoning ordnance are all inputs to CONTACA and hence to ATWAR.

l. Tactical Air Attrition Factors. - The probabilities that various types of aircraft will be killed per sortie are inputs.

m. Ammunition Supply Requirements. - The logistics routine requires the input of ammunition stockage objectives and actual stockage at four echelons by type of ammunition and by sector, throughput capacity by sector, initial supplies in transit by type and by sector, and transit times between echelons by sector.

4. Model Outputs. - The ATWAR is formatted with gamer designated options to output by combat cycle, by day, or at campaign conclusion, or all three, or at other gamer specified intervals. The following data is output by ATWAR:

a. FEBA location by sector.

b. Total casualties and ground weapons systems losses by cause.

c. Casualties and ground weapons systems losses by sector due to tactical air.

d. Status of ground weapons systems, including personnel, by type, sector, and day of combat.

e. Tactical air availability, aborts, actual launches, losses, and effective sorties by aircraft type, by wave, and by day.

f. Tactical air effective sorties by mission allocation, type aircraft, wave, day, and sector.

g. Status of aircraft prior to each wave commitment by type aircraft, wave, day, and whether sheltered or unsheltered.

5. Sequence of Operations. - The above paragraphs describe the components of ATWAR. The sequence in which they simulate ground/air theater combat may be followed by referring again to Figure III-3.

a. Initialization. - Input data is read into the central processor unit, and counters are initialized for the first day, first cycle of combat.

b. Updating. - For the second and succeeding days of combat, the deployment schedule and schedule for arrival of individual replacements are checked and forces and replacement pool updated if appropriate. Likewise, results of the repair cycle are checked for returns to duty of personnel and repaired weapons systems. Any returns enter the replacement pool. Available replacements are added in proportion to shortfalls in all sectors. In addition to individual replacements, Red divisions are replaced on line if a committed division is attrited below the user determined breakpoint and if a division is available for unit replacement. This updating occurs only at the first of the two daily cycles.

c. Tactical Air Allocations. - The tactical air routines allocate available tactical air to missions in accordance with the current tactical air plan and then to sectors in accordance with the user selected option (paragraph 2 g (a)). These allocations occur only once daily and are not updated for the second 12-hour cycle of the model. Half are applied in the first cycle and half in the second cycle of each combat day.

d. Second Cycle Updating. - As shown on the flow chart, the remaining updating and the combat assessments occur twice daily, once for each 12-hour cycle.

e. Supply and Transport Status. - The amount of ammunition that should arrive into committed units is calculated from throughput rates and amounts in transit and added to unit stockage. Demands from the previous cycle's consumption are subtracted from rearward echelons and enter the supply stream. After resupply, ammunition on hand is compared to stockage objectives and if lower, further demand is made on rear echelons. Also the fraction on hand (up to 1.0) is stored for use as a multiplier against loss assessments.

f. Interdiction Assessment. - The effects of interdiction on throughput capacity of the lines of communication are assessed and throughput reduced accordingly.

g. Combat Activity Level. - For the first cycle of combat, the activity level is input from the scenario. For succeeding cycles, the activity level is obtained by comparing the status of forces in each sector with decision point criteria using the tactical decision logic (Paragraph 2e) to change posture if the decision point has been exceeded.

h. FEBA Location. - For sectors in which the defender is in delay or withdrawal posture, a movement rate for the FEBA is selected from the terrain and posture matrix, and the distance moved in 12 hours is calculated; the movement distance is compared to the distance to the next planned defensive position, and if it does not exceed that distance, the FEBA is moved. If the movement distance calculated is greater than the distance to the next defensive position, the FEBA stops at the defensive position, and the forces enter a defense posture for at least the next cycle.

i. Assessments. - Attrition is calculated in all sectors in the sequence:

(1) Aircraft losses by all causes.

(2) Ground combat interactions.

(3) Ground losses due to tactical air.

j. Reassessments. - Losses in ground combat are modified by multiplying the losses by that fraction of unit ammunition stockage objective actually on hand.

k. Force Update. - Losses are subtracted from theater air and ground forces.

l. Intermediate Output. - A summary of output data for the cycle is printed at this point.

m. Recycle. - If this cycle was the first of the day, the program returns as indicated on the left path (Figure III-3) to update the period counter and iterates, beginning with updating of supply and transport status. If it was the second cycle of the day, the program returns as indicated on the right path, checks whether this is the last day of the campaign and, if not, returns to iterate through another first cycle of combat. If this day was the last day of the campaign, a final summary output would be printed out and the program halts. If intermediate summaries are desired at specified numbers of daily intervals, this option may be inserted in the right hand loop.

6. Subsequent Documentation. - This concludes the narrative description of ATWAR. User and programmer documentation of the ATWAR Model will be published separately.

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# CHAPTER IV
# ATWAR SENSITIVITIES

1. General. - The third objective set forth in the Tasking Directive was to determine the sensitivity of the new methodology to its inherent assumptions, estimates, and judgments. This was accomplished through a series of computer test runs of the model varying the following parameters:

a. Replacement rates.

b. Level of tactical air support.

c. Tactical air deployment options.

d. Location and number of defensive positions.

e. Equipment repair cycle.

f. Tactical decision criteria.

The data base used in the test runs was that of the latest published Nonnuclear Ammunition Combat Rates Programing modified to the ATWAR matrix of postures and 12-hour combat periods. The emphasis in these test runs was placed on model behavior rather than accuracy of the input data.

2. Geometry. - The geometry for the test runs is shown in Figure IV-1. The terrain (classes A, B, C, and D) was abstracted from a portion of Central West Germany. The series of defensive positions on the right of the figure simulate the forward defenses near the eastern frontier; the double lines of defensive positions simulate the Rhine River barrier. The numbers at the top show distances from the initial line of contact. A four-sector simulation was conducted. Each test run was for 30 days of combat. The measure of effectiveness was total FEBA movement during the 30 days, that is, the maximum displacement of the FEBA among the four sectors.

3. Base Case. - A single base case was established as a reference run for all the sensitivities. Parametric variations were then conducted from the base case. The data shown in Table IV-1 applies to the base case.

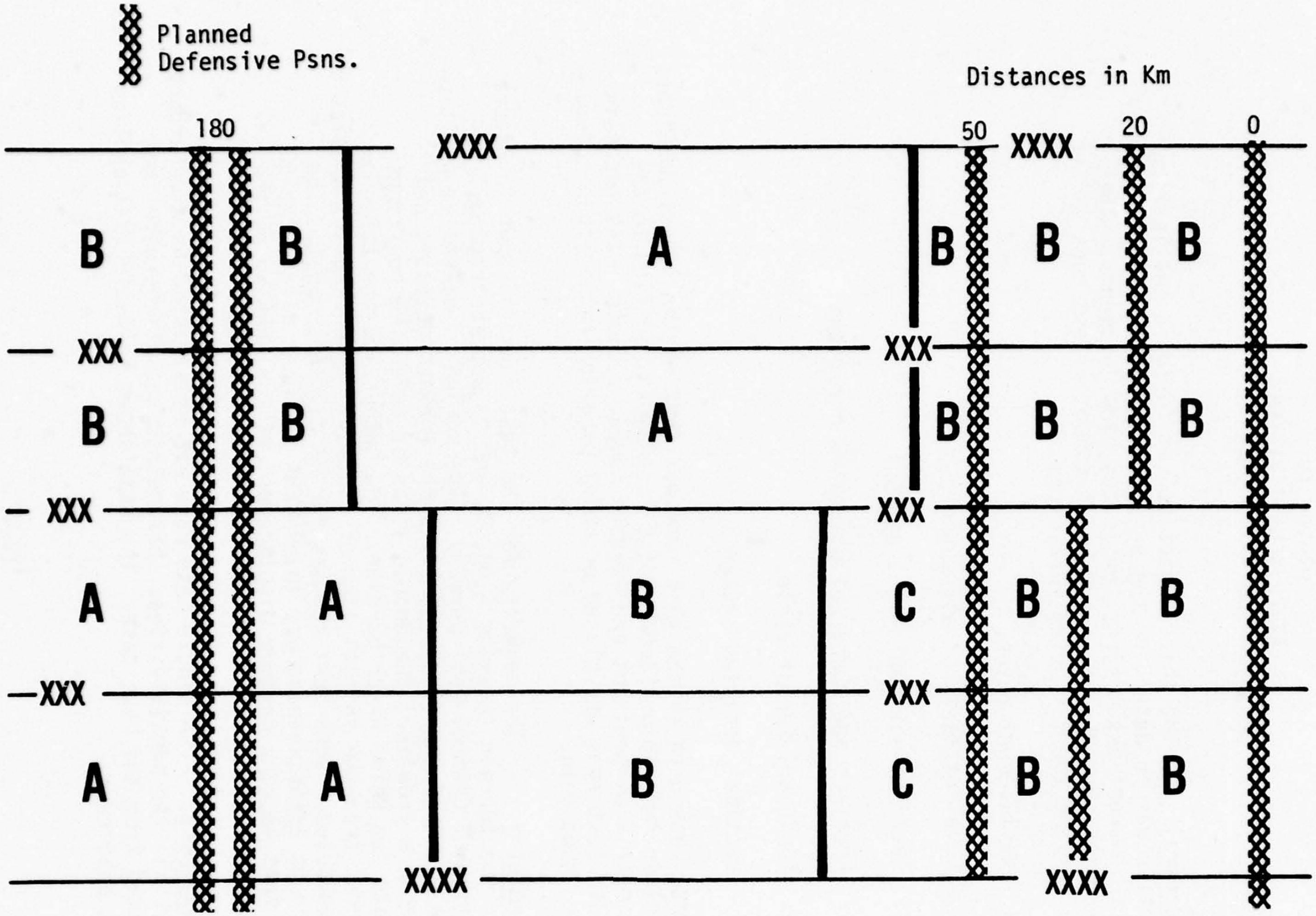


FIGURE IV-1, Abstract Terrain, ATWAR Test Runs

TABLE IV-1, Base Case Data

Tactical decision point criteria based on the fraction of initial tanks and antitank weapons remaining: Attacker: 0.6
Defender: 0.8

Daily equipment and personnel replacements

| | Red | Blue |
|---|---|---|
| Personnel ........ | 5,500 | 664 |
| Tanks ............ | 46 | 0 |
| Personnel carriers | 127 | 0 |
| Helicopters ..... | 0 | 5 |

Repair cycle (tanks only)

| | Red | Blue |
|---|---|---|
| Fraction of tank kills to higher echelon repair ... | .115 | .128 |
| Days in repair ... | 4 | 4 |
| Fraction of tank kills to lower echelon repair .... | .209 | .232 |
| Days in repair ... | 3 | 3 |

Tactical Air Option: Assets apportioned equally to all sectors

Maximum flank separation option: 50 kilometers between FEBA in adjacent sectors

4. Varying Equipment and Personnel Replacement Rates. - Five variations on the base case were conducted:

a. Blue forces received an additional 50 tanks per day.

b. Blue forces received an additional 10 attack helicopters per day.

c. Blue forces received an additional 500 personnel per day.

d. Red forces' tank replacement rate was cut in half.

e. Red forces' personnel replacement rate was cut in half.

The results are shown in Figure IV-2. In the base case, the maximum FEBA displacement after 30 days of combat was 180 kilometers, placing the engaged forces on the Rhine River. Adding 50 tanks per day to Blue forces reduces the displacement to 50 kilometers in 30 days. The other variations had no effect. This reveals the significance of the tactical decision criterion, which was a specified fraction of the sum of tank and antitank weapons. The additional tanks keep the sector tank inventory above the decision criterion, permitting the sector forces to remain longer on a given defensive position. Cutting Red forces' tank replacements had no significant effect because the Red forces already had a very large number on hand.

5. Varying Blue Tactical Air Assets. - Two variations involving Blue tactical air assets were conducted, one with twice as many are shown in Figure IV-3. Varying total Blue tactical air assets appears to have very little impact on the outcomes because Red targets not depleted by tactical air increased the number susceptible to ground weapons systems kill. Conversely, as the number killed by tactical air increased, those susceptible to ground systems kill were diminished. Increasing the tactical air assets did achieve somewhat better results than the maximum FEBA movement indicates, however. Blue forces vacated the third defensive position 4 days later than in the base case.

6. Varying Tactical Air Deployment Options. - In the base case, both Blue and Red forces deploy equal assets to all sectors. The following variations were conducted using the tactical air deployment options described in Chapter III:

a. Blue deploys 50 percent to all sectors evenly and the balance to the sector with the worst FEBA location; Red deploys 50 percent to all sectors evenly and the balance to the sector

Base Case Replacement Data: (Per Day)

| | BLUE | RED |
|---|---|---|
| Personnel | 664 | 5500 |
| Tanks | 0 | 46 |
| Pers. Carriers | 0 | 127 |
| Helicopters | 5 | 0 |

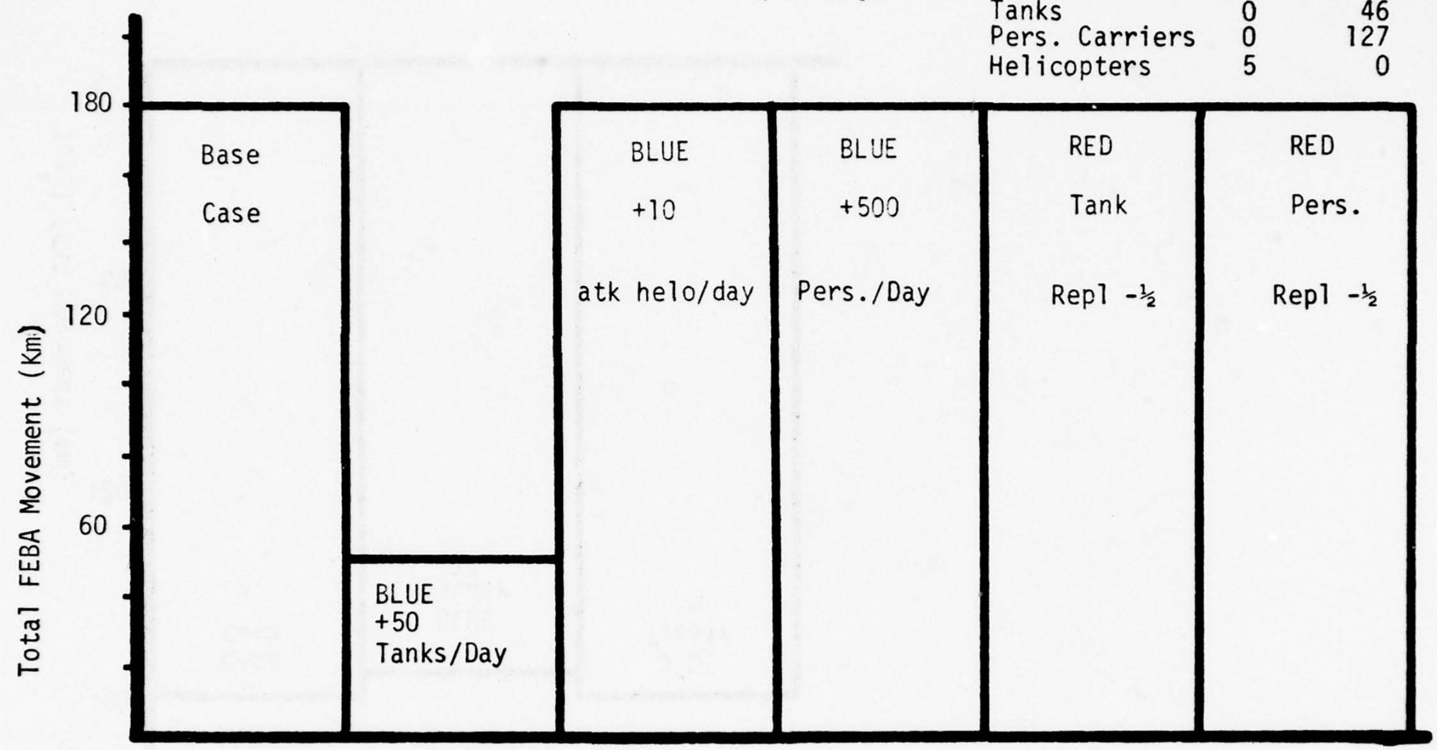


FIGURE IV-2, Varying Equipment and Personnel Replacement Rate

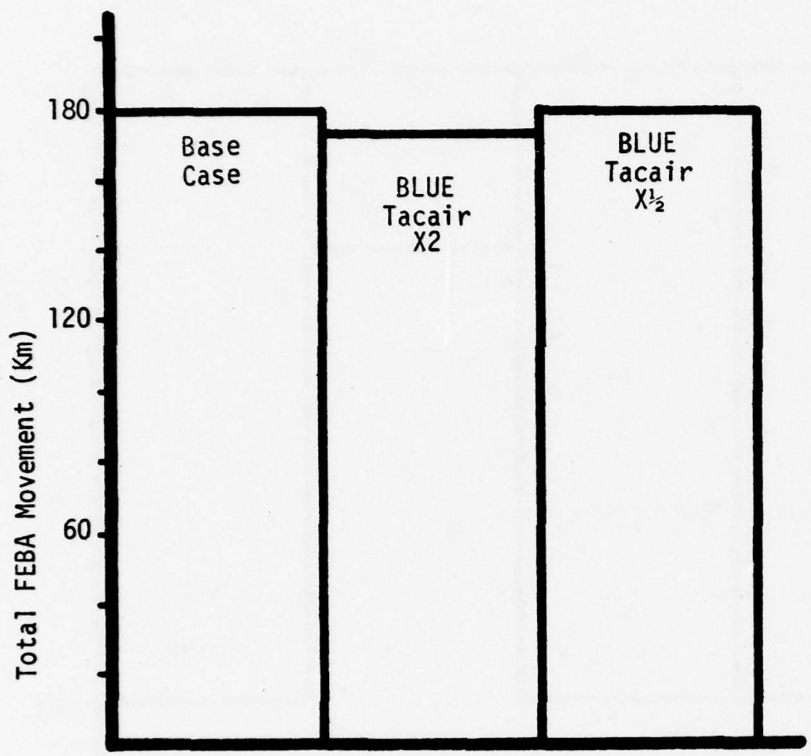


FIGURE IV-3, Varying BLUE Tactical Air Assets with the best FEBA location.

b. Blue deploys as in a above; Red deploys 50 percent evenly to all sectors and the balance to the sector with the greatest tank/antitank strength.

c. Blue deploys 50 percent to all sectors evenly and the balance to the sector with the weakest tank/antitank strength; Red deploys as in b above.

d. Blue deploys as in c above; Red deploys as in a above.

The results are shown in Figure IV-4. By concentrating a portion of tactical air assets in the sector having the least success, Blue forces significantly impede FEBA movement. By concentrating that same portion in the weakest sector in terms of the tactical decision criterion, FEBA movement is impeded even more because the sector receives assistance before the decision point is reached. The model is sensitive to this user option.

7. Defensive Positions. - An additional defensive position was inserted in all sectors 80 kilometers from the initial FEBA location (Figure IV-1). The result of this variation is shown in Figure IV-5. As one might expect, the addition of more defensive positions restricts total FEBA movement throughout the remainder of the campaign, after the new positions enter game play.

8. Varying the Repair Cycle. - The repair cycle data was changed in two variations from the base case. First, the time to repair Red tanks damaged in combat was doubled at both lower and higher maintenance echelons. As shown in Figure IV-6, this had no effect on total FEBA movement because of the very large number of Red tanks remaining in action. The fraction of Blue tanks repairable at either echelon was doubled in the second variation. This reduced total FEBA movement considerably, indicating model sensitivity to this feature when there are relatively few of a critical item on hand.

9. Tactical Decision Criteria. - A set of four computer runs was conducted varying the tactical decision criteria as shown in Figure IV-7. The model was revealed to be highly sensitive to this feature. Raising the defender's decision point from 0.8 in the base case to 0.9 causes him to give up more ground faster. At the same time, the defender sustains slightly fewer losses while inflicting more on the enemy. As the criteria for attacker or defender are made more nearly equal, or exactly equal, the defender retains more ground. When the attacker's decision point is equal to or higher than the defender's, there is no FEBA movement. When

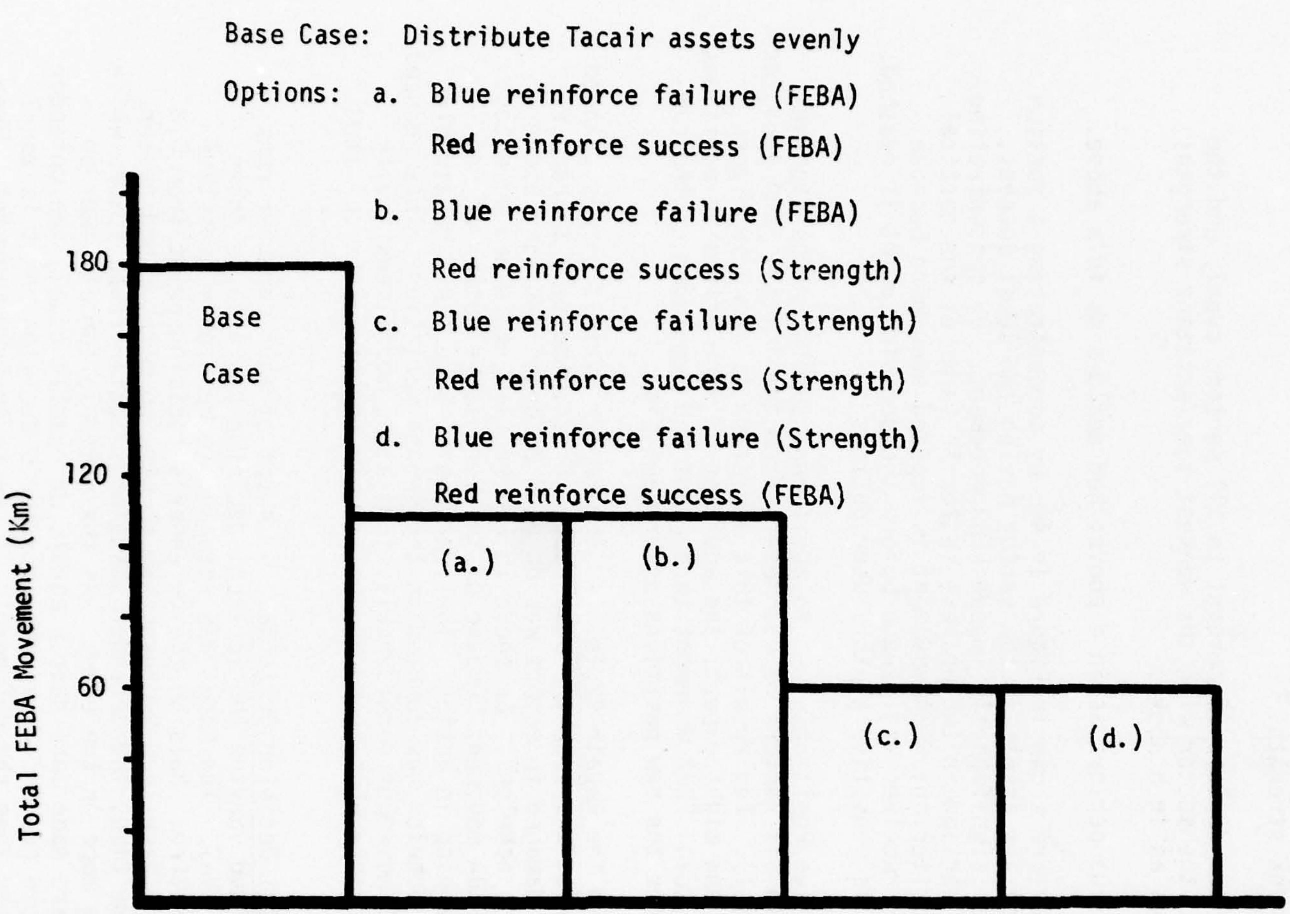


FIGURE IV-4, Varying Tactical Air Deployment Options

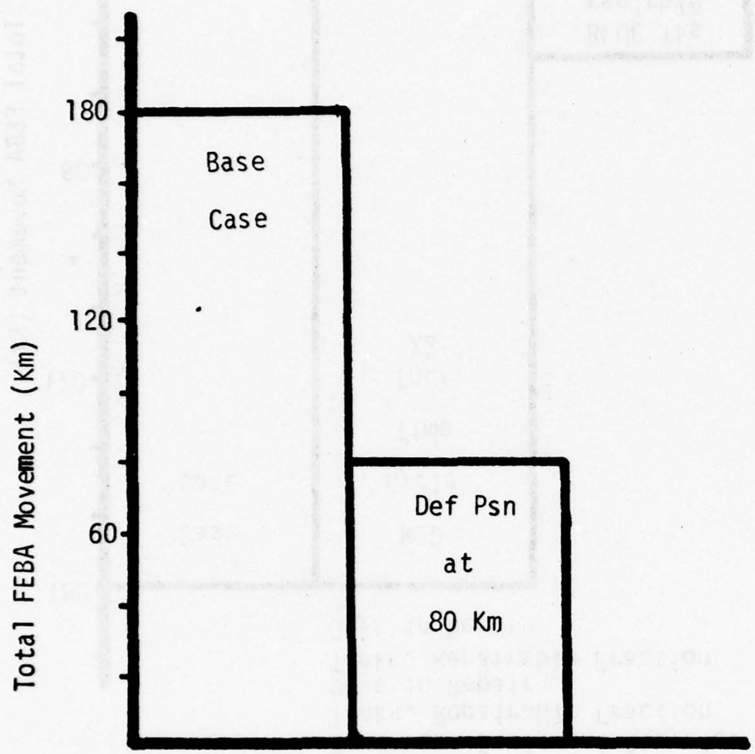


FIGURE IV-5, Additional Defensive Position

| Base Case Equipment Recycle: | BLUE | RED |
|---|---|---|
| Tanks, Repairable Fraction | .232 | .209 (lower ech) |
| Days in Repair | 3 | 3 |
| Tanks, Repairable Fraction | .128 | .115 (higher ech) |
| Days in Repair | 4 | 4 |

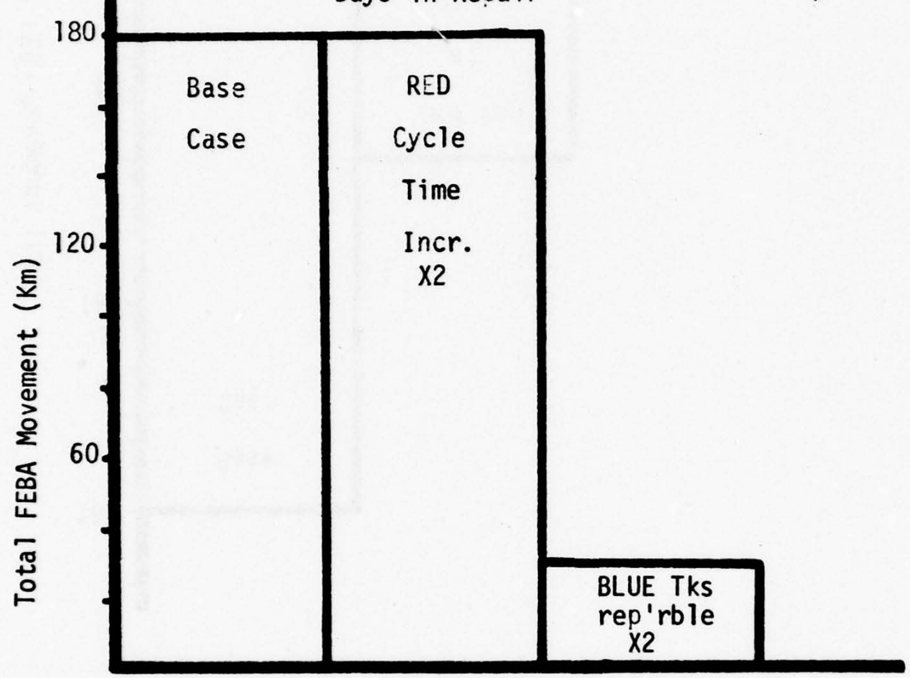


FIGURE IV-6, Varying Maintenance Cycle

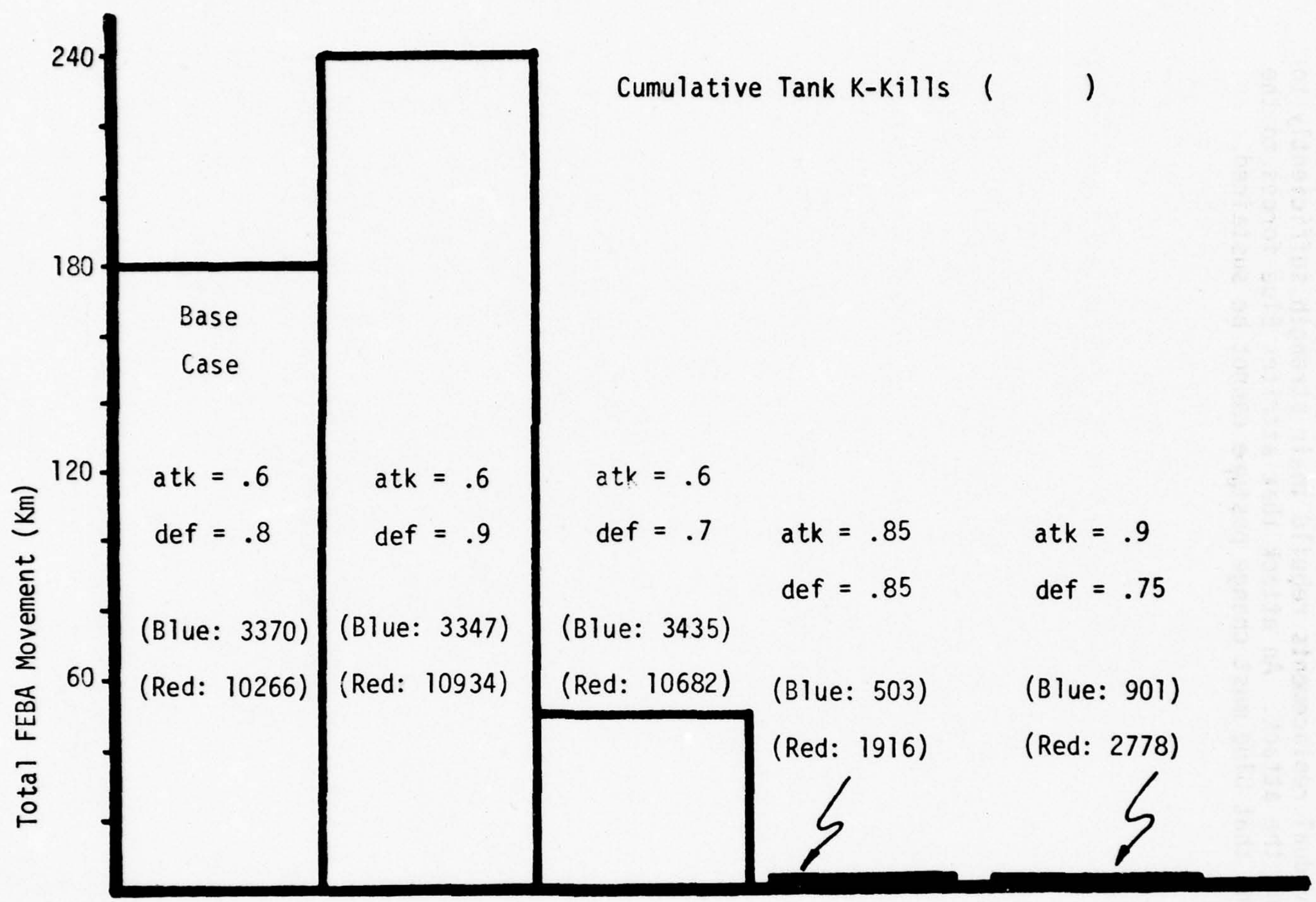


FIGURE IV-7, Varying Tactical Decision Criteria attacking Red forces have relatively high decision points, the forces change from an attack to a hold posture very early, until individual replacements rebuild their strength sufficiently to resume the attack. An attack that attrites Blue forces to the extent that Blue must change posture cannot be sustained.

# CHAPTER V
# RESPONSES TO ESSENTIAL ELEMENTS OF ANALYSIS

The essential elements of analysis (EEA) are addressed herein, based upon the material presented in the preceding chapters.

1. EEA 1: Are there direct approaches to the assessment of losses of personnel, weapons, and other equipment which will permit the elimination of the use of a single number, aggregated measure of effectiveness in theater-level models?

   Yes. The ATWAR Model achieves this end using an inventory of combat samples and the outputs of high resolution computerized combat simulations to extrapolate to theater-level campaigns. In the COMCAP II and COMCAP III Studies[17, 18] the General Research Corporation has also developed a theater-level hierarchy that is not completely firepower/force ratio dependent. Vector Research, Inc, and Lulejian & Associates, Inc, have developed direct approaches that appear credible.[19, 20]

2. EEA 2: Are there field test results available which make comparisons of small units, multiple armored vehicle engagements, and combined arms team mixes in a variety of missions, weather, terrain, and scenario situations?

   Yes. To a limited extent there are field test results. The TETAM Study[21] is generating useful data, for example. However, ATWAR extrapolates from existing combat samples and low level, high resolution models, and the source of data was not addressed comprehensively.

3. EEA 3: Can the relationship between battle outcomes and movements at lowest engagement levels be extrapolated to higher levels, considering barriers, force levels, missions, environments, and other variables?

   Yes. ATWAR accomplishes these extrapolations with the exception of barriers.

4. EEA 4: Can the ATLAS, CEM, or TARTARUS Models be modified to accept the new data and approach to yield more credible movement and losses and yet retain the capability to respond rapidly?

The CEM and TARTARUS were not examined in detail for reasons discussed in Chapter II. The ATLAS was found to be so dependent on force ratio that to eliminate force ratios would have meant creating a new model. Hence, as far as ATLAS is concerned, the answer to this EEA is negative.

5. EEA 5: Is the new approach, when applied in the modified theater-level models, more valid and objective than current theater-level models?

The ATWAR Model is more valid and objective in those applications where absolute, rather than relative, values of attrition are significant. These values are calculated in low level, high resolution models based on weapons performance data. They are therefore considered absolute rather than relative as in those theater models which assess losses using weapons scores adjusted by a judgmentally determined factor that makes the losses appear reasonable.

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# CHAPTER VI
# OBSERVATIONS

The principal product of this study is the ATWAR Model. The following observations pertain to the application of that model to war gaming problems.

## 1. Advantages

a. The ATWAR Model is not dependent on firepower scores or force ratios to assess losses or move the FEBA.

b. The ATWAR Model provides a consistent model hierarchy linking the combat samples and submodels of the AMMORATES Methodology to a comprehensive theater-level simulation of air/ground combat.

c. The ATWAR tactical air routines and ground combat routines are designed to be mutually interactive on a daily basis.

d. Given the availability of combat sample analyses and AMMORATES submodel outputs, ATWAR provides a very rapid simulation of theater combat both in terms of setup time (1 or 2 technical man-days) and central processor time (about 1 second per day of combat).

## 2. Limitations

a. The ATWAR Model is closely bound to the matrix of manually gamed combat samples. Any significant change in forces, weapons mix, or terrain influencing tactics would require a new sample matrix.

b. The ATWAR Model does not have a logic for automatically committing the reserve.

c. The ATWAR Model does not have a logic for creating new sectors during a campaign.

d. The ATWAR Model does not simulate envelopments or flank engagements except to the extent that they may have been considered in the combat samples.

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APPENDIX A
STUDY TEAM

1. Study Director

COL Joseph B. Murphy, War Gaming

2. Team Members

LTC Zach Hagedorn, Jr. - Project Team Leader
Mr. R. Glenn Stockton - ATWAR Model

3. Contributors

MAJ Edward R. Janusz - Multiple Ratios
Mr. Thomas A. Sanders - CONTACA inputs

4. Support Personnel

Mrs. Angela T. Johnson

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COMBAT MODULES IN WAR GAMES

# APPENDIX B
# REFERENCES

## SECTION 1
## CITED REFERENCES


1. Kerlin, Edward P. and Robert H. Cole, Research Analysis Corporation, "ATLAS: A Tactical, Logistical, and Air Simulation: Documentation and User's Guide," RAC-TP-338, McLean, VA, Apr 69.

2. McNamara, J. T., J. R. Kalbach, and P. M. McGroddy, US Army Strategy and Tactics Analysis Group, "TARTARUS IV N/COCO, Players and Technical Manual," Bethesda, MD, undated.

3. General Research Corporation, Operations Analysis Division, "Conceptual Design for the Army in the Field (CONAF), Alternative Force Evaluation, CONAF Evaluation Model (CEM) IV, Draft Report," McLean, VA, 14 May 74; and Part 2, Draft Report, June 74.

4. US Army Concepts Analysis Agency, "CONAF III Study Plan," Bethesda, MD, Jun 73, p. 3-3.

5. US Army Concepts Analysis Agency, "Nonnuclear Ammunition Combat Rates Programming FY 76-80 (AMMO P 76-80), USAREUR, USARPAC, ROKA, Final Report," Bethesda, MD, Jan 74. (SECRET)

6. US Army Concepts Analysis Agency, "Nonnuclear Ammunition Combat Rates Programming FY 75-79 (AMMO P 75-79), Final Report, Volume IV. Annex C: Methodology - Part I and Part II," Bethesda, MD, Jul 73. (Part I - UNCLASSIFIED; Part II - SECRET)

7. Institute for Defense Analyses, "IDA Ground-Air Model I (IDAGAM I), Vols. 1-5 Review Draft," Report R-199, Arlington, VA, May 74.

8. Vector Research, Inc., "VECTOR-0, the Battle Model Prototype: Vols. I-V," WSEG Report 222, Washington, DC, Dec 73.

9. Lulejian & Associates, Inc., "Prototype of Theater-Level Tactical Combat Model, Vols I-III," WSEG Report 227, Washington, DC, Feb 74.

10. US Army Concepts Analysis Agency, "Firepower Potential Methodology Review," Bethesda, MD, 31 Dec 73. (CONFIDENTIAL)

11. General Research Corporation, Operations Analysis Division, "NATO Combat Capabilities Analysis II (COMCAP II)," Draft Client Report, McLean, VA, 31 Oct 72. (SECRET)

12. General Research Croporation, Gaming and Simulations Department, "NATO Combat Capabilities Analysis III (COMCAP III)," Draft Contract Report, McLean, VA, Jul 74. (CONFIDENTIAL)

13. US Army Concepts Analysis Agency, "Nonnuclear Ammunition Combat Rates Programming FY 75-79 (AMMO P 75-79), Final Report, Volume IV. Annex C: Methodology - Part I and Part II," Bethesda, MD, Jul 73. (Part I - UNCLASSIFIED: Part II - Secret)

14. Ibid.

15. Ibid.

16. US Army Strategy and Tactics Analysis Group, "CONTACA, Players and Technical Manual," Bethesda, MD, Mar 72.

17. General Research Corporation, Operations Analysis Division, "NATO Combat Capabilities Analysis II (COMCAP II)," Draft Client Report, McLean, VA, 31 Oct 72. (SECRET)

18. US Army Concepts Analysis Agency Discussion Paper, subject: "COMCAP III Approaches," Bethesda, MD, 5 Nov 73.

19. Vector Research, Inc., op. cit.

20. Lulejian & Associates, Inc., op. cit.

21. US Army Combat Developments Command, "Tactical Effectiveness Testing of Antitank Missiles," CDEC Experiment 11.8, Ft Ord, CA, Feb 74.

GREATER DISTINCTION BETWEEN
COMBAT MODULES IN WAR GAMES

APPENDIX B
REFERENCES

SECTION 2
ADDITIONAL REFERENCES


Bonder, Seth, "A Generalized Lanchester Model to Predict Weapons Performance," Systems Research Group, Ohio State University, Columbus, OH, Jun 65.

_______, "The Lanchester Attrition Rate Coefficient," Operations Research, 15:2, Mar-Apr 67.

Clark, Gordon M., "The Combat Analysis Model," Ohio State University, University Microfilms, Ann Arbor, MI, 1969.

Cockrell, James, "The Simulated Assault Battle Environment Research (SABER) Model," Report GM-2144-H-2, Cornell Aeronautical Laboratory, Inc,. Buffalo, NY, 1967.

Dept. of Army, Office of the Assistant Chief of Staff for Force Development, "Proceedings of the Twelfth Annual US Army Operations Research Symposium, Vols I and II," conducted at the Army Research Office, Durham, NC, 2-5 Oct 73.

Evans, Kenneth A., "ATLAS Summary (Draft)," US Army Concepts Analysis Agency, Bethesda, MD, May 73.

Hall, Garrett S., "Lanchester's Theory of Combat: The State of the Art in Mid-1970," Masters Thesis, US Naval Postgraduate School, Monterey, CA, Mar 71.

Historical Evaluation and Research Organization, "Developing a Methodology to Describe the Relationship of Mobility to Combat Effectiveness," McLean, VA, Feb 67.

_______, "Average Casualty Rates for War Games Based on Historical Combat Data," McLean, VA, Oct 67.

_______, "The Quantified Judgment Method of Analysis of Historical Combat Data," Dunn Loring, VA, Jan 73.

Joint Chiefs of Staff, Studies Analysis and Gaming Agency, "Catalog of War Gaming Models," SAGA-209-71, 5th ed., Washington, DC, 30 Jun 71. (FOR OFFICIAL USE ONLY)

Kerlin, Edward P., et al, "Computerized Quick Game: A Theater Level Combat Simulation (U)", RAC-TP-266, Research Analysis Corp., McLean, VA, Nov 67. (CONFIDENTIAL)

Lockheed Missle and Space Corp., "Report of Simulation Support for the Evaluation of Candidate Tank Configurations Using the IUA Simulation Model (U), Vols I and II," LMSC-D009535, Sunnyvale, CA, 1 Dec 72. (CONFIDENTIAL)

Newman, John T., et al, "The FOREWON Force Planning System," RAC-R-86, Research Analysis Corp., McLean, VA, 1970.

Parsons, Norman W., "Staff Memorandum - Military Unit Rates of Advance in Attack", SM-29-CORG, Combat Operations Research Group, Ft Belvoir, VA, Sep 54.

Research Analysis Corp., "Theater Battle Model (TBM-68), Vol VII, Technical Report," RAC-R-36, McLean, VA, Jan 68.

________, "Land Combat Systems Study, (LCS-1), Vol I, Gaming Methodology and Results for Land Combat System I Study (U)," RAC-CR-53, McLean, VA, May 72. (SECRET)

US Army Combat Developments Command, "Force Developments, the Measure of Effectiveness," Pamphlet 71-1, Ft Belvoir, VA, Jan 73.

US Army Materiel Systems Analysis Agency, "Joint AMC/CDC M60 Tank Study (U), Vols I-III," AMSAA TM 102, Aberdeen Proving Ground, MD, Feb 71. (Vol I, SECRET; Vols II and III, CONFIDENTIAL)

US Army Models Review Committee, "Review of Selected Army Models," Washington, DC, May 1971.

US Army Strategy and Tactics Analysis Group "Comparative Weapons Effectiveness Study (CWES)," Draft, Bethesda, MD, Jan 72. (FOR OFFICIAL USE ONLY)

US Army War College, "Research Analysis Corporation Theater Combat Model (TCM)," Group Study Project Individual Research Report, Carlisle Barracks, PA, 12 Mar 71.

Weapons Systems Evaluation Group, "Methodologies for General Purpose Force Planning (U), Vol X, Firepower Score Review," WSEG Report 165, Arlington, VA, Apr 71. (SECRET)

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# APPENDIX C
# MULTIPLE RATIOS APPROACH

## SECTION 1
## DETAILED DESCRIPTION

1. Purpose. - The purpose of this appendix is to describe in detail a new concept of treating measures of effectiveness (MOE) in the ATLAS Model. The concept proposes three ICE (Indices of Combat Effectiveness), makes the ICE a function of the opposing force, and obviates the need for computing the correlation factors. The essential simplicity of the ATLAS Model is maintained. Although the approach is presented in terms of Firepower Potential (FPP), it can be extended to other MOE, and may have application in FPP-74* or other projects.

2. Current Methodology for Combining Dissimilar Types of Fire. - One of the major criticisms of the FPP methodology centers around the "f" factor--a factor which relates the area fire weapons to the direct fire weapons. Hidden deeper in the methodology is the correlation factor equating "bullets" (direct fire small arms) to area fire weapons. The derivation of the latter is somewhat less tenuous than the "f" factor, in that both area fire weapons and "bullets" are fired against personnel. There is no need here to itemize the problems associated with the derivation of the factors--suffice it to say that there is no generally accepted way and that a great deal of judgment on the part of the analyst is necessary. The correlation factors serve essentially three purposes:

a. Establish a common scale among bullets, area fire weapons, and direct fire antitank weapons.

b. Interject relative military worth of the various classes of weapons.

c. Allow the analyst to introduce a certain amount of judgment into the calculations.

Closely related to the correlation factors is the problem of the force ratio being independent of the opposing force composition. For example, an infantry division, if reinforced with sufficient

*Firepower Potential Methodology Improvements in FY 74.

artillery, may have a high force ratio when compared to an armored division. This may not realistically reflect its ability to stop an armored attack, which is a recognized shortcoming that is accepted to maintain the simplicity of the ATLAS Model. The approach presented here is aimed at preserving that simplicity while achieving greater distinction between units of different types.

3. Proposed Approach. - The proposed approach defines the unit in three force components:

| | |
|---|---|
| Total "bullets" potential | (Bullets) |
| Total area fire potential | (Area Fire) |
| Total antiarmor potential | (Antiarmor) |

The current approach adds the three together, adjusting by the appropriate correlation factors ($f_1$ and $f_2$) to normalize all categories to area fire.

$$FPP = f_1 \text{ (Bullets)} + \text{Area Fire} + f_2 \text{ (Antiarmor)}$$

The force ratio is then expressed as:

$$\frac{\text{FPP attacker}}{\text{FPP defender}}.$$

This serves to conceal the relative strengths and weaknesses of the forces. When comparing two opposing forces it would appear to be more meaningful to have three ratios such as:

$$\frac{\text{Bullets (attacker)}}{\text{Bullets (defender)}}, \quad \frac{\text{Area Fire (attacker)}}{\text{Area Fire (defender)}}, \text{ and } \frac{\text{Antiarmor (attacker)}}{\text{Antiarmor (defender)}},$$

or to express the potential per opposing tank or potential per opposing man by the following three ratios:

| | Symbol |
|---|---|
| $\frac{\text{Bullets (attacker)/Defender personnel}}{\text{Bullets (defender)/Attacker personnel}}$ | $\frac{\text{B (attacker)}}{\text{B (defender)}}$ |
| $\frac{\text{Area Fire (attacker)/Defender personnel}}{\text{Area Fire (defender)/Attacker personnel}}$ | $\frac{\text{AF (attacker)}}{\text{AF (defender)}}$ |
| $\frac{\text{Antiarmor (attacker)/Defender armor}}{\text{Antiarmor (defender)/Attacker armor}}$ | $\frac{\text{A AR (attacker)}}{\text{A AR (defender)}}$ |

These ratios are referenced by the indicated symbols in the subsequent figures. It is assumed that movement rate is a function of these ratios. Again, to avoid the single valued MOE and the correlation factors, the following approach could be used:

A predominant force component is selected as the independent variable in determining the rate of movement. In Europe it is armor, in Northeast Asia it may be artillery. Hence, a curve such as that shown in Figure C-1 could be developed, assuming initially that antipersonnel FPP (from area fire weapons and bullets) of both sides is equal and that armor is the predominant component. All ratios in the following charts are adjusted by the composition of the opposing force as discussed earlier.

If the attacker has an area fire FPP advantage of 1.1, another curve is added, as in Figure C-2. The same rationale could be used to extend the family of curves to the whole spectrum of force ratios, as in Figure C-3. This principle could be extended to encompass the "bullets" ratio by forming an envelope of curves such as those shown in Figure C-4. In the ATLAS Model this would be stored as a three dimensional matrix. The numbers inside the matrix would be the rate of movement. A different set of these curves, or possible appropriate multipliers, would be required for different unit mobility rates and types of terrain.

The rationale developed can be extended to other MOE. For example, it may be possible to combine the "bullets" and the area fire into one MOE, and add some measure of mobility as the third value.

The movement rate curves would have to be developed by judgment supported by low resolution models, field test data, or historical combat data. While this approach is far from ideal, applying judgment to this type of data appears more valid than to a single valued, total force ratio.

The only additional inputs per unit required for ATLAS would be:

a. "Bullet" FPP.

b. Area Fire FPP.

c. Anitarmor FPP.

d. Total number of personnel vulnerable to "bullets" and area fire.

e. Total number of tanks or other armored vehicles.

f. Total number of antiarmor weapons.

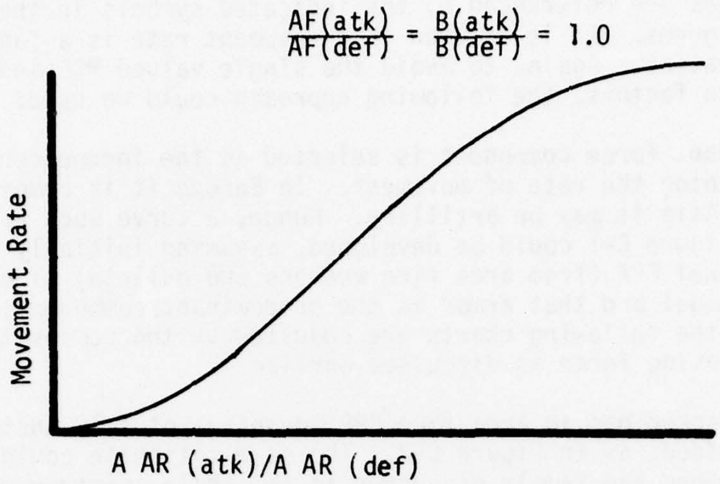


FIGURE C-1, Movement Rate vs. Anitarmor Ratio with Constant Area Fire and Bullet Ratios

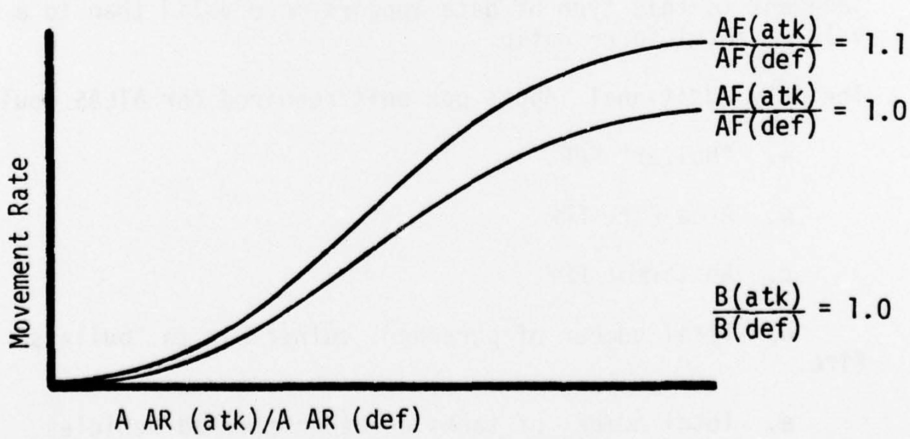


FIGURE C-2, Movement Rate vs. Antiarmor with Two Area Fire Ratios

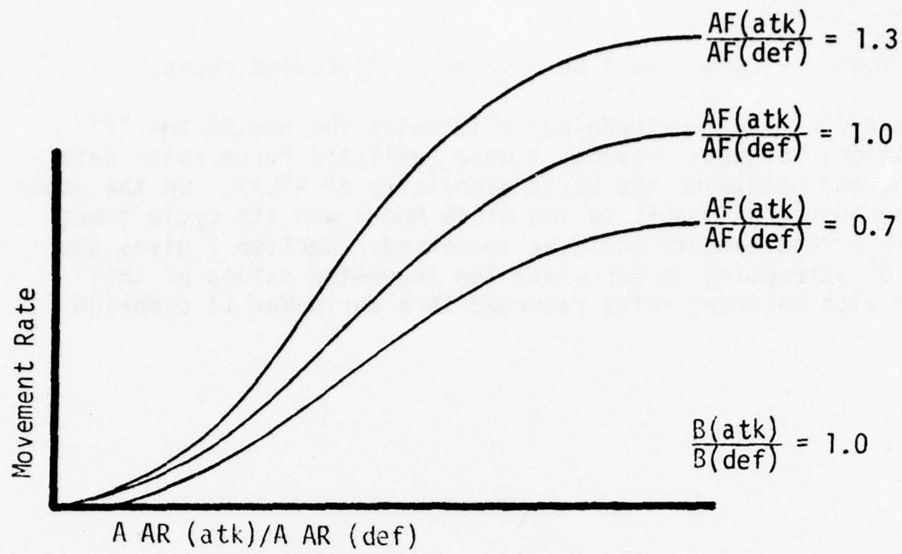


FIGURE C-3, Movement Rate vs. Antiarmor Ratio with Varying Area Fire Ratios

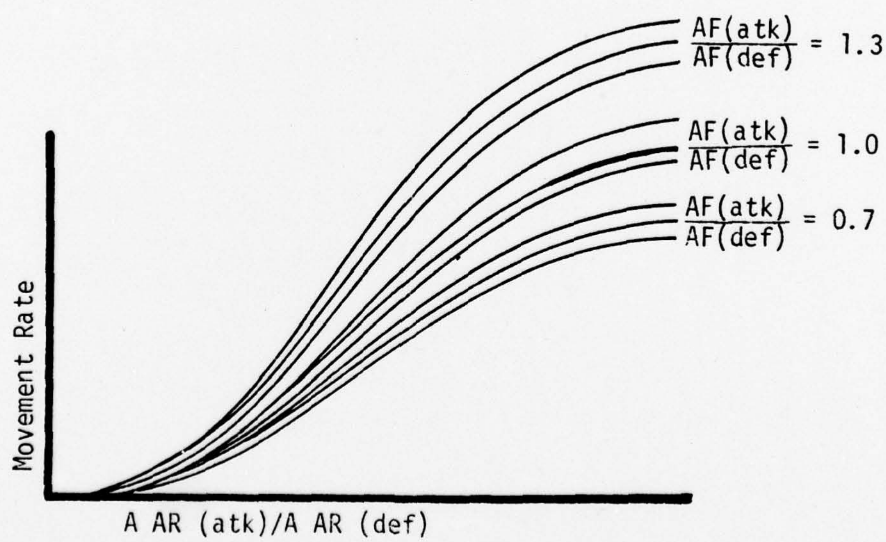


FIGURE C-4, Movement Rate vs. Antiarmor Ratio with Varying Area Fire and Bullet Ratios

And the movement curves must be revised as discussed above.

4. Summary. - This methodology eliminates the use of the "f" (correlation) factors, provides a more realistic force ratio determination, and maintains the basic simplicity of ATLAS. On the other hand, the number of inputs to the ATLAS Model and its cycle times and storage requirements would be increased. Section 2 gives the results of attempting to correlate the suggested ratios of this approach with movement rates recorded in a World War II campaign.

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APPENDIX C
MULTIPLE RATIOS APPROACH

SECTION 2
RESULTS

1. The approach of Section 1 proposed the use of three indices of combat effectiveness in ratio form in order to eliminate the judgmental "f" factor from the FPP methodology. The ratios proposed were the following:

$$\frac{\text{Bullets (attacker)/Defender personnel}}{\text{Bullets (defender)/Attacker personnel}}$$

(Bullets referring to small arms, direct fire weapons)

$$\frac{\text{Area Fire (attacker)/Defender personnel}}{\text{Area Fire (defender)/Attacker personnel}}$$

$$\frac{\text{Antiarmor (attacker)/Defender armor}}{\text{Antiarmor (defender)/Attacker armor}}$$

The concept was to establish the ratio of attackers' weapons to their expected targets and divide that by the corresponding defenders' ratio of weapons to targets. Establishing separate ratios for area fire and direct fire weapons and subsequently correlating the two with movement rate offered the apparent advantage of eliminating the judgmental "f" factor from the MOE.

2. Mathematically rearranging the above ratios gives:

$$\frac{\text{Bullets (attacker) X Attacker personnel}}{\text{Bullets (defender) X Defender personnel}}$$

$$\frac{\text{Area Fire (attacker) X Attacker personnel}}{\text{Area Fire (defender) X Defender personnel}}$$

$$\frac{\text{Antiarmor (attacker) X Attacker Armor}}{\text{Antiarmor (defender) X Defender Armor}}$$

A set of data on 60 battles from the World War II Italian Campaign obtained by USACAA from the Historical Evaluation and Research Organization for another study project offered a convenient basis for examining the multi-ratio concept. Accordingly, a short computer program was prepared to calculate the required ratios and match them with corresponding movement rates from the historical data.

3. Only weapons counts rather than weapons scores were used because a complete set of WW II scores is not available nor are the specific identities of the weapons employed in those 60 battles known. In using weapons counts instead of scores, there are inherent assumptions that expected expenditure of ammunition is the same for both attacker and defender and that weapons effectiveness is also the same for both sides.

4. The results of the calculations for the area fire X personnel ratios and for antiarmor X armor ratios were analyzed using a multiple regression correlation technique. (The bullets X personnel ratio was not checked because only machinegun inventory was available.) Analysis of these results shows little correlation for either ratio with movement rate. The antiarmor X armor ratios extend over an extremely broad range from less than one to hundreds. Larger numbers were obtained when defender had no tanks, causing a zero in the denominator. These instances were neglected, but the remaining 48 battles still show no correlation between movement rate and the antiarmor X armor ratio. Likewise, the area fire X personnel strength ratios do not correlate.

5. Correlation coefficients were computed for these ratios versus movement rate, after discarding the data from 12 battles because they contained a zero in the denominator of the antiarmor X armor ratio. The calculations yielded the following correlations (R):

FEBA movement vs. antiarmor X armor ratio - .031

FEBA movement vs. area fire X personnel ratio +.068

FEBA movement vs. posture - .108

These are very poor correlations; R = 0.7 or better would be good. Correlations were also calculated separately within each posture, yielding the results shown in Table C-1.

TABLE C-1, Correlation Coefficients (R)[a]

| Posture<br>Ratio | Delay | Hasty Defense | Prep Defense | Fortified Defense |
|---|---|---|---|---|
| Antiarmor X armor | -.137 | +.286 | +.029 | -.217 |
| Area fire X personnel | -.123 | +.340 | +.411 | -.230 |

[a] In most instances the correlations were very poor also.

6. This examination of historical data indicates that the multiple ratio concept is not a useful criterion for predicting rate of FEBA movement. Consequently, this approach was terminated.

NOT USED